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Natural Philosophy, Abstraction, and Mathematics among Materialists: Thomas Hobbes and Margaret Cavendish on Light

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Abstract: The nature of light is a focus of Thomas Hobbes's natural philosophical project. Hobbes's explanation of the light (*lux*) of lucid bodies differs across his works, from dilation and contraction in *Elements of Law* to simple circular motions in *De corpore*. However, Hobbes consistently explains perceived light (*lumen*) by positing that bodily resistance (endeavor) generates the phantasm of light. In Letters I.XIX–XX of *Philosophical Letters*, fellow materialist Margaret Cavendish attacks the Hobbesian understanding of both *lux* and *lumen* by claiming that Hobbes has illicitly made abstractions from matter. In this paper, I argue that Cavendish's criticisms rely on an incorrect understanding of the nature of Hobbesian geometry and the role it plays in Hobbes's natural philosophy. Rather than understanding geometry as wholly abstract, Hobbes attempts to ground geometry in different ways of considering bodies and their motions. Furthermore, Hobbes's own criticisms of abstraction suggest that he would share many of the worries she raises but deny that he falls prey to them.

Keywords: Thomas Hobbes; Margaret Cavendish; geometry; natural philosophy; optics; perception

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1. Introduction

The nature of light is a focus of Thomas Hobbes's natural philosophical project. Hobbes's account of the light (*lux*) of lucid bodies differs across his works: in *Elements of Law* I.II.8 he suggests it is "manifest . . . by experience" that their light is caused by motions of "dilation, and contraction . . . alternately, commonly called scintillation or glowing," but later in *De corpore* XXVI he posits that the sun "by its simple circular motion" moves the parts of the ether that are near it [1] (I.364). However, Hobbes consistently explains perceived light (*lumen*) by positing that inward-moving pressure beginning at sense organs meets resistance as it continues inside the body, rebounds outward, and generates the phantasm of light. As Hobbes uses the terms, then, lux is a property of a glowing body and lumen is the phantasm of light generated by inward and outward motions. [1]

In Letters I.XIX–XX of *Philosophical Letters*, fellow materialist Margaret Cavendish attacks the Hobbesian understanding of both *lux* and *lumen* by claiming that Hobbes has illicitly made "abstractions of Motion and Figure from Matter" [3] (p. 65). In this paper, I argue that Cavendish's criticisms rely on an incorrect understanding of the nature of Hobbesian geometry and the role it plays in Hobbes's natural philosophy. Rather than understanding geometry as wholly abstract, Hobbes attempts to ground geometry in different ways of considering bodies and their motions. Furthermore, Hobbes's own criticisms of abstraction suggest that he would share many of the worries she raises but deny that he falls prey to them.

The paper is in three stages. First, I discuss Hobbes's adaptation of the *lux*/*lumen* distinction to his natural philosophy and his well-known account of human perception. Next, I examine Cavendish's development of a materialistic, non-mathematical explanation of human perception and natural light in *Philosophical and Physical Opinions* [4], and I show how she uses it against Hobbes in her criticisms in *Philosophical Letters* [3]. Finally, I argue that Cavendish's anti-abstractionist claims against Hobbes's account of light fail to appreciate Hobbes's ideal of natural philosophy as a kind of mixed-mathematics as well

as Hobbes's own resistance both to abstraction and to the hubris of thinking that natural philosophy provides knowledge of actual causes.

2. Hobbes, Perception, and the Lux/Lumen Distinction

2.1. Hobbesian Sensation and Visual Perception

Hobbes's interests in optics began early in his writing period and remained throughout many of his major works. Mersenne published an optical treatise of Hobbes's in *Ballistica* (1644), [2] and Hobbes discusses issues related to optics in the many works that follow it. Whenever Hobbes is concerned to discuss the source of conceptions, or ideas, and the actions of the human mind such as imagining, willing, or understanding, he frequently begins with an account of his supposition that sensation by the various senses is by means of pressure. Hobbes famously does this in the opening chapter of *Leviathan*, even though he admits that doing so in that context was "not very necessary to the business now in hand" [2] (p. 22) [9] (p. 3). The account of sensation that Hobbes offers there in *Leviathan* 1 and elsewhere is well known: the motions of bodies either press against the human perceiver directly (touch and taste) or indirectly by motions propagated through media (sight, sound, and smell). These pressing motions that impact the sentient are continued into the body, eventually pressing on the brain and the heart, at which time they are met with "resistance" or what Hobbes calls an "endeavour" of the heart. This resistance results in motion outward, which Hobbes posits is responsible for perceivers taking the causes of their conceptions to be external bodies. [3]

The description of sensation so far might seem to place Hobbes in a troubling position with respect to visual perception of bodies that are at rest. It seems that Hobbes must either hold that bodies do not truly rest even if they appear to do so, as Margaret Cavendish does, or that resting bodies are imperceivable to humans. [4] Hobbes cannot take the former route since the notion of 'rest' figures in the two *a priori* principles of his natural philosophy. [5] Heinrichs raises the latter as a concern by claiming that according to Hobbes "if a body were possessed only of magnitude, it would be unobservable" [13] (p. 85). However, Hobbes has a clear response to this supposed worry: it is not simply the local motions of bodies that are responsible for sensation. Additionally, the motion from a light source that illuminates a body enables humans to perceive it. Thus, Hobbes's complete account of visual perception involves both the motions of bodies as well as the illumination of light.

Given the account sketched so far, Hobbes's claim that light will be a type of motion should be unsurprising. Not only does this understanding of light as motion follow from Hobbes's account of visual perception discussed already, but it also follows from Hobbes's more general assumption that only bodies exist and his further claim in *De corpore* IX.9 that motion is the cause of all change [14] (I.126) [1] (I.111). However, so far, the account lacks precision, which can be seen by posing a couple of questions that relate to Cavendish's objections to be considered later. Is Hobbesian light itself a body or simply the motions *of* bodies? How does Hobbes account for light producing bodies and the light which they generate? To answer these questions, it is necessary to see how Hobbes accommodates the vocabulary of the distinction between *lux* and *lumen* and adapts it to his own account.

2.2. Hobbes on Lux and Lumen

In the early work *Elements of Law* (1640) [15], Hobbes suggests that "by experience" it is "manifest" that the light of "lucid, shining and illuminated" bodies is caused by motion. Regarding lucid bodies themselves, Hobbes identifies fire as the "only lucid body here on earth" and suggests that it moves in a particular manner: by motions of "dilation, and contraction . . . alternately, commonly called scintillation or glowing" [15] (I.II.8). This Hobbes offers as a possible cause for fire, and for the sun as well, since "we have no reason to doubt" that the sun moves in this way. However, by the time of *De corpore*, Hobbes had abandoned dilation and contraction as possible causes of the behavior of lucid bodies and instead appealed to what he called "simple circular motion." [6]

Hobbes's discussion of the nature of light in *De corpore* XXVII begins by introducing suppositions related to "intersidereal" bodies concerning their consistencies, magnitudes, motions, and figures [14] (I.445) [1] (I.362). Hobbes notes that he takes some consistencies to be hard and others to be soft. Regarding their magnitudes, he states that he will suppose them only to be small enough to save the phenomena, although he recognizes that quantity is indefinitely divisible "by the understanding" (*intellectu*) [14] (I.445–447) [1] (I.362–364). Similarly, Hobbes supposes only motions and figures of these bodies required to provide possible causes. [7] In setting out these initial suppositions, Hobbes's approach to light is similar to other explanations that he offers in natural philosophy insofar as he seeks to offer a *possible* cause to explain the phenomena surrounding light.

In proposing a possible cause for light, Hobbes shows his familiarity with the distinction between *lux* and *lumen*, [8] stating that he is seeking a possible "cause of the light of the sun [*causam lucis solaris*]" [1] (I.364). The possible cause he proposes is that the body of the sun moves by "simple circular" motion, which motion is propagated to the ether surrounding it and is continued until it reaches some other body against which it presses. [9]

The type of body of interest to Hobbes is, of course, the sense organs of human perceivers. As will be discussed below, Hobbes discusses simple circular motion in the section on geometry in *De corpore* (Part III). Although the status of those claims as *mathematical* will be a focus later in the paper, for now I will briefly describe how Hobbes understood this motion and its propagation. Hobbes claims in *De corpore* XXI.1 that when a body moves in simple circular motion, all its points describe the circle the body makes. This type of motion occurs when a body moves in a sieve-like fashion. Hobbes furthermore claims in *De corpore* XXI.10 that simple circular motion generates simple circular motion as it propagates, so as the sun moves in this way and causes *lux*, it generates simple circular motion that is propagated throughout the ether. Likewise, as that motion presses upon the eye it propagates simple circular motion into the perceiver's body until it reaches the heart. As mentioned already, when the pressure reaches the heart, it encounters resistance and rebounds outward. In addition to attributing a perceiver's judgment that the cause of their perception was an external object to this rebounding, outward motion, in *De corpore* XXVII.2 Hobbes identifies it as "light [*lumen*], or the phantasm of a lucid body [*lucidi*]" [1] (I.365).

3. Cavendish on Perception and Light and Her Criticisms of Hobbes

Margaret Cavendish, similar to Hobbes, held that all that existed in nature was matter in motion. [10] However, rather than holding, as Hobbes does, that one part of matter can only be put into motion by another part and that parts are sometimes at rest, Cavendish claims that there are different "degrees" of matter—animate and inanimate matter—that are mixed together throughout nature [27] (p. 158). She further subdivides animate matter into sensitive matter and rational matter. Against a view similar to Hobbes's, Cavendish claims that animate matter is capable of self-motion, and since the degrees of matter are mixed one with another throughout nature, her view implies that all of nature is constantly in motion. She allows that there may be cases of apparent rest, for example, the "retentive motions" that she posits hold together parts of nature [27] (pp. 18–19), but even if humans do not perceive it matter is never at rest [27] (p. 131). These continual motions present throughout all matter are responsible for variety [4] (p. 9).

This section discusses how Cavendish develops a materialistic, non-mathematical explanation of human perception and natural light in *Philosophical and Physical Opinions* (hereafter *Opinions*) [4] and shows how she uses it against Hobbes in her criticisms in *Philosophical Letters* [3] (hereafter *Letters*). The motivation behind attending to the *Letters* (I.XIX–XX) is natural since Cavendish there explicitly criticizes Hobbes's understanding of light. However, before turning to the *Letters* this section will first examine Cavendish's own discussions of light in *Opinions*. Cavendish herself saw continuity between her views in *Letters* and *Opinions*, and she encourages the reader of *Letters* to "read first my Book called *Philosophical and Physical Opinions*, before you censure this, for this Book is but an explanation of the former, wherein is contained the Ground of my Opinions" [3] (preface).

3.1. Cavendish on Visual Perception and Light

Cavendish appeals to the self-motions of matter to explain human visual perception. Against the Hobbesian view that visual perception is caused by pressure from illuminated external objects continued through media until reaching the sense organs, [11] Cavendish posits that sensitive matter and rational matter coordinate with one another in perception. In *Letters* she describes this as a "double perception" (Letter I.IV) [3] (pp. 18–19), and later, in *Observations upon Experimental Philosophy*, she identifies this as a "double degree of perception" [27] (p. 138). Although all parts of nature perceive one another, since sensitive matter is mixed throughout, she hypothesizes that human visual perception occurs by means of patterning self-motions [27] (p. 15), asserting that no creature can know all of the many other possible ways that the parts of nature perceive one another [27] (pp. 140, 169). [12]

Cavendish's treatment of perception in *Opinions* lacks the phrase "double perception," but what she says in *Opinions* suggests that her view of perception is similar to the later texts. Cavendish states that "for the most part" reason "moves according to the Senses" [4] (pp. 301–302). When the rational matter "streight moves its own matter and motions in the same Prints or Figures, by which it informs itself of the Sensitive Actions," she holds that this produces "Knowledge or Understanding" [4] (p. 49). Sensitive matter self-moves to pattern an external object's self-motions, which Cavendish describes as the creation of "prints" [4] (pp. 48–49, 301–302) [27] (p. 79). Next a perceiver's rational matter self-moves and patterns the motions of the sensitive matter so that it can "inform itself of the Sensitive Actions" [4] (p. 49) [38] (p. 57). In copying the self-motions of the sensitive matter, Cavendish posits that the rational matter creates "Voluntary figures" such as "imagination or Conception" [4] (pp. 49, 58) [38] (pp. 57–58). These voluntary figures that the rational matter, which is freer than that sensitive matter, creates enable it to go beyond what is perceived by the sensitive matter. For example, when standing at the shore a perceiver's "eyes may see the Sea, or Air" but her eyes will not see the "Compass, and so [not] the Earth or Heavens" [4] (p. 296). In such a case, the small portion of the sea in front of the perceiver serves as the "figurative ground" used by the perceiver's rational matter to form a conception of the entire ocean. When the perceiver's rational matter makes a voluntary figure, such as the imagined ocean, it copies the prints from sensitive matter and puts them together to form something beyond sense, but which relies on what sense has patterned. Another example Cavendish provides is "the Object of the whole Earth" [4] (p. 64), which cannot be patterned by sense except in "Pieces and Parts." However, reason can copy these individual "Pieces and Parts," put them together, and then make "Globes" and "Compasses." So much for this brief description of Cavendish's account of perception. Although it is materialistic, and so rejects appeals to *species* and the like, it appeals to motions as solely responsible for visual perception in human perceivers. For example, just as Hobbes will say that the conception 'dog' I am currently considering is constituted just by motions remaining in the mind after perceiving some particular dog here or there, Cavendish likewise holds that the matter of my brain (self-) moving in some way is just my conception of whatever I am considering at the time. [13]

Cavendish discusses the sun and the "natural light" it produces in both editions of *Opinions* [4,40]. While my primary focus will be upon the 1663 edition [4], since it more directly informs the criticisms of Hobbes that she makes in *Letters*, I will briefly describe similarities and differences between her views in these works. In the 1655 edition, she posits that natural light is constituted by a "spinning" motion [40] (p. 77) where parallel lines of light are drawn out from their source like "drawing a small thread from a spindle" [40] (p. 86). She emphasizes, as she will also later claim, that although light is characterized by a particular kind of motion (spinning) "there can be no motion without some matter" [40] (p. 78). Her insistence that light must be matter in motion makes sense against the Hobbesian background. Whereas in *Elements* Hobbes appealed to fire to infer that the sun also moves by dilation and contraction (EL I.II.8), Cavendish resists such reduction in light to just a type of motion present in diverse bodies. Instead, she asserts, that there are "as many various lights, as faces, and as different kinds of lights, as there are

different kinds of Animals, or vegetables, or minerals . . . " [40] (p. 78). Cavendish holds, for example, that there is light, firelight, meteor light, glow worm light, and rotten wood light [40] (p. 78) [4] (p. 183), and each of these would be unique insofar as they would each have their own characteristic motions.

Cavendish repeats and expands upon these claims in the second edition of *Opinions*. She notes that "But were not Light a Body, it would not be subject to Sight, for although all Bodies are not subject to Sight, yet Sight cannot possibly see what is not a Body, which is not" [4] (p. 183). Although this emphasis on the materiality of light seems contrary to Hobbes's appeal simply to motion in explaining *lux*/*lumen*, Cavendish shows a debt to Hobbes's early view of *lux* by identifying it with dilation: "But if the sun, as some Modern opinions hold, doth not move out of his place, but is as it were fixed, [. . .] then the motions of the sun, are onely by dilation, and attractions: from which light, and heat proceeds . . . " [40] (p. 85). She expands on this dilation-type motion in 1663 by explaining that light-as-a-body moves *through* and *with* air: "Light can Dilatate and Contract *through the Air*, and *with the Air*, and spread upon Solid bodies without Diminishing its Substance, or Altering its proper Nature" (emphasis added) [4] (p. 184).

She reiterates this feature of the way light-as-a-body moves by dilation by emphasizing that "the Lines of Natural light which issue from the Sun, do Dilate with an Extraordinary Swiftness, Eveness, or Equalness, Smallness, and Straightness" [4] (p. 183). Here, the contrast with Hobbes becomes clearer: rather than Hobbes's account of the ether surrounding the sun propagating the motions of the sun by receiving those motions through pressure (whether dilation in *Elements* or simple circular motion later in *De corpore*), Cavendish claims that natural light, in this case *lux*, as Hobbes would use it, is itself a kind of body that moves in a particular way, namely, in spinning, dilatory motions that form parallel lines. In other words, according to Cavendish natural light is not just this or that body moving in a particular way, as it is for Hobbes, but instead it is a particular kind of body moving in that way.

What is the *perception* of light according to Cavendish (what Hobbes uses *lumen* to identify)? Given her account of visual perception by patterning, the answer she gives is unsurprising: in the visual perception of light, the sensitive matter of the human perceiver will be "drawing motions [that] make lines of light" [4] (p. 297), which motions could also be patterned by their rational matter. In other words, since on Cavendish's view visual perception occurs by patterning, *lux* and *lumen* are constituted by the same type of motion. Cavendishian *lux* is the production of dilatory motion from the sun by a light-body, and *lumen* is the imitation of that body's motions by human perceivers by double perception.

3.2. Criticisms of Hobbes on Light in Letters

This section examines Cavendish's criticisms against Hobbes in Letter I.XIX and briefly notes her related comments in Letter I.XX. Letter I.XIX opens with a denial that the light of the Sun enables an animal to see. Were this the case, Cavendish holds, a perceiver's eyes would be in pain when perceiving, similar to the pain that fire can cause when "it sticks its points into our skin or flesh" [3] (p. 63). Furthermore, Cavendish claims that humans "see inwardly" when they dream, which implies that the self-motions of the eye and brain themselves "make such a figure as Light" [3] (p. 63). Although Cavendish suggests that human perceivers "see" during their dreams, she admits that dreaming, say, of light, merely presents "the figure of light on the inside of the eye, as they did pattern out the figure of light on the outside of the eye when awake" [3] (p. 64). In other words, "seeing" light while dreaming is merely replaying on the inside what one perceived of some external object.

Given Cavendish's view that all motion is self-motion, it may appear at first glance that she would hold that all light is lux insofar as each self-moving, perceiving part of nature will generate its own representation of light. However, Cavendish does not go this route and instead alludes to the lux/lumen distinction (without using the Latin terminology): [14]

> But there is some difference between those figures that perceive light, and those that are light themselves; for when we sleep, there is made the figure of light, but

> not from a copy; but when the eye seeth light, that figure is made from a copy of the real figure of the sun; but those lights which are inherent, as in Glow-worms-tails, are original lights, in which there is as much difference as between a Man and his Picture [3] (p. 64).

The perception of light by patterning (while awake) involves making a copy of external light that is currently present; dreams lack a "copy" in this sense insofar as they have no currently external object of which they are a copy. However, the representation of external light in perception and in dreaming both differ from "original lights" such as the sun itself, glow-worms, and (her earlier example) cats' eyes. [15]

Cavendish's account in Letter I.IX has so far primarily criticized the Hobbesian explanation of perception as pressure, but her next criticism is more general and relates to her assertion that Hobbes's philosophy is abstractionist. Before making her anti-abstractionism explicit, she first makes a related criticism against Hobbes's appeal to simple circular motion, mentioned already. She argues regarding light and fire that it is "very probable" that they are made by "swift and violent motions" but that it is not appropriate to infer that *all* instances of such motions would generate them. She supports this claim by noting that the "swift and violent Circular motion of Whirlewind neither makes light nor fire" [3] (p. 64), a clear attack on Hobbes's identification of light with simple circular motion.

Cavendish's worry that Hobbes overgeneralizes circular motion as the cause of all kinds of light, and her appeal to the motion of whirlwinds as a counterexample, leads to her more general criticism: Hobbes has failed to consider nature's parts in terms of their individuality. She emphasizes that rather than appealing to some generally applicable type of motion, such as circular motion, one must instead "consider Figures of every Creature, as well as their motions, and must not make abstractions of Motion and Figure from Matter, nor of Matter from Motion and Figure, for they are inseparable, as being but one thing, *viz*. Corporeal Figurative Motions" [3] (p. 65). There is no general account of light (*lux*) for the natural philosopher to give, according to Cavendish, but instead there are myriad particularities such as the lights of fires, the sun, glow worms, cats' eyes, fish bones, and so on. Against Hobbes, she argues that "whoever conceives of [Corporeal Figurative Motions] as abstract will . . . very much erre" [3] (p. 65).

On the interpretation I have offered here, Cavendish's objection to Hobbes is an *epistemic* one. In other words, Cavendish rejects Hobbes's attempts to infer from the apparent motion of one lucid body, such as fire, that all lucid bodies, including the sun, move in that way. On this epistemic reading, Cavendish's claim that matter, motion, and figure are "inseparable, as being but one thing, viz. Corporeal Figurative Motions" [3] (p. 65) concerns what humans should avoid attempting to infer: humans should not illicitly attempt to form abstractions because they cannot even *mentally* consider, say, motion apart from some matter or other. Indeed, although in *Opinions* IV.III Cavendish similarly says that motion and matter are "inseparably united" and are thus "but one Thing" [4] (p. 95), in the same context she allows for the metaphysical possibility of there being motionless matter, stating that "there might be Matter and Figure without Motion, as an Infinite and Eternal dull Lump" [4] (p. 93). Motion counts as "a Thing" not because it is identical to matter, but because all matter is moving in nature's current arrangement, though it could have been otherwise. Thus, Cavendish can hold that "there could be no such Degree or Extract of Matter without Motion" [4] (p. 93). All Cavendishian matter is also created, extended, and divisible. Cavendish could therefore say of "creation," "extension," and "divisibility" that each is also "a Thing."

Adams [11] (pp. 503–507) offers a similar reading of Cavendish's criticisms of Hobbes in Letter I.XVII [3] (pp. 56–58). There Cavendish argues against Hobbes's (epistemic) account of "imaginary space" and the reliance of Hobbesian "place" upon it. She similarly asserts in that Letter that "Place, Magnitude, and Body are but one thing" [3] (p. 56). Given Hobbes's understanding that imaginary space is a mind-dependent after-effect of experiences of external bodies, it follows on his view that "place" is as well. Claiming they are "but one thing" against Hobbes in that context implies that Hobbes's mind-dependent

conception "imaginary place" is incoherent and should be rejected; instead, to claim these are "but one thing" is for Cavendish to suggest that "place" is a feature of *bodies* and not something mind-dependent.

However, one could understand Cavendish's claim that one "must not make abstractions of Motion and Figure from Matter, nor of Matter from Motion and Figure" [3] (p. 65) as a *metaphysical* objection against any appeal to accidents. In other words, one could take these objections to signal her rejection of the substance/accident distinction. Cavendish later holds such a view and argues, for example, in *Observations* that "the distinction . . . is to no purpose; since there cannot really be, no not imagined, such a thing as an incorporeal or substanceless motion or action in nature" [27] (p. 193). Note that she denies both that there is such a distinction ("there cannot really be") but also that it is even conceivable ("not imagined"). However, in the *Opinions* of 1664 and the *Letters* of 1664, it does not appear that she fully has rejected the distinction yet and is focused on whether one can abstract in the mind. For example, in *Opinions* she is willing to countenance thinking of effects being *in* matter and states that "Motion is but the Effect of Matter" [4] (p. 94). Concerning Hobbes's definition of 'accident', which she quotes, she claims in Letter I.XVI that she gives willing "consent" to it but objects that "these qualities cannot be separated from the body, for as impossible it is that the essence of Nature should be separable from Nature, as impossible is it that the various modes or alterations, either of Figures or Motions, should be separable from matter or body" [3] (p. 52). Since the definition Hobbes provides is epistemic insofar as an accident is merely "the manner of our Conception of body," any separation that occurs is in the mind alone and Hobbes need not hold that accidents such as color or figure are separable in a metaphysical sense. Even Hobbes's simplest conceptions such as 'place' and 'imaginary space' and 'time, which he introduces in the annihilation of the world thought experiment of *De corpore* VII, are not wholly separable in the mind. There will be no wholly abstracted conception 'place' according to Hobbes; there will only be this or that particular conception that a thinker considers in a particular by ignoring all other features, such as 'place'.

However, one might nevertheless see Cavendish's criticism in this letter (Letter I.XVI) as against Hobbesian accidents entirely. She quotes Hobbes's claim in *De corpore* VIII.3 that "[a]n accident is not a body, but in a body, yet not so, as if any thing were contained therein, as if for example, redness were in blood in the same manner as blood is in a bloody cloth; but as magnitude is in that which is great, rest in that which resteth, motion in that which is moved." Cavendish replies that " . . . not anything in Nature can be without a body, and that redness is as well in blood, as blood is in a bloody cloth . . . ; for there is no colour without body, but every colour hath a body as anything else . . . " [3] (p. 52). Hobbes would agree with the claim that nothing can be without a body, but Hobbes countenances a *mental* ability to consider this or that accident apart from other accidents. Again, Hobbes would endorse Cavendish's claim that "there is no colour without body, but every colour hath a body as anything else . . . ", but what Hobbes allows is the mental ability to consider red apart from blood, which ability is likewise used in geometrical reasoning when we consider only certain accidents of bodies, such as straight line or rectangular. In other words, Hobbes and Cavendish are both willing to say (1) that no colors exist apart from bodies, but Hobbes also holds (2) that the mind can consider color apart from body. Cavendish denies point 2.

Given how difficult it is to tell what alternative metaphysics Cavendish means to propose, my proposal is to read Cavendish's objection in Letter I.XVI as against the very possibility of *mental* abstraction, or in Hobbes's terms the ability to "consider as." [16] Section 4 below suggests that Hobbes would agree with Cavendish that *total* abstractions in the mind are not possible. All that is possible, according to Hobbes, is a type of abstraction in which we *consider* this or that accident of a body and ignore its other features.

So far, Cavendish's criticisms against Hobbes seem to involve a resistance to abstraction so that each kind has its own unique motion. However, talking about motion of this or that *kind* is, of course, already a sort of abstraction (e.g., not just the dilatory motion constitutive of a particular fish skeleton but of fish skeletons generally). Furthermore, how can

Cavendish hold such an anti-abstractionist view alongside her own claim in *Opinions* that nature's 'infinite motions' can be "reduced to six Principal sorts, as, Atraction, Contraction, Retention, Digestion, Dilation, and Expulsion" [4] (p. 8). Why would talk of "dilation" as a principal sort of motion be meaningful if in the end one should really be concerned with dilatory motions of particulars such as motions of individual fish bones? Rather than seeing Cavendish's criticisms of Hobbes in 1664 as inconsistent with her account in *Opinions* of 1663, I suggest that her criticism of Hobbes is that he has taken a *single type of circular motion* to be responsible for light in *all bodies everywhere*. Her resistance is not to abstraction as such, since she seems to think it is intelligible to talk of these principal sorts of motions (more on this later); rather, her worry concerns Hobbes's hubris in that simple circular motion, and the geometric demonstrations following from it, describe nature.

Her criticism thus is that the project of using geometrical principles to explain natural phenomena requires that one take a single type of motion to describe myriad different types of bodies. This anti-geometrical bent is clear in *Opinions* when she seems to ridicule the opening lines of the Introduction to *Leviathan*: " . . . I have heard some say, Geometry to be the Ground of Natural Philosophy, and not Natural Philosophy the Ground of Geometry; we may as well say, Art produceth Nature, and not Nature Art" [4] (viii). [17] Furthermore, although Cavendish tells her reader that the *Opinions* is similar to an "Unpolish'd Stone or Metall," she states that the reader will find only "Plain Sense and Reason, Plainly Declared, without Geometrical Demonstrations, Figures, Lines, and Letters" [4] (xv). Against seeing geometrical principles as explanatory, Cavendish resists understanding nature as acting the same way, and with the same exactness, in all instances. She argues in *Opinions* that:

> Motion hath not Spare time as to Move or to Work so Curiously, as to Shape and Form every Particular Part of every Particular Creature so Exactly, as to Form them Mathematically or Geometrically, so as when any Creature is so Exact, as no Fault can be found, it seems rather a Work by Chance, than any Design in Motion to Work so Exactly [4] (p. 248).

In sum, the reason why geometrical principles fail in natural-philosophical explanations is that nature simply does not act so consistently. [18] Given these other references to appeals to geometrical principles, we can understand Cavendish as committed to abstraction only in a loose sense. Therefore, when she asserts, say, that glow worms produce light by dilatory motions, she could hold that each glow worm dilates broadly speaking, but each does so in its own unique way.

Letter I.XX deals with potential objections to Cavendish's view that someone sympathetic to Hobbes's philosophy would likely offer. The third objection that she addresses relates to her anti-abstractionist account described already. Cavendish provides the worry as follows: "They may ask me, if sight be made in the eye, and proceeds not from the outward object, what is the reason that we do not see inwardly, but outwardly as from us?" [3] (p. 68). Recall the earlier discussion of Hobbes's supposition that motions from external objects reach the brain and the heart and then they are met with "resistance," which Hobbes identifies as "endeavour" from the heart. This resistance causes the motions to rebound outward, and it explains why perceivers take the causes of their conceptions to be external bodies. Additionally, Hobbes explains the perception of light, *lumen*, by appealing to this rebound outward. Cavendish elsewhere resists the pressure perception account because she thinks it would lead to disorder [29,44], but we can also see her criticism as founded in her anti-abstractionist tendencies.

Given Cavendish's worries about exact abstractions being used to explain variegated natural phenomena, she resists any appeal to a single type of motion being responsible for disparate phenomena. Thus, holding that a single type of motion (endeavor outward) causes the perception of all varieties of perceived light, from fire to sunlight, oversimplifies the way she thinks nature plausibly acts. Instead, Cavendish holds that the patterning responsible for human perception of external objects happens on the outside of the eye and, because the exterior of the eye is "outwardly convex," the object is perceived as such [3] (p. 68). The "seeing" of dreams, mentioned earlier, is by contrast caused when we

"see inwardly." Cavendish's appeal to the convex shape of the human eye may seem at odds with her worries about the use of geometry; indeed, one can easily imagine how a geometrical approach would attempt to generalize from the case of the convex human eye to all instances of convex-shaped, translucent bodies. Cavendish would resist such a move and simply say that at least in the case of *human* perception, which she posits as being by patterning, this is a likely cause. For other creatures, and for other parts of nature, however, she states that we are unable to say how perception happens [27] (pp. 140, 169) and thus could say we cannot say one way or the other that all convex figures influence perception in this way.

4. Materialist Natural Philosophy: Mathematics and Abstraction

Cavendish's attack on Hobbes's project of mathematizing natural philosophy as abstractionist and overly ambitious is directly at odds with Hobbes's own appraisals. This section provides Hobbes-inspired replies to Cavendish's criticisms by focusing on three aspects of Hobbes's understanding of mathematical objects and of explanations in natural philosophy. First, I describe Hobbes's own opposition to abstraction and his preferred description of mathematical objects as formed when a body is considered in a particular manner, a cognitive activity for which Hobbes frequently uses the locution "consider as." Second, I discuss Hobbes's frequent disavowals of certainty in his own natural philosophy and his descriptions of providing possible causes. Finally, I briefly describe how Hobbes's view that "true physics" is mixed mathematics is a consequence of these two aspects of his thought.

In various works, Hobbes criticizes those who hold that abstraction results in wholly abstract concepts or ideas that can then be signified by names. For example, in *Anti-White* XXX.36 Hobbes targets those who use names that have no connection to *particular* conceptions from sense: " . . . the speech of the greatest number of those who philosophize is accompanied by no thoughts of things, but words received rashly, variously mingled, and compounded into propositions, until finally they seem to signify something excellent" [45] (p. 366) [46] (p. 388). [19] Hobbes complains that Thomas White has done this when "discussing abstractions [*abstractions*] from place, from continuous parts, from time, and the like" (Ibid.). Hobbes's alternative is "speaking clearly from a consideration [*considerationem*] of place, parts, and time" (Ibid.). Hobbes declares that it "not difficult to consider [*considerare*] place apart from a consideration [*consideratione*] of body" since any unphilosophical person (*rusticus*) understands place simply as space in which a body can be. An unphilosophical person would think a speaker "mad" (*insanire*) who claimed that place is abstract (*abstrahere*) [45] (p. 366) [46] (p. 388). Later in *Leviathan*, Hobbes emphasizes that, when properly understood, abstract names such as 'motion' and 'length' are "severed (not from Matter but) from the account of Matter" [2] (p. 58) [9] (p. 16). Abstractions, then, are treated in the mind *as if* they were independent—apart from being considered with body.

Hobbes's understanding of mathematical objects follows from this more general account of the proper nature of abstraction. Although some have seen Hobbes as endeavoring to emulate Euclid in method [48], Hobbes harshly criticizes Euclid's account of mathematical objects as well as Euclid's definitions. The Hobbesian alternative treats mathematical objects as artificial bodies that humans create in the mind or on paper when they consider real bodies in certain ways. Rather than seeing a geometrical point as instantaneous, Hobbes argues that a point is a body considered not as that which "has no quantity, or which cannot by any means be divided; for there is no such thing in nature" but rather as a body "whose quantity is not at all considered, that is, whereof neither quantity nor any part is computed in demonstration" [14] (I.206) [1] (I.177). In the same way, humans create lines by considering bodies that have breadth as if they had no breadth [14] (VII.202); [45] (pp. 114–115) [46] (pp. 37–38).

Hobbes also criticizes Euclidean definitions insofar as they lack information concerning how to create the figures in question; in Hobbes's terms, Euclidean definitions are not

generative. Against Euclid's understanding of 'line' [14] (VII.202), Hobbes contends that a line is "made by the motion of a point" [1] (I.63) [47] (p. 297). Likewise, a surface is made by the motion of a line, and a solid is made by the motion of a surface. In each of these examples, to understand the definition one must have some particular body or other in one's imagination and then consider that particular *as if* it were without certain features (breath, magnitude, and so on). The particular never leaves the mind as abstractions enable mathematical inquiry to proceed. Although Hobbes's most incisive criticisms of abstraction are in *Anti-White*, his view is well represented in *De corpore* and in *Leviathan*, both of which were available to and cited by Cavendish. As a result, when Cavendish claims that "whoever conceives of [Corporeal Figurative Motions] as abstract will . . . very much erre" [3] (p. 65), it seems Hobbes would do nothing more than agree with her. Thus, Cavendish's assertion that Hobbes is guilty of claiming that motion and geometrical figures are abstract misses the mark.

Second, Hobbes repeatedly disavows the possibility of having certainty in natural philosophy. [20] For example, in the Epistle Dedicatory to *Six Lessons*, Hobbes distinguishes between arts that are demonstrable and those that are not. Demonstrable arts begin from "precognition of the causes, generation, and construction" of their objects. Demonstrable arts include geometry because we make the figures ourselves and civil philosophy because we "make the commonwealth ourselves" [14] (VII.183–184). Natural philosophy, however, is not demonstrable because humans cannot know the actual causes responsible for phenomena, as Hobbes claims "of natural bodies we know not the construction but seek it from the effects" so we can know "only of what [the causes] may be" [14] (VII.184). In *De homine* 10.5, Hobbes similarly argues that since "the causes of natural things are not in our power" we can demonstrate only what their causes *may* be, not what they are [49] (p. 42) [1] (II.93). Hobbes elsewhere consistently describes the project of natural philosophy in this way [14] (I.388) [1] (I.316). Furthermore, there may be various suppositions, or hypotheses, of possible causes that natural philosophers propose, and in *De corpore* XXVI.5 Hobbes explicitly notes six that he himself posits to save the phenomena. The fundamental requirements for such suppositions are that they provide a possible cause and that they are not "absurd" [14] (I.425) [1] (I.347). With such minimal requirements for what can be offered as a supposition, it is easy to see why Hobbes himself changed his mind on the possible cause to explain *lux* between *Elements* and *De corpore*.

Finally, these two aspects of Hobbes's mathematics and natural philosophy—his anti-abstractionist claims and his statements regarding a lack of certainty—come together when Hobbes describes how explanations should ideally work in natural philosophy. Hobbes makes clear in *De homine* 10.5 that "true physics" is mixed mathematics:

> [. . .] since one cannot proceed in reasoning about natural things that are brought about by motion from the effects to the causes without a knowledge of those things that follow from that kind of motion; and since one cannot proceed to the consequences of motions without a knowledge of quantity, which is geometry; nothing can be demonstrated by physics without something also being demonstrated a priori. Therefore physics (I mean true physics) [*vera physica*], that depends on geometry, is usually numbered among the mixed mathematics [*mathematicas mixtas*]. [. . .] Therefore those mathematics are pure which (like geometry and arithmetic) revolve around quantities in the abstract [*in abstracto*] so that work [in them] requires no knowledge of the subject; those mathematics are mixed, in truth, which in their reasoning some quality of the subject is also considered, as is the case with astronomy, music, physics, and the parts of physics that can vary on account of the variety of species and the parts of the universe [49] (p. 42) [1] (II.93).

According to Hobbes, then, explanations in natural philosophy should ideally be a mixture of knowledge (*cognitio*) drawn from sense or memory and causal, geometrical principles borrowed from geometry (*scientia*). [21] The former shows *that* something is the case, whereas a borrowed principle of the latter provides the *why*. Not all of Hobbes's

explanations in natural philosophy meet this ideal, but, as Adams [50,51] has argued, some of his explanations in works such as *De corpore*, *De homine*, and *Dialogus Physicus* show Hobbes's attempts to do this in practice. In these instances, Hobbes explicitly cites geometrical principles from *De corpore* to provide the *why*. Importantly, given Hobbes's worries about humans' inability to know the causes of natural phenomena, he cannot hold that borrowing such causes (the *why*) from geometry surmounts this obstacle. Instead, we can understand Hobbes as holding that mixed-mathematical explanations in natural philosophy possess what we may call suppositional certainty: the natural philosopher knows that if such a motion *were* present in actual bodies then certain effects would necessarily follow from that motion. [22] This places knowledge in natural philosophy as between factual knowledge from sense and memory (*cognitio*) and certain knowledge (*scientia*).

5. Concluding Thoughts: Cavendish's Criticisms and Materialist Explanations

The preceding section has argued that Cavendish's criticisms of Hobbes's account of light miss their target. Although she accuses Hobbes of being guilty of abstraction, Hobbes's broader views resist understanding mathematics as fully abstractionist. Hobbes often uses the term 'abstract' to contrast pure with mixed mathematics, as in the extended quotation from *De homine* 10.5 above, but his own attacks on those who take abstract concepts to be "severed" from matter show that he cannot be committed to strong abstraction in the way I have suggested that Cavendish seems to hold.

What about Cavendish's claim that nature does not work to the exacting standards supposed by those who suppose that mathematics describes external bodies? Recall her assertion that "Motion hath not Spare time as to Move or to Work so Curiously, as to Shape and Form every Particular Part of every Particular Creature so Exactly, as to Form them Mathematically or Geometrically . . . " [4] (p. 248). Hobbes would likely agree with her worry about humans' lack of understanding about *precisely* how nature works, and he could fall back on his overarching assumption that humans have no access to the causes of nature. Natural philosophers simply posit that nature behaves in a particular manner and then deduce consequences from those suppositions. Hobbes clearly thinks that such activity—positing possible causes—is useful to humankind, and he lauds the benefits of *scientia*. [23] Hobbes need not hold that natural bodies perfectly instantiate mathematical objects to see the use of mathematics as beneficial.

Hobbes's attempt to understand light *generally*, made possible by borrowing a geometrical principle related to simple circular motion, is motivated by his aim to make nature intelligible. Making nature more intelligible imparts benefits on those who possess or use the fruits of natural philosophy. Given Cavendish's emphasis on the inexactitude of nature's works accompanied by her resistance of thinking about general kinds such as 'light', what is the aim of her natural philosophy? An early answer Cavendish provides to this question in *The World's Olio* suggests that natural philosophy is "of little or no use, onely to exercise Their Opinions at The guessing at The Causes of Things, for know Them They cannot" [52] (p. 158). She further compares natural philosophy with poetry insofar as both are to be "used as a Delight and Recreation in Mens Studies" and are both "Fictions" [52] (p. 161).

Were this Cavendish's settled view, and it is not, even if Hobbes had provided the replies suggested above to her criticisms in *Letters*, it seems Cavendish would declare that Hobbes's explanations of *lux*/*lumen* had no more grip on nature itself than a fanciful poem. However, these comments in *The World's Olio* are in the period in which some of her works also entertained atomistic themes, which some have argued Cavendish later rejects, and furthermore Deborah Boyle discusses how in this period Cavendish distinguishes between fanciful ideas in poetry and true ideas [31] (pp. 56–61). In the Epistle to the Reader for *Opinions*, the work immediately preceding the *Letters*, Cavendish states that "The Truth is, that without Natural Philosophy Men could not tell how to live" and furthermore that "all the Arts and Sciences are produced" from it (sig. b3.rect) [4]. This certainly has a Hobbesian

ring to it. She continues by emphasizing that motions must always be considered with the kind of matter in which they are present: " . . . when I Treat of Natural Creations and Dissolutions, or Natural Transmigrations, Metamorphoses, and the like, I do not Obstruct Artificial Transmigrations, Productions, Alternations" and so on (sig. c.ver) [4]. [24]

Her ultimate response to the Hobbes-inspired replies offered in this paper would seem to insist that *any* separation of motion from the way in which it occurs in nature is itself an abstraction. In other words, one cannot ever treat any type of motion generally but rather must always consider motions as they appear naturally in this or that kind of body. Thus, in Cavendish's view, Hobbes's inference in *Elements* from motions he posits to be in fire to motions he posits in the sun would be illegitimate. Likewise, for this same reason Cavendish holds that Hobbes's attempt to characterize all *lux* as simple circular motion and *lumen* as rebounding endeavor similarly fail. Her alternative is to examine instances of light as they are naturally found in the parts of nature, such as in glow worm light, sunlight, and fish bone light. Here, it is worth returning to the claim of Cavendish's, mentioned above, that nature's 'infinite motions' can be "reduced to six Principal sorts, as, Atraction, Contraction, Retention, Digestion, Dilation, and Expulsion" [4] (p. 8). Although such references to motion such as "dilation" may seem general (and thus abstract), Cavendish ultimately would reject thinking of these as such. Instead, dilation and the other motions must be considered only as they are present in moving natural bodies. [25]

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Notes

1 Sometimes Hobbes is inconsistent in his use of the Latin terminology related to light. For example, he describes the object of sense using *lux* in *De corpore* XXV.3. This is unsurprising since elsewhere he sometimes inconsistently uses Latin words that are fundamental to his philosophy. For example, he clearly distinguishes *scientia* from *cognitio* when needing to emphasize their differences [1] (I.58–59); however, other times he uses *scientia* for the more general form of 'science', for example, as the 1668 translation of 'science' from the 1651 edition of *Leviathan* [2] (pp. 72–73).

2 Hobbes's early optics is represented in *A Minute or First Draught of the Optiques* (1983/1646) [5]. Shapiro [6] traces the influence of the Hobbesian account of refraction and theory of light. Malet [7] (pp. 315–317) discusses Hobbes's criticisms of Claude Mydorge and Walter Warner. See also Prins [8] regarding accusations by Seth Ward that Hobbes plagiarized others' work in optics.

3 This account relies upon the *Leviathan* rendition, but in *De corpore* XXIX and *Elements of Law* I.VII.1 Hobbes offers slightly different accounts of the roles played by heart and brain [10] (p. 8).

4 For discussion of Cavendish's criticisms of the Hobbesian notion of 'rest' and her view that matter is always in motion, see Adams [11].

5 See Jesseph [12] for discussion of these principles.

6 Stroud suggests that Hobbes's view changed because of his later reticence to countenance vaccua in nature, see [5] (p. 30).

7 Hobbes mentions a final supposition at the end of *De corpore* XXVII.1: " . . . I suppose, that the parts of the pure aether, as if it were the first matter, have no motion at all but what they receive from bodies which float in them, and are not themselves fluid" [14] (I.448). However, this is not so much a supposition related specifically to these intersidereal bodies but is rather a consequence of one of the *a priori* principles that Hobbes holds regarding motion (cf. fn. 5 above). Insofar as they are bodies, the parts of the "pure aether" are not unique and, as such, Hobbes holds that they behave in accordance with those principles. Relevant to the issue at hand is the following principle from *De corpore* VIII.19: "whatever is at rest, is understood to always be at rest, unless there be some other body besides it, by which it is supposed, it may no longer remain at rest" [1] (I.102). The English translation, repeated in the Molesworth edition, adds that a body causes a resting body to move "by endeavouring to get into its place by motion" [14] (I.115), but this addition imports a conception of force not allowed by Hobbes's definition of motion, see [12,16] (pp. 84–85). That translation does not add 'endeavor' to the recurrence of this principle later in *De corpore* XV.1 [14] (I.205).

8 For discussion of the distinction between *lux* and *lumen*, see Lindberg [17] (p. 356) and Smith [18] (32ff).

[9] Galileo's *Dialogo* may be a source of Hobbes's use of simple circular motion [19] (330ff) [20,21]. On Galileo as a potential source, see also Baldin [22] (pp. 78–79).

[10] Some scholarship on Cavendish's works has argued that in her epistemology she aimed to offer ways for women to enter into natural philosophy. For example, Megan Poole [23] has recently argued that Cavendish's epistemology aimed to expand women's agency in this way. Lisa Sarasohn offers a similar view of Cavendish's natural-philosophical project, arguing that "[b]y emphasizing the rationality that characterizes stones, beasts, and women, Cavendish's universe became both animate and free, and the existence of a female natural philosopher possible" [24] (p. 54). In this same vein, Karen Detlefsen has argued that Cavendish's "position on laws of nature and natural order presages [the] contemporary feminist account" in philosophy of science by Evelyn Fox Keller [25] (p. 73). Against such views, Boyle [26] has cogently argued that Cavendish's natural philosophy does not show proto-feminist leanings. Although I find Boyle's conclusion persuasive, further discussion of whether Cavendish's epistemology, and, indeed, her overall natural-philosophical project, had feminist motivations is beyond the scope of this article, so I leave these issues to the side and assume that Cavendish did not operate with such aims in mind. As a result, when I advocate below for what I call an epistemic interpretation of Cavendish's criticisms of Hobbes, I assume without further consideration that in the 1664 *Letters* Cavendish did not seek to advance a proto-feminist epistemology against Hobbes's mechanical philosophy. I thank an anonymous referee for emphasizing these aspects of Cavendish's view.

[11] Lisa Walters has suggested that "Cavendish's interest in removing force and pressure from optical theories may also have been prompted by the early modern trend for figuring the relation between nature and science as one of mastery and force," and Walters connects this claim to Evelyn Fox Keller's framework in which "the relationship between the powerful force of the male scientist's mind and the resistant but ultimately submissive body of female nature" is a point of focus [28] (pp. 380–381). Discussing such aspects of Cavendish's view are beyond the bounds of this paper, but it should suffice to say that whether or not the gendered representation of natural philosophy/nature is behind Cavendish's critique of the perception-as-pressure account from Hobbes, Cavendish's primary criticism is that the Hobbesian explanation simply fails to save the phenomena and that, were it correct, vision would be disorderly and the sense organs would be annoyed and damaged by the continuous application of pressure upon them. See Adams [29] for discussion of this latter point in the criticisms Cavendish makes in *Letters* of Hobbesian optics.

[12] For discussion of Cavendish's views on this coordination by sense and reason in visual perception, see Boyle [30,31] (pp. 76–77, 90), Cunning [32] (pp. 42–43, 106–161), Detlefsen [33] (pp. 171–181), James [34] (pp. 231–233), Michaelian [35] (p. 39), Richter [36] (p. 109), and Wilkins [37] (p. 253).

[13] I assume that Cavendish would agree with Hobbes that ideas, or conceptions, are images. For discussion of this aspect of her view, see Cunning [32] (pp. 21–27); also, see Cavendish's description of ideas in *Observations* as "the picture of some object" [27] (p. 88), which Duncan [39] (p. 406) suggests offers a Hobbesian argument.

[14] That she does not use this terminology is unsurprising since Cavendish was not skilled in Latin. She notes in the preface to *Letters* that she consulted works in her native language for the figures she criticizes, except for Descartes, whose work she had someone translate (sig. B1v) [3].

[15] A worry for Cavendish's account is that in human perception it would seem that the perceiver would become the same kind of thing as the thing perceived. This worry arises since she holds that human perception is patterning and since she claims that what makes one bit of matter different from another is its unique motions. Thus, in patterning the motions of a Golden Retriever as I perceive it, it would seem that I become a Golden Retriever. Cavendish registers this worry later in *Observations* (phrased as " . . . you will say, If the eye did patter out the figure of light, it would become light itself . . . ") [27] (p. 186) and answers it by appeal to her view that perceiving occurs by making a *copy* of that which is perceived. The eye patterns light but it does so only by copying its "exterior figure"; the interior motions responsible for an object's nature are not perceived and thus not patterned. The perceiver fails to become the perceived because it perceives only its exterior motions by making a copy of them. For discussion of this issue, see Lascano [41] (p. 417).

[16] Chamberlain [42] (p. 327, fn. 67) discusses this claim about "one thing" and notes some of the difficulties in understanding what Cavendish could mean if her proposal is to be understood metaphysically.

[17] This appears aimed at Hobbes's claim that nature is the art God used: "Nature (the Art whereby God hath made and governes the World) is by the *Art* of man, as in many other things, so in this also imitated, that it can make an Artificial Animal" [2] (p. 16) [9] (p. 1). On Hobbes's view Divine art produced the natural world and human art produces artificial entities, such as geometrical figures and commonwealths.

[18] For discussion of this aspect Cavendish's thought in her broader works, see Peterman [43] (pp. 3537–3543).

[19] On the distinction between abstract and concrete names, see *De corpore* III.3–4 [1] (I.28–30) [47] (pp. 227–231).

[20] Cavendish embraces a similar fallibilistic account of human knowledge. For discussion, see Cunning [32] (Chapter 1).

[21] Hobbes makes this distinction between *cognitio* and *scientia* in *De corpore* VI.1 [47] (p. 289) [1] (I.59).

[22] Jesseph [12] (p. 139) makes a similar point regarding applying principles from first philosophy to natural philosophy.

[23] For example, Hobbes identifies *scientia* with power [1] (I.6) [47] (p. 183) and highlights the comforts it provides [1] (I. 6–7) [47] (pp. 183–185) as well as the harms it helps avoid [1] (I.8) [47] (p. 187).

[24] The text reads 'obstruct' here, but given the context it seems likely that Cavendish intends 'abstract' instead.

[25] Boyle [26] (pp. 204–205) argues that Cavendish endorses moderate skepticism in the 1663 edition of *Opinions*, which she argues is somewhat mitigated in *Letters*.

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