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For final version, see

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Introduction

In the seventeenth century the new science was introduced through the works of Bacon, Hooke, Boyle, Power, and others. The advocates of the new science promised to divulge the inner workings of nature and to help man overcome his painful fallen state by means of controlling nature. The new sciences of mechanism and corpuscularism were to be based on objective experiments that would reveal the secret inner natures of minerals, vegetables, animals, the sun, moon, and stars. These experiments were done with new and improved telescopes and microscope with magnifications of up to 100 times.

One early critic of the new science was Margaret Cavendish. Cavendish was skeptical of the ambitious claims, methodology, instruments, and institutions of the new science. In her work, *Observations Upon Experimental Philosophy*, Cavendish argued against "experimental and dioptrical writers," provided her own account of the natural world, investigated aspects of chemistry, medicine, and the nature of heat and color, as well as many other topics in natural

philosophy (OEP 10). While many think Cavendish landed on the wrong side of history with respect to her skepticism regarding microscopes and telescopes, her criticisms of the new science were wide ranging and she was by no means the only one to question the value of such experiments and instruments. While several commentators, like Eve Keller (1997), have argued that Cavendish was against all things experimental, several recent commentators, Emma Wilkins (2014) and Deborah Boyle (2018), have tried to show the much more complicated relationship between Cavendish and the Royal Society and medical studies, respectively. In addition, some commentators, such as Lisa Sarasohn (1984, 2010) and Eve Keller (1997), have argued that Cavendish's criticisms of the new science are based on her belief that Nature, as a representation of the feminine, was under attack by the experimentalists desire to "penetrate" and "manipulate" her for their own ends. While it is certainly true that Cavendish and many of the experimentalists personified nature as a woman, and that Cavendish does portray the men as trying to make her into something she is not, I agree with Deborah Boyle (2004) that these descriptions are not the focus of her objections to experimentalism. Rather than hold that Cavendish is concerned with, as Sarasohn claims, "the sexual implications for both women and nature of the new philosophy" (2010: 147), it seems that Cavendish's objections were largely based on her philosophical commitments. However, I believe there is one aspect of the new science that Cavendish does critique from a feminist perspective, and that is what she sees as its institutional nature and its exclusion of women on the basis of sex, and to this I will turn in the last section of the chapter.[1]

My aim is to address Cavendish's three major critiques of the new science. The chapter is divided as follows: The first section provides a brief overview of Cavendish's views on the nature of bodies and perception. The second regards her critique of the methods and aims of the new science as represented by Bacon and Boyle. The third section examines her critique of

Hooke and the instruments of experimentalism. The final section lays out her feminist critique of the institution of the new science.

Cavendish on the Nature of Matter, Individuals, Causation, Perception, and Bodies

In order to understand Cavendish's objections to the claims of the experimentalists, we must examine her positions regarding the nature of bodies and perception.

Cavendish holds that everything in the world is material and vital. Matter is composed of three "degrees" – animate rational, animate sensitive, and inanimate – which are completely blended in such a way that every portion of matter contains all three degrees. Cavendish denies that there is any smallest part of matter (no atoms) and rejects the possibility of a vacuum. This results in all of nature being one material substance that is self-moving, perceptive, rational, and sensitive. Due to the homogenous nature of completely blended matter, every part of matter is convertible into any sort of thing. That is, the parts of matter that now compose my ears, after my dissolution may form into, for instance, a cat's tail. What makes some portion of matter one particular thing, rather than some other particular thing, are its *corporeal figurative motions*. So, while the very same portion of matter may at one time be a human ear and at another time a cat tail, it has different capabilities or powers at each of those times due to its motions, shape, and the organization of its parts. A portion of matter formed into a human ear, for example, has the ability to pattern sounds at a distance and relay this information to the brain. That same bit of matter formed into a cat tail, while still perceptive, sensitive, and rational, does not have the ability to pattern external objects in this same way.

For Cavendish, an individual, whether it is a plant, animal, or glass jar, is a collection of sympathetically moving parts. These individuals can change and grow and gain or lose matter, as

long as the sympathetic movements are maintained. These sympathetic figurative movements determine the organization, color, capacities, exterior shape, knowledge, and perceptions of the objects in question. Cavendish holds that due to the regularity and harmony of Nature's motions, natural beings fall into various kinds and species. These natural kinds are contrasted with artificial kinds (or as she sometimes calls them "art" or "artifice"), which are man-made objects.

The way in which particular parts of matter can move and express their sensitive and rational capacities depends upon their circumscribed figurative motions. Since nature moves in regular ways, her parts conjoin into (generally) regular figures, which can be sorted into the natural kinds we recognize, such as animals, vegetables, and minerals, and the particular sorts of each category.

Cavendish's self-moving matter provides her with an account of causation and perception that is different from the mechanists. According to Cavendish, causation and perception are due to the self-moving nature of composed parts. Cavendish provides an example in which a hand moves a string or ball. She writes,

> Therefore when a man moves a string, or tosses a ball, the string or ball is no more sensible of the motion of the hand, than the hand is of the motion of the string or ball; but the hand is only an occasion that the string or ball moves thus or thus. I will not say, but that it may have some perception of the hand, according to the nature of its own figure; but it does not move by the hand's motion, but by its own: for, there can be no motion imparted, without matter or substance (OEP 140).

Since every part of matter is perceptive and self-moving, according to Cavendish, interactions between the composed parts of nature are usually instances of occasional causation. For example, when a person sees a chipmunk, the chipmunk serves as the occasion for the

person's sense organs to pattern the external motions and figure of the chipmunk. The chipmunk is the occasional cause and the person's sense organs are the principal and primary cause of the perception.[2]

According to Cavendish, objects have both interior and exterior parts and motions. The distinction might seem merely to direct us to spatially inner and outer parts of bodies. But as Deborah Boyle (2015: 442) notes, Cavendish refers to interior parts as the "inherent nature" of a thing. But what is this inherent nature? It seems clear that for Cavendish, the interior parts are those parts that make a thing a particular part or creature by means of their motions and figures. Cavendish writes,

> … it is to be observed, that in composed figures, there are interior and exterior parts; the exterior are those which may be perceived by our exterior senses, with all their proprieties…*But the interior parts are the interior, natural, figurative motions, which cause it to be such or such a part or creature*: As for example, man has both his interior and exterior parts, as is evident; and each of them has not only their outward figure or shape, *but also their interior, natural, figurative motions, which did not only cause them to be such or such parts; (as for example, a leg, a head, a heart, a spleen, a liver, blood, etc.) but do also continue their being*. (OEP 162, emphasis mine)

Exterior parts are those that are visible. These parts, by their figurative motions, have color, size, weight, etc., and are available to human sensory experience. When perception occurs, the exterior sensory organs of a creature pattern the exterior motions of an object. This patterning is a sort of information transfer to the interior of the creature and causes the creature to move in accordance with its interior nature in response to the exterior movements of the object. But these interior motions are not subject to our exterior sensory organs.

Cavendish claims that a ball cannot know the interior motions of the hand, and thus cannot move by the hand's interior motion. The hand's interior motions cause it to be a hand and enable the type of movements a hand has. However, the ball has its own interior motions, which enable it to move in accordance with its figure. Different types of interior motions and figures constitute different things. When a ball perceives the exterior motions of the hand, it patterns these motions through its perceptive senses and moves itself in accordance with its nature in reaction to the motions of the hand. Thus, the hand is an occasional cause of the self-motion of the ball. The ball is the efficient cause of its own motion. Nevertheless, the ball would not move in the way that it does without the existence of the hand's particular exterior motions.

Cavendish's Critique of the Methodology and Aims of the New Science

With this general account of Cavendish's views on body and perception, we may now turn to her views concerning the experimentalists' methodologies, aims, and instruments. I limit myself to discussing Cavendish in relation to Bacon and Boyle in this section and Hooke in the next. However, I should note that Cavendish had a rather impressive command of the new science. She discusses chemistry and alchemy, medicine, optics, astronomy, and physics in her works. In doing so, she addresses the views of Hobbes, Descartes, Gassendi, Harvey, Glanvill, Jon Baptist van Helmont, and Henry Power in addition to those already mentioned. Moreover, Cavendish was not criticizing microscopes from the armchair; as Emma Wilkins (2014: 3) notes, Cavendish had her own microscope, as well as access to the six her husband had, some of which were made by Eustachio Divino, an Italian experimental philosopher. While Eve Keller (1997) has characterized Cavendish as an outsider whose critiques of the Royal Society were gender based, Cavendish was not an outsider in the sense that she was barred from access to the writings

of the experimentalists or lacked the support and finances to pursue her interest in natural philosophy.[3] Of course Cavendish was not a member of the Royal Society, as women were not allowed to join. However, Cavendish would be the only woman in the 17th century, and I believe the 18th, to be granted a visit to the society. There she observed Robert Hooke's and Robert Boyle's experiments. It is true, however, that very few philosophers engaged with Cavendish. She knew Hobbes, who praised her plays, through her husband and brother-in-law, but claims she never spoke with Descartes (despite his presence in her house) and she failed to engage Henry More despite repeated solicitations. Cavendish did have correspondence with several natural philosophers though, including Joseph Glanvill, Henry Power, and Christiaan Huygens (Akkerman and Corporaal 2004; Broad 2007; Broad 2019).

One philosopher, who is often mentioned in the scholarly literature on Cavendish and the new science, but who is rarely discussed is Francis Bacon. Cavendish never cites Bacon, but it is clear that the Baconian conception of the scientific enterprise is in the background of much of her later works. We know that Cavendish aims criticism of his male-dominated scientific utopia, *New Atlantis*, in her own science fiction work, *Blazing World*, which was published with *Observations Upon Experimental Philosophy*. Moreover, in *Observations*, Cavendish discusses many of the same examples that Bacon uses in the *New Organon* – the nature of heat and cold, and wind – although she draws different conclusions from her observations.

Bacon's suggested methodology in the *New Organon* is an inductive-deductive method that moves from observation to general principles and back to observation. In the *New Organon*, he begins with the production of lists or charts that are made by observation. He takes heat as his example. The first table of "instances meeting in the nature of heat" is a list of twenty-eight cases of the phenomenon of heat (Bacon 2000: 110-111). After this list comes another "Closely related

instances which are devoid of the nature of heat" (Bacon 2000: 112-119). After this, a third "table of the degrees or a comparison on heat" is provided (Bacon 2000: 119-126). These lists of observations are the starting point of investigation into the form, or structural nature, of a particular thing. Bacon thought that by examining the lists of presence, absence, and degrees, one could rule out accidental correlations and thereby come to only those that are essential. Bacon held that the observations and experiments which excluded various instances were key to divulging the form of a particular nature. For instance, we can exclude heat as having an "elemental nature" because it is instanced in the rays of the sun. Through this inductive method (though not an enumerative one), Bacon believed that one could arrive at axioms that would hold at various levels of phenomena. These are confirmed by deductive arguments. Although there are further steps in the methodology, involving privileged instances, relational instances, etc., the upshot is that observation and experimentation are aided by reasoning about which instances are perspicuous, what inductive generalizations hold, and what the next steps in testing should be.

As far as general methodology in science is concerned, it seems unlikely that Cavendish would have objected to Bacon's account. Her own methodology in *Observations* is quite similar. She often cites phenomena that we know through sense and reason. That is, she sees herself as providing explanations of the things we experience in the world. She writes, "the best study, is rational contemplation joined with the observations of regular sense" (OEP 53). For instance, she discusses decay and death and change and generation. Cavendish spends quite a bit of time discussing the nature of heat, cold, fire, snow, as well as the motions of plants and animals. She recounts the changing of a chrysalis into a butterfly (OEP 61-2). There is no doubt that her interest in observation comes from her reading of Bacon, and his leading proponent, Robert Boyle. We know that Cavendish read Boyle and observed his experiments at the Royal Society.

However, as Emma Wilkins notes, Boyle preferred to leave the work of creating machines and running experiments to others (2014: 9) and focused, like Bacon, on methodology. Boyle, like Bacon, cautions against the hasty establishment of universal "principles and axioms" from too few experiments and observations and claims that "an absolute suspension of the exercise of Reasoning were exceeding troublesome, if not impossible" (Boyle 1669: 9).

Cavendish was not critical of observation, nor was she necessarily critical of all experiments. Commenting in *Philosophical Letters* on the work of Boyle, Cavendish notes that his method concentrates, like Bacon's, on studying "different parts and alterations, more than the motions, which cause the alterations in those parts," which are what Cavendish holds to be fundamental (PL 496). She then goes on to note "*for certainly experiments are very beneficial to man*" (PL 496, emphasis mine).

Another point of agreement between Cavendish and Bacon was the use of hypotheses and a healthy distrust of human sense. Bacon writes,

> The senses are defective in two ways: they may fail us altogether or they may deceive. First, there are many things which escape the senses even when they are healthy and quite unimpeded; either because of the rarity of the whole body or by the extremely small size of its parts, or by the distance, or by its slowness or speed, or because the object is too familiar, or for other reasons. And even when the senses do grasp an object, their apprehensions of it are not always reliable. For the evidence and information given by the senses is always based on the analogy of man not of the universe; it is a very great error to assert that the senses are the measure of things. (Bacon 2000: 17-8)

Like Bacon, Cavendish thinks that we are limited by our particular sensory abilities. These, she believes are not keen enough to get to the interior natures of things (if indeed it is

possible to do so at all). However, this does not mean that Cavendish completely distrusted sensitive knowledge. In her discussion of the various degrees of heat and cold, she writes

> …some degrees and sorts of heat and cold, are subject to the human perception of sight, some to the perception of touch, some to both, and some to none of them; there being so many various sorts and degrees both of heat and cold, as they cannot be altogether subject to our grosser exterior senses…for although our sensitive perceptions do often commit errors and mistakes, either through their own irregularity, or some other ways; yet, next to the rational, they are the best informers we have: for, no man can naturally go beyond his rational and sensitive perception. (OEP 109-10)

Bacon claims that the senses are in need of assistance, which he claims comes not so much from instruments, but from experiments (2000: 18). While his general methodology and his commitment to reason were both likely in accord with Cavendish's views, she disagreed with the stated aims of the Baconian enterprise. According to Bacon (and Boyle) the end of science is the discovery of the forms of a nature, which Bacon defines as "nothing more than those laws and determinations of absolute actuality which govern and constitute any simple nature, as heat, light, weight, in every kind of matter and subject that is susceptible of them" (Bacon 2000: 145–6). This nature must be the same in all cases where the phenomenon actually occurs and will include ways in which the nature changes and reacts with other natures. Gaining knowledge of the forms was not an end in itself, but a necessary step in coming to control and modify nature.

The pursuit of the Forms of nature is the main disagreement that Cavendish has with Bacon and Boyle. In her lengthy discussions of the various types of heat and cold, she comes to exactly the opposite conclusion than they come to. That there is a simple nature of every kind of thing that can be discerned and manipulated is simply false, according to Cavendish. There is no

one cause or principle of heat, rather different corporeal figurative motions in individuals produce various kinds of heat. There is a sort of family resemblance between the things that we call "heat," but there is no one thing that is heat. While Bacon holds, like Cavendish, that the perception of heat is subjective, so that different people perceive heat in different ways, he believes that there is only one cause and one simple nature for all instances of heat. Cavendish, in contrast, holds that this subjectivity holds across all entities and so it is impossible that there be one nature of heat or one cause of heat. She writes,

> …one prime action or motion cannot produce all sorts of heat or cold. For, though all sorts of heat or cold, are still heat and cold (as all sorts of animals, are still animals) yet all the several sorts or kinds of them, are not one and the same kind, but different. Nor does one particular action, produce all those several sorts or kinds. For, if there were no differences in their productions, then would not only all men be exactly like, but all beasts also; that is, there would be no difference between a horse and a cow, a cow and a lion, a snake and an oyster. (OEP 115)

Cavendish's claim here is that different kinds of animals are all still animals, yet in order to get different kinds, they must be produced in different ways that causes their different interior structures. That is, cows are produced differently than sheep. The same goes for different kinds of heat, such as chemical heat, the heat of fire, or the burning sensation caused by ice. Given her account of causation and perception, an understanding of heat will always involve the motions and structure of both the occasional and the efficient cause. From this it is easy to see why Cavendish is critical of the notion that there are forms in nature that are over and above the resemblance class that constitutes what we call "species." As she notes, "form cannot be created without matter, nor matter without form; for form is no thing subsisting by itself without matter"

(OEP 203). So, Cavendish's critique of forms involves two parts: the denial of the existence of form without matter, and the denial of a single cause of every type of entity.

Moreover, Cavendish is extremely critical of philosophers who try to distill the complex workings of nature down to a few principles (or worse one principle). In section II.6 of *Observations* titled, "Whether There Be Any Prime or Principle Figure in Nature; and of the True Principles of Nature," Cavendish argues that those who try to distill the complex workings of nature down to one principle ("globular figures," salt, water, one of the four elements, etc.) make the mistake of taking one part of nature to be the principle of the whole. Rather, composed bodies are merely effects of nature or self-moving matter, and as effects they cannot be the cause of all of nature. Cavendish claims that self-moving matter can be called the "principles of nature," but this, of course, is just to say that all of matter is the principle of matter, and so talk of principles is meaningless (OEP 206).

Cavendish's Critique of Experimental Philosophy

While Cavendish's discussions of Bacon and Boyle tend to the general methodological worries and aims of science, her criticisms of Hooke are more pointed. At issue here are three claims. First, Hooke claims that we, as human beings, are uniquely suited to understand nature's workings. Second, he advances the mechanist conception of nature as artifice. And finally, that the true natures of bodies can be seen through the microscope.

Hooke published *Micrographia* in 1665. The book was meant to show the previously unseen world that is revealed by the microscope and features etchings of various insects and plants along with descriptions of their appearances under the lens. The "Preface" contains

Hooke's vision for science. First, he claims that mankind is above the rest of nature and has the unique ability to alter, assist and improve nature.

> It is the great prerogative of Mankind above other Creatures, that we are not only able to behold the works of Nature, or barely to sustain our lives by them, but we have also the power or considering, comparing, altering, assisting, and improving them to various uses. (Hooke 1665: unpaginated preface)

Cavendish's response to this claim is that no part of nature is able to understand the whole of nature. Human beings, according to Cavendish, are not special in nature. She claims that many non-human animals have abilities that far outstrip ours. Moreover, she holds that since nature is infinite in her motions, no finite being could possibly comprehend her works.

Next, Hooke makes clear that the model for understanding nature is a mechanistic one. "[W]e may perhaps be inabled to discern all the secret workings of Nature, almost in the same manner as we do those that are the productions of Art, and are manag'd by Wheels, and Engines, and Springs, that were devised by humane Wit" (Hooke 1665: unpaginated preface). Cavendish, of course, did not think that nature motions were mechanistic, but rather vitalistic. In addition, she did not think that the workings of machines made by human art could help us understand nature. As she writes, "The rules of art cannot be the rules of nature, nor the measures of art the measures of nature…for though art proceeds from nature, yet nature does not proceed from art, for the cause cannot proceed from the effect" (PPO Preface XXVI). Art is an effect of nature in the sense that humans are only able to create with art what is possible according to nature, but this art does not work in the same way that nature works, according to Cavendish.

Her most extensive objections to Hooke are based on her views of perception and the nature of bodies in her criticism of the microscope's ability to get to the essence of beings. She

claims that "could experimental philosophers find out more beneficial arts than our forefathers have done," for improving farming, housing, and trade, as well as clearing up disputes in the church with their experiments, then their pursuits would be praiseworthy. However, she goes on to note, "But, as boys that play with watery bubbles or fling dust into each other's eyes, or make a hobbyhorse of snow, are worthy of reproof rather than praise, for wasting their time with useless sports" (OEP 51-2).

Cavendish does not see how looking at flies under microscopes could possibly make human existence easier. Given the immediate needs of human beings there are more profitable ways of spending one's time than playing with test tubes or trying to make snow in a laboratory. She concludes that those that invented microscopes, and such like dioptrical glasses, at first, did, in my opinion, the world more injury than benefit (OEP 51).[4]

Cavendish claims microscopes can only reveal "phenomena or the exterior figures of objects" (OEP 51). That is, she thinks that what is revealed through the lens of the microscope is not the real natures of things, but merely the outer surfaces of objects. Moreover, she thinks these exterior figures may not be accurate. Her reason for thinking so is two-fold, but it is due partly to Hooke's own descriptions of the difficulty of getting the "true form" of what was under the microscope. In *Micrographia*, he tells us that the engravings in the book are composites of drawings he made of various parts of his subjects. For it was often impossible to get a whole specimen under the lens and it was difficult to ascertain features of what he could see. He writes,

> …and that in making of them, I indeavoured (as far as I was able) first to discover the true appearance, and next to make a plain representation of it. This I mention the rather, because of these kind of Objects there is much more difficulty to discover the true shape, then of those visible to the naked eye, the same Object seeming quite differing, in one

> position to the Light, from what it really is, and may be discover'd in another. And therefore I never began to make any draught before by many examinations in several lights, and in several positions to those lights, I had discover'd the true form. For it is exceeding difficult in some Objects to distinguish between a prominency and a depression, between a shadow and a black stain, or a reflection and a whiteness in the color. (Hooke 1665: unpaginated Preface)

While the microscopes that Hooke used were the best in his day, they were by no means what we would consider good. The images were dim and the lenses often quite irregular. In addition, the experimenter relied on ever-changing ambient light to illuminate his subject. This led to the belief that the process was unreliable. If an object looks different in different lighting conditions or in various positions, how does one determine what the "true form" is given that there is no independent verification for something that cannot be seen with the naked eye? Cavendish makes this point.

> Nay, artists do confess themselves, that flies, and the like, will appear of several figures or shapes, according to the several reflexions, refractions, mediums and positions of several lights; which if so, how can they tell or judge which is the truest light, position, or medium, that doth present the object naturally as it is? (OEP 51)

The same worry holds for telescopes given that they claim to reveal things that are beyond the scope of human perception. This uncertainty gave Cavendish reason to withhold her approval of microscopes, but she was not skeptical of all kinds of lenses.

> But, mistake me not; I do not say, that no glass presents the true picture of an object: but only that magnifying and multiplying, and the like optic glasses, may, and do oftentimes present falsely the picture of an exterior object; I say, the picture, because it is not the real

body of the object which the glass presents, but the glass only figures or patterns out the picture presented in and by the glass, and there mistakes may easily be committed in taking copies from copies. (OEP 50-1)

Here, Cavendish hints at the second reason for her skepticism about microscopes – her view that every part of nature is perceptive. According to Cavendish, when we look into a mirror, we pattern the exterior image of the glass. But it is also the case that the glass of the mirror is patterning us. The image we pattern from the mirror involves a sort of double perception. The mirror patterns us and we pattern what the mirror patterns. Since we have no idea how a mirror patterns, we might be skeptical of the claim that a mirror patterns our external shape in an accurate manner. Of course, in the case of seeing our reflection in a mirror, independent verification is possible. Someone else can tell us that their perception, when they look directly at us, is similar to the one they see in the mirror. However, in the case of microscopes (and telescopes), we cannot be certain that the glass of the microscope is patterning the true image of its subject and there is no possibility of independent verification. Because we merely pattern the pattern of the microscope (copy the copy), we cannot be certain of the veracity of our perception when using such instruments.

We can see that Cavendish had a number of criticisms of the aims, claims, and instruments of experimental philosophy. However, it is clear that Cavendish was not against all scientific inquiry and experimentation. Cavendish was both involved with the new science and a critic of it. She thinks human beings are capable of ascertaining knowledge of nature and that some of this knowledge is capable of improving our lives. She writes,

That the undoubted truth in Natural Philosophy, is, in my opinion, like the Philosopher's Stone in Chymistry, which has been sought for by many learned and ingenious Persons,

> and will be sought as long as the Art of Chymistry doth last; but although they cannot find the Philosophers Stone, yet by the help of this Art they have found out many rare things both for use and knowledg. The like in Natural Philosophy, although Natural Philosophers cannot find out the absolute truth of Nature, or Natures ground-works, or the hidden causes of natural effects; nevertheless they have found out many necessary and profitable Arts and Sciences, to benefit the life of man; for without Natural Philosophy we should have lived in dark ignorance, not knowing the motions of the Heavens, the cause of the Eclipses, the influences of the Stars, the use of Numbers, Measures, and Weights, the vertues and effects of Vegetables and Minerals, the Art of Architecture, Navigation, and the like. (PL 508)

Cavendish is clearly in favor of natural philosophy and its use in certain domains for the benefit of human life. In building better ships and houses, in aiding navigation, and in improving trade and measures, science does make life better. In this way, as Emma Wilkins notes, Cavendish was in line with the Baconian belief that the fruit of scientific endeavor is practical application (Wilkins 2014: 10). However, it is clear that not just any manipulation of nature counts as beneficial. For Cavendish, much of the work done through the microscope either did not rise to the level of helpfulness or would not bear fruit in a reasonable enough time to be undertaken. Finally, although Cavendish's relation to the new science is complex, there is one aspect of it which she was clearly against and that is its complete exclusion of women.

Cavendish's Critique of the Institution of Natural Philosophy

As we saw in the previous sections, Cavendish's arguments against the methods, aims, and instruments of the new science are based on her views of the nature of bodies, human

understanding, and causation and perception. In addition to these criticisms, Cavendish also confronted the institutional barriers that prevented women from participating in natural philosophy. In this section, I situate Cavendish's criticisms in terms of a feminist critique.

Following recent work by Eileen O'Neill (2019), we can trace three core components of feminism back to (at least) the 17th century. They are (1) criticism of misogyny and male supremacy, (2) the conviction that women's condition is not an immutable fact of nature and can be changed for the better, and (3) a sense of gender group identity, the conscious will to speak "on behalf of women," or "to defend the female sex," usually aiming to enlarge the sphere of action open to women.[5] While, Deborah Boyle has argued convincingly that Cavendish's natural philosophy was not feminist (2004) nor is she accurately described an advocate of women with respect to marriage or certain social reforms (2018: 166-188), I do think her critique of the exclusion of women from natural philosophy exemplifies all three of the core components of feminism. Cavendish recognizes the fact that she, as a member of the female sex, no matter how capable and knowledgeable, is not allowed to participate fully in the new science. Cavendish points to misogyny and the barring of women from universities as key factors in this exclusion.

There are several places in *Observations* where Cavendish complains that women are not allowed to participate in Natural Philosophy. The first of these occurs in the "To the Reader." She writes,

> But that I am not versed in learning, nobody, I hope, will blame me for it, since it is sufficiently known, that our sex being not suffered to be instructed in schools and universities, cannot be bred up to it. I will not say, but many of our sex may have as much wit, and be capable of learning as well as men; but since they want instructions, it is not possible they should attain to it: for learning is artificial, but wit is natural. (OEP 11)

Here, Cavendish clearly claims that women are not innately inferior to men – they are capable of learning. The reason for the difference in their actual abilities is due to education. No amount of natural ability can make up for the fact that women were not educated in the same way as men. In this passage, she clearly is expressing component (2) above.

Another criticism comes in a passage discussing her study of Ancient philosophers. She notes that after reading the ancients, she found so much difference between their views and her own that she thought she might like to start her own school of philosophy.

> …were it allowable or usual for our sex, I might set up a sect or school for myself, without any prejudice to them [the ancient philosophers]: But I, being a woman, do fear they would soon cast me out of their schools; for, though the muses, graces and sciences are all of the female gender, yet they were more esteemed in former ages, than they are now; nay, could it be done handsomely, they would now turn them all from females into males: So great is grown the self-conceit of the masculine, and the disregard of the female sex. (OEP 249)

Here, Cavendish clearly states that men have very little regard for women, even women who are capable of doing the things that they find valuable, like philosophy. This explicit recognition of the fact that she would not be allowed to teach philosophy or even associate with a school of philosophers is quite telling. The feminine might be used as a muse, grace or representation of science, but she is not allowed to participate. This is clearly a lamentation of male misogyny, which is the first core component of feminism mentioned above.

Cavendish, as noted, often depicts Nature as female. But in *Observations*, Nature is a woman engaging in the methods of experimental science. She writes, “Nature being a wise and provident lady, governs her parts very wisely, methodically, and orderly” as a “good housewife

does in brewing, baking, churning, spinning, sowing, etc. as also in preserving, for those that love sweetmeats; and in distilling, for those that take delight in cordials" (OEP 105).

Not only does Cavendish describe Nature as a housewife, she goes on in this passage to make the connection between women's experimentation with recipes and alchemy/chemistry. She suggests rather coyly that women:

> would prove good experimental philosophers, and inform the world how to make artificial snow, by their creams, or possets beaten into froth: and ice, by their clear, candied, or crusted quiddities, or conserves of fruits: and frost, by their candied herbs and flowers: and hail, by their small comfits made of water and sugar, with whites of eggs: And many other the like figures, which resemble beasts, birds, vegetables, minerals, etc. (OEP 105-106)

Here Cavendish notes the ways in which women have already succeeded in imitating nature in their kitchens. She suggests that women could help men by actually doing the experiments and then the men could "study the causes" of them. She writes, "I am confident, women would labour as much with fire and furnace, as men; for they'll make good cordials and spirits" (OEP 106).

Cavendish acknowledges the fact that all women have been distilling and brewing medicines for generations. Here (and in the other passages) she speaks for all women (component 3 above) who have quietly been engaged in medicine, chemistry, and experimentation throughout history. These practical sciences were handed down through generations of women and recorded for future use in households. In the 17th century, Cavendish was witness to the fact that the art of taking care of the sick would be given over to men who studied chemistry and medicine in schools where women were not allowed. There is no doubt

that this exclusion was all the more insulting given that these arts (chemistry, alchemy, and medicine) had been practiced by women for years without credit. In forwarding these criticisms, Cavendish speaks on behalf of all women against the misogyny that prevents women from developing their intellects and participating in philosophy. In doing so, is safe to say that Cavendish did put forth a feminist critique of the institutions of natural philosophy in addition to her other criticisms of the new science.

Conclusion

Margaret Cavendish had extensive knowledge of 17th century natural philosophy. She was conversant in metaphysics, physics, astronomy, medicine, optics, and what we now call botany and biology. She successfully corresponded with several natural philosophers, developed her own philosophical system, and wrote philosophical texts criticizing what she saw as the overreach of some of the most famous experimentalists of her time. But to a large extent her work was unacknowledged. The fact is that no one bothered to engage with her because of her sex, and she acknowledged this injustice in her criticisms of the institutions of science.

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[1] For an excellent refutation of earlier attempts to read Cavendish as presenting a feminist critique, see Boyle (2004).

[2] Occasional causation, as defined by Steven Nadler (1994: 39) "denotes the entire process whereby one thing, A, occasions or elicits another thing, B, to cause e. Even though it is B that A occasions or incites to engage in the activity of efficient causation in producing e, the relation of occasional causation links A not just to B, but also (and especially) to the effect, e, produced by B."

[3] She was, of course, limited by her lack of formal education since women were not allowed to attend university. As a result, she could not read Latin or French.

[4] Wilkins (2014: 4-5) notes that John Locke also objected that when we are looking at the inside of bodies we are not actually seeing the interior nature or essence of the being. In his early work with Thomas Sydenham, "Anatomica," he argues that looking at the inner parts of a man does not show the inner operations of his organs (Dewhurst 1958).

[5] O'Neill relied on Akkerman T. and Stuurman S. (1998: 3-4) for these components.

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