

Observations upon Experimental Philosophy

[Preface; Observations 2–3, 25, 32, 34; Further Observations 1–2, 4]

Margaret Cavendish

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The Preface to the Ensuing Treatise

'Tis probable, some will say, that my much writing is a disease; but what disease they will judge it to be, I cannot tell; I do verily believe they will take it to be a disease of the brain, but surely they cannot call it an apoplexical or lethargical disease: Perhaps they will say, it is an extravagant, or at least a fantastical disease; but I hope they will rather call it a disease of wit. But, let them give it what name they please, yet of this I am sure, that if much writing be a disease, then the best philosophers, both moral and natural, as also the best divines, lawyers, physicians, poets, historians, orators, mathematicians, chemists, and many more have been grievously sick, and *Seneca, Plinius, Aristotle, Cicero, Tacitus, Plutarch, Euclid, Homer, Virgil, Ovid, St. Augustin, St. Ambrose, Scotus, Hippocrates, Galen, Paracelsus*, and hundreds more, have been at death's door with the disease of writing; but to be infected with the same disease, which the devoutest, wisest, wittiest, subtlest, most learned and eloquent men have been troubled withal, is no disgrace, but the greatest honor, even to the most ambitious person in the world: and next to the honor of being thus infected, it is also a great delight and pleasure to me, as being the only pastime which employs my idle hours; in so much, that, were I sure nobody did read my works, yet I would not quit my pastime for all this; for although they should not delight others, yet they delight me; and if all women that have no employment in worldly affairs, should but spend their time as harmlessly as I do, they would not commit such faults as many are accused of.

I confess, there are many useless and superfluous books, and perchance mine will add to the number of them; especially is it to be observed, that there have been in this latter age, as many writers of natural philosophy, as in former ages there have been of moral philosophy; which multitude, I fear, will produce such a confusion of truth and falsehood, as the number of moral writers formerly did, with their over-nice divisions of virtues and vices, whereby they did puzzle their readers so, that they knew not how to distinguish between them. The like, I doubt, will prove amongst our natural philosophers, who by their extracted, or rather distracted arguments, confound both divinity and natural philosophy, sense and reason, nature and art, so much as in time we shall have rather a chaos, than a well-ordered universe by their doctrine: Besides, many of their writings are but parcels taken from the ancient; but such writers are like those unconscionable men in civil wars, which endeavor to pull down the hereditary mansions of noble-men and gentlemen, to build a cottage of their own; for so do they pull down the learning of ancient authors, to render themselves famous in composing books of their own. But though this age does ruin palaces, to make cottages; churches, to make conventicles; and universities to make private colleges;

and endeavor not only to wound, but to kill and bury the fame of such meritorious persons as the ancient were, yet, I, hope God of his mercy will preserve state, church, and schools, from ruin and destruction; Nor do I think their weak works will be able to overcome the strong wits of the ancient; for setting aside some few of our moderns, all the rest are but like dead and withered leaves, in comparison to lovely and lively plants; and as for arts, I am confident, that where there is one good art found in these latter ages, there are two better old arts lost, both of the Egyptians, Grecians, Romans, and many other ancient nations; (when I say lost, I mean in relation to our knowledge, not in nature; for nothing can be lost in nature) Truly, the art of augury was far more beneficial than the lately invented art of micrography; for I cannot perceive any great advantage this art doth bring us. Also the eclipse of the sun and moon was not found out by telescopes, nor the motions of the loadstone, nor the art of the card, nor the art of guns and gun-powder, nor the art of printing, and the like, by microscopes; nay, if it be true, that telescopes make appear the spots in the sun and moon, or discover some new stars, what benefit is that to us? Or if microscopes do truly represent the exterior parts and superficies of some minute creatures, what advantages it our knowledge? For unless they could discover their interior, corporeal, figurative motions, and the obscure actions of nature, or the causes which make such or such creatures, I see no great benefit or advantage they yield to man: Or if they discover how reflected light makes loose and superficial colors, such as no sooner perceived, but are again dissolved; what benefit is that to man? For neither painters nor dyers can enclose and mix that atomical dust, and those reflections of light to serve them for any use. Wherefore, in my opinion, it is both time and labor lost; for the inspection of the exterior parts of vegetables, doth not give us any knowledge how to sow, set, plant, and graft; so that a gardener or husbandman will gain no advantage at all by this Art: The inspection of a bee, through a microscope, will bring him no more honey, nor the inspection of a grain more corn; neither will the inspection of dusty atoms, and reflections of light, teach painters how to make and mix colors, although it may perhaps be an advantage to a decayed lady's face, by placing herself in such or such a reflection of light, where the dusty atoms may hide her wrinkles. The truth is, most of these arts are fallacies, rather than discoveries of truth; for sense deludes more than it gives a true information, and an exterior inspection through an optic glass, is so deceiving, that it cannot be relied upon: Wherefore regular reason is the best guide to all arts, as I shall make it appear in this following treatise.

It may be the world will judge it a fault in me, that I oppose so many eminent and ingenious writers, but I do it not out of a contradicting or wrangling nature, but out of an endeavor to find out truth, or at least the probability of truth, according to

that proportion of sense and reason nature has bestowed upon me; for as I have heard my Noble Lord¹ say, that in the art of riding and fencing, there is but one truth, but many falsehoods and fallacies: So it may be said of natural philosophy and divinity; for there is but one truth in each, and I am as ambitious of finding out the truth of nature, as an honorable dueler is of gaining fame and repute; for as he will fight with none but an honorable and valiant opposite, so am I resolved to argue with none but those which have the renown of being famous and subtle philosophers; and therefore as I have had the courage to argue heretofore with some famous and eminent writers in speculative philosophy²; so have I taken upon me in this present work, to make some reflections also upon some of our modern experimental and dioptrical writers. They will perhaps think myself an inconsiderable opposite, because I am not of their sex, and therefore strive to hit my opinions with a side stroke, rather covertly, than openly and directly; but if this should chance, the impartial world, I hope, will grant me so much justice as to consider my honesty, and their fallacy, and pass such a judgment as will declare them to be patrons, not only to truth, but also to justice and equity; for which Heaven will grant them their reward, and time will record their noble and worthy actions in the register of fame, to be kept in everlasting memory.

Observations upon Experimental Philosophy

2 Of Art, and Experimental Philosophy

Some are of opinion, that

[By art there can be] a reparation made of the mischiefs and imperfections mankind has drawn upon itself by negligence and intemperance, and a willful and superstitious deserting the prescripts and rules of nature, whereby every man, both from a derived corruption, innate and born with him, and from his breeding and converse with men, is very subject to slip into all sorts of errors.³

But the all-powerful God, and his servant nature, know, that art, which is but a particular creature, cannot inform us of the truth of the infinite parts of nature, being but finite itself; for though every creature has a double perception, rational

¹I.e., William Cavendish, her husband; see his *A New Method, and Extraordinary Invention, to Dress Horses, and Work Them According to Nature* (1667), 41.

²Thomas Hobbes, René Descartes, Henry More, and Jan Baptist van Helmont; see Margaret Cavendish, *Philosophical Letters* (1664).

³Hooke, *Micrographia* (1665), Preface; added brackets indicate Cavendish's gloss.

and sensitive, yet each creature or part has not an infinite perception; nay, although each particular creature or part of nature may have some conceptions of the infinite parts of nature, yet it cannot know the truth of those infinite parts, being but a finite part itself, which finiteness causes errors in perceptions; wherefore it is well said, when they confess themselves, that “the uncertainty and mistakes of human actions proceed either from the narrowness and wandering of our senses, or from the slipperiness or delusion of our memory, or from the confinement or rashness of our understanding.” But, say they,

It is no wonder that our power over natural causes and effects is so slowly improved, seeing we are not only to contend with the obscurity and difficulty of the things whereon we work and think, but even the forces of our minds conspire to betray us: And these being the dangers in the process of human reason, the remedies can only proceed from the real, the mechanical, the experimental philosophy, which hath this advantage over the philosophy of discourse and disputation, that whereas that chiefly aims at the subtlety of its deductions and conclusions, without much regard to the first ground-work, which ought to be well laid on the sense and memory, so this intends the right ordering of them all, and making them serviceable to each other.⁴

In which discourse I do not understand, first, what they mean by our power over natural causes and effects; for we have no power at all over natural causes and effects, but only one particular effect may have some power over another, which are natural actions; but neither can natural causes nor effects be overpowered by man so, as if man was a degree above nature, but they must be as nature is pleased to order them; for man is but a small part, and his powers are but particular actions of nature, and therefore he cannot have a supreme and absolute power. Next, I say, that sense, which is more apt to be deluded than reason, cannot be the ground of reason, no more than art can be the ground of nature: Wherefore discourse shall sooner find or trace nature’s corporeal figurative motions, than deluding arts can inform the senses; for how can a fool order his understanding by art, if nature has made it defective? Or how can a wise man trust his senses, if either the objects be not truly presented according to their natural figure and shape, or if the senses be defective, either through age, sickness, or other accidents, which do alter the natural motions proper to each sense? And hence I conclude, that experimental and mechanic philosophy cannot be above the speculative part, by reason most experiments have their rise from the speculative, so that the artist or mechanic is but a servant to the student.

⁴Hooke, *Micrographia* (1665), Preface.

3 Of Micrography, and of Magnifying and Multiplying Glasses

Although I am not able to give a solid judgment of the art of *micrography*, and the several dioptrical instruments belonging thereto, by reason I have neither studied nor practiced that art; yet of this I am confident, that this same art, with all its instruments, is not able to discover the interior natural motions of any part or creature of nature; nay, the question is, whether it can represent yet the exterior shapes and motions so exactly, as naturally they are; for art doth more easily alter than inform: As for example; art makes cylinders, concave and convex-glasses, and the like, which represent the figure of an object in no part exactly and truly, but very deformed and misshaped: also a glass that is flawed, cracked, or broke, or cut into the figure of lozenges, triangles, squares, or the like, will present numerous pictures of one object. Besides, there are so many alterations made by several lights, their shadows, refractions, reflections, as also several lines, points, mediums, interposing and intermixing parts, forms and positions, as the truth of an object will hardly be known; for the perception of sight, and so of the rest of the senses, goes no further than the exterior parts of the object presented; and though the perception may be true, when the object is truly presented, yet when the presentation is false, the information must be false also. And it is to be observed, that art, for the most part, makes hermaphroditical, that is, mixed figures, as partly artificial, and partly natural: for art may make some metal, as pewter, which is between tin and lead, as also brass, and numerous other things of mixed natures; In the like manner may artificial glasses present objects, partly natural, and partly artificial; nay, put the case they can present the natural figure of an object, yet that natural figure may be presented in as monstrous a shape, as it may appear misshapen rather than natural: For example; a louse by the help of a magnifying-glass, appears like a lobster, where the microscope enlarging and magnifying each part of it, makes them bigger and rounder than naturally they are.⁵ The truth is, the more the figure by art is magnified, the more it appears misshapen from the natural, in so much as each joint will appear as a diseased, swelled and tumid body, ready and ripe for incision. But mistake me not; I do not say, that no glass presents the true picture of an object; but only that magnifying, 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 may easily mistakes be committed in taking copies from copies. Nay, artists do confess themselves, that flies, and the like, will appear of several figures or shapes, according to the several

⁵Hooke, *Micrographia* (1665), Observation 37 and [Scheme 35](#).

reflections, refractions, mediums and positions of several lights⁶; 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? And if not, then an edge may very well seem flat, and a point of a needle a globe⁷; but if the edge of a knife, or point of a needle were naturally and really so as the microscope presents them, they would never be so useful as they are; for a flat or broad plain-edged knife would not cut, nor a blunt globe pierce so suddenly another body, neither would or could they pierce without tearing and rending, if their bodies were so uneven; and if the picture of a young beautiful lady should be drawn according to the representation of the microscope, or according to the various refraction and reflection of light through such like glasses, it would be so far from being like her, as it would not be like a human face, but rather a monster, than a picture of nature. Wherefore those that invented microscopes, and such like dioptrical glasses, at first, did, in my opinion, the world more injury than benefit; for this art has intoxicated so many men's brains, and wholly employed their thoughts and bodily actions about phenomena, or the exterior figures of objects, as all better arts and studies are laid aside; nay, those that are not as earnest and active in such employments as they, are, by many of them, accounted unprofitable subjects to the commonwealth of learning. But though there be numerous books written of the wonders of these glasses, yet I cannot perceive any such, at best, they are but superficial wonders, as I may call them. But could experimental philosophers find out more beneficial arts than our fore-fathers have done, either for the better increase of vegetables and brute animals to nourish our bodies, or better and commodious contrivances in the art of architecture to build us houses, or for the advancing of trade and traffic to provide necessaries for us to live, or for the decrease of nice distinctions and sophisticated disputes in churches, schools and courts of judicature, to make men live in unity, peace and neighborly friendship, it would not only be worth their labor, but of as much praise as could be given to them: But as boys that play with watery bubbles, or fling dust into each others eyes, or make a hobby-horse of snow, are worthy of reproof rather than praise; for wasting their time with useless sports; so those that addict themselves to unprofitable arts, spend more time than they reap benefit thereby. Nay, could they benefit men either in husbandry, architecture, or the like necessary and profitable employments, yet before the vulgar sort would learn to understand them, the world would want bread to eat, and houses to dwell in, as also cloths to keep them from the inconveniences of

⁶Hooke, *Micrographia* (1665), Observation 39: "Examining [the head of the drone fly] according to my usual manner, by varying the degrees of light, and altering its position to each kind of light, I drew that representation of it which is delineated in [Scheme 24]."

⁷Hooke, *Micrographia* (1665), Observations 1–2 and [Scheme 2](#).

the inconstant weather. But truly, although spinsters were most experienced in this art, yet they will never be able to spin silk, thread, or wool, etc. from loose atoms; neither will weavers weave a web of light from the sun's rays, nor an architect build an house of the bubbles of water and air, unless they be poetical spinsters, weavers and architects; and if a painter should draw a louse as big as a crab, and of that shape as the microscope presents, can any body imagine that a beggar would believe it to be true? But if he did, what advantage would it be to the beggar? For it doth neither instruct him how to avoid breeding them, or how to catch them, or to hinder them from biting. Again: if a painter should paint birds according to those colors the microscope presents, what advantage would it be for fowlers to take them? Truly, no fowler will be able to distinguish several birds through a microscope, neither by their shapes nor colors; They will be better discerned by those that eat their flesh, than by micrographers that look upon their colors and exterior figures through a magnifying-glass.⁸ In short, magnifying-glasses are like a high heel to a short leg, which if it be made too high, it is apt to make the wearer fall, and at the best, can do no more than represent exterior figures in a bigger, and so in a more deformed shape and posture than naturally they are; but as for the interior form and motions of a creature, as I said before, they can no more represent them, than telescopes can the interior essence and nature of the sun, and what matter it consists of; for if one that never had seen milk before, should look upon it through a microscope, he would never be able to discover the interior parts of milk by that instrument, were it the best that is in the world; neither the whey, nor the butter, nor the curds. Wherefore the best optic is a perfect natural eye, and a regular sensitive perception, and the best judge is reason, and the best study is rational contemplation joined with the observations of regular sense, but not deluding arts; for art is not only gross in comparison to nature, but, for the most part, deformed and defective, and at best produces mixed or hermaphroditical figures, that is, a third figure between nature and art: which proves, that natural reason is above artificial sense, as I may call it: wherefore those arts are the best and surest informers, that alter nature least, and they the greatest deluders that alter nature most, I mean, the particular nature of each particular creature; (for art is so far from altering infinite nature, that it is no more in comparison to it, than a little fly to an elephant, no not so much, for there is no comparison between finite and infinite.) But wise nature taking delight in variety, her parts, which are her creatures, must of necessity do so too.

⁸Hooke, *Micrographia* (1665), Observation 36: "These colors are only fantastical ones, that is, such as arise immediately from the refractions of the light."

25 Of the Motions of Heat and Cold⁹

Those which affirm that *heat* and *cold* are the two primary and only causes of the productions of all natural things, do not consider sufficiently the variety of nature, but think that nature produces all by art; and since art is found out and practiced by man, man conceits himself to be above nature; But as neither art, nor any particular creature can be the cause or principle of all the rest, so neither can heat and cold be the prime cause of all natural productions, no more than paint can produce all the parts of a man's face, as the eyes, nose, forehead, chin, cheeks, lips and the like, or a periwig¹⁰ can produce a natural head, or a suit of clothes can make the body of man, for then whensoever the fashioned garments or mode-dresses do change, men would of necessity change also; but art causes gross mistakes and errors, not only in sensitive, but also in rational perceptions; for sense being deluded, is apt to delude reason also, especially if reason be too much indulgent to sense; and therefore those judgments that rely much upon the perception of sense, are rather sensitive than rational judgments; for sense can have but a perception of the exterior figures of objects, and art can but alter the outward form or figure, but not make or change the interior nature of anything; which is the reason that artificial alterations cause false, at least uncertain and various judgments, so that nature is as various in men's judgments, as in her other works. But concerning heat and cold, my opinion is, that they are like several colors, some natural, and some artificial; of which the artificial are very inconstant, at least not so lasting as those that are not made by art; and they which say, that both heat and cold are not made by the sensories or sensitive organs, are in the right, if their meaning be that both heat and cold in their natures and with all their proprieties, as they are particular creatures, are not made or produced by human or animal senses; nevertheless the sensitive animal perception of heat and cold is made by the sensitive motions in their sensitive organs, for what heat and cold soever an animal creature feels, the perception of it is made in the sense of touch, or by those sensitive motions in the parts of its body; for as the perception of any other outward object is not made by a real entrance of its parts into our sensories, so neither is all perception of heat and cold made by the intermixture of their particles with our flesh, but they are patterned and figured out by the sensitive motions in the exterior parts of the body as well as other objects: I will not say, that cold or heat may not enter and intermix with the parts of some bodies, as fire doth intermix with fuel, or enters into its parts; but my meaning is,

⁹Philosophers debated whether cold was a separate quality or a "privation of heat": Descartes, *Meditations on First Philosophy* (1641), Meditation Three; Boyle, *New Experiments and Observations Touching Cold* (1665), Title 17.

¹⁰"Any highly stylized wig of a kind formerly worn by men and women" (OED).

that the animal perception of heat and cold is not made this way, that is, by an intermixture of the parts of the agent with the parts of the patient, as the learned call them; that is, of the exterior object, and the sentient; or else the perception of all exterior objects would be made by such an intermixture, which is against sense and reason; and therefore even in such a commixture, where the parts of the object enter into the body of the sentient, as fire doth into fuel, the perception of the motions of fire in the fuel, and the fuel's consumption or burning, is not made by the fire, but by the fuel's own perceptive motions, imitating the motions of the fire; so that fire doth not turn the fuel into ashes, but the fuel doth change by its own corporeal figurative motions, and the fire is only an occasion of it: The same may be said of cold. Neither is every creature's perception alike, no more than it can be said, that one particular creature, as for example man, hath but one perception; for the perception of sight and smelling, and so of every sense, are different; nay, one and the same sense may have as many several perceptions as it hath objects, and some sorts of perceptions in some creatures, are either stronger or weaker than in others; for we may observe, that in one and the same degree of heat or cold, some will have quicker and some slower perceptions than others; for example in the perception of touch, if several men stand about a fire, some will sooner be heated than others; the like for cold, some will apprehend cold weather sooner than others, the reason is, that in their perception of touch, the sensitive motions work quicker or slower in figuring or patterning out heat or cold, than in the perception of others. The same may be said of other objects, where some sentient bodies will be more sensible of some than of others, even in one and the same kind of perception. But if in all perceptions of cold, cold should intermix with the bodies of animals, or other creatures, like as several ingredients, then all bodies upon the perception of cold would dissolve their figures, which we see they do not; for although all dissolving motions are knowing and perceptive, because every particular motion is a particular knowledge and perception, yet not every perception requires a dissolution or change of its figure: 'Tis true, some sorts or degrees of exterior heat and cold may occasion some bodies to dissolve their interior figures, and change their particular natures, but they have not power to dissolve or change all natural bodies. Neither doth heat or cold change those bodies by an intermixture of their own particles with the parts of the bodies, but the parts of the bodies change themselves by way of imitation, like as men put themselves into a mode-fashion, although oftentimes the senses will have fashions of their own, without imitating any other objects; for not all sorts of perceptions are made by imitation or patterning, but some are made voluntarily, or by rote; as for example, when some do hear and see such or such things without any outward objects. Wherefore it is not certain steams, or agitated particles in the air,

nor the vapors and effluvioms of exterior objects, insinuating themselves into the pores of the sentient, that are the cause of the perception of heat and cold, as some do imagine¹¹; for there cannot probably be such differences in the pores of animal creatures of one sort, as for example of men, which should cause such a different perception as is found in them; for although exterior heat or cold be the same, yet several animals of the same sort will have several and different perceptions of one and the same degrees of exterior heat and cold, as above mentioned; which difference would not be, if their perception was caused by a real entrance of hot and cold particles into the pores of their bodies: Besides, burning-fevers and shaking-agues, prove that such effects can be without such exterior causes. Neither can all sorts of heat and cold be expressed by wind, air and water, in weather-glasses; for they being made by art, cannot give a true information of the generation of all natural heat and cold; but as there is great difference between natural and artificial ice, snow, colors, light, and the like; so between artificial and natural heat and cold; and there are so many several sorts of heat and cold, that it is impossible to reduce them all to one certain cause or principle, or confine them to one sort of motions, as some do believe that all sorts of heat and cold are made by motions tending inward and outward, and others, that by ascending and descending, or rising and depressing motions, which is no more probable, than that all colors are made by the reflexion of light, and that all white is made by reflecting the beams of light outward, and all black by reflecting them inward; or that a man when he is on horse-back, or upon the top of an house, or steeple, or in a deep pit or mine, should be of another figure than of the figure and nature of man, unless he were dissolved by death, which is a total alteration of his figure; for neither gravity nor levity of air, nor atmospherical pillars, nor any weather-glasses, can give us a true information of all natural heat and cold, but the several figurative corporeal motions, which make all things in nature, do also make several sorts of heat and cold in several sorts of creatures. But I observe experimental philosophers do first cry up several of their artificial instruments, then make doubts of them, and at last disapprove them, so that there is no trust nor truth in them, so much as to be relied on; for it is not an age, since weather-glasses were held the only divulgers of heat and cold, or change of weather, and now some do doubt they are not such infallible informers of those truths¹²; by which it is evident,

¹¹Boyle, *New Experiments and Observations Touching Cold* (1665), 6–7: “Sometimes we may meet with certain steams in the air that have . . . a certain hidden power of chilling, as *opium* . . . strikes a coldness into the body by the subtle *effluvioms* that insinuate themselves at the pores of the skin.”

¹²Boyle, *New Experiments and Observations Touching Cold* (1665), 1: “Not only our senses, but common weather-glasses, may misinform us about cold.”

that experimental philosophy has but a brittle, inconstant and uncertain ground, and these artificial instruments, as microscopes, telescopes, and the like, which are now so highly applauded, who knows, but may within a short time have the same fate, and upon a better and more rational enquiry, be found deluders rather than true informers. The truth is, there's not anything that has and doth still delude most men's understandings more, than that they do not consider enough the variety of nature's actions, and do not employ their reason so much in the search of nature's actions, as they do their senses, preferring art and experiments before reason, which makes them stick so close to some particular opinions, and particular sorts of motions or parts, as if there were no more motions, parts, or creatures in nature, than what they see and find out by their artificial experiments.

Thus the variety of nature is a stumbling-block to most men, at which they break their heads of understanding, like blind men that run against several posts or walls; and how should it be otherwise, since nature's actions are infinite, and man's understanding finite? For they consider not so much the interior natures of several creatures, as their exterior figures and phenomena, which makes them write many paradoxes, but few truths, supposing that sense and art can only lead them to the knowledge of truth, when as they delude rather their judgments instead of informing them. But nature has placed sense and reason together, so that there is no part or particle of nature which has not its share of reason as well as of sense; for every part having self-motion, hath also knowledge, which is sense and reason, and therefore it is fit we should not only employ our senses, but chiefly our reason in the search of the causes of natural effects; for sense is only a workman, and reason is the designer and surveyor, and as reason guides and directs, so ought sense to work. But seeing that in this age, sense is more in fashion than reason, it is no wonder there are so many irregular opinions and judgments amongst men; However, although it be the mode, yet I for my part shall not follow it, but leaving to our moderns their experimental or mode-philosophy built upon deluding art, I shall addict my self to the study of contemplative-philosophy, and reason shall be my guide. Not that I despise sense or sensitive knowledge, but when I speak of sense, I mean the perception of our five exterior senses, helped (or rather deluded) by art and artificial instruments; for I see that in this present age, learned men are full of art and artificial trials, and when they have found out something by them, they presently judge that all natural actions are made the same way; as for example, when they find by art that salt will make snow congeal into ice, they instantly conclude from thence that all natural congelations are made by saline particles, and that the *primum frigidum*, or the principal cause of all natural cold must needs be salt, by reason they have found by

art that salt will do the same effect in the aforesaid commixture with snow.¹³ But how grossly they are deceived, rational men may judge: If I were a chemist, and acknowledged their common principles, I might perchance have some belief in it, but not whilst I follow reason; nay, I perceive that oftentimes our senses are deluded by their own irregularities, in not perceiving always truly and rightly the actions of art, but mistaking them, which is a double error; and therefore that particular sensitive knowledge in man which is built merely upon artificial experiments, will never make him a good philosopher, but regular sense and reason must do it, that is, a regular sensitive and rational inquisition into the various actions of nature; For put the case a microscope be true concerning the magnifying of an exterior object, but yet the magnitude of the object cannot give a true information of its interior parts, and their motions, or else great and large bodies would be interiorly known even without microscopes: The truth is, our exterior senses can go no further than the exterior figures of creatures, and their exterior actions, but our reason may pierce deeper, and consider their inherent natures and interior actions; and although it do sometimes err, (for there can be no perfect or universal knowledge in a finite part concerning the infinite actions of nature) yet it may also probably guess at them, and may chance to hit the truth. Thus sense and reason shall be the ground of my philosophy, and no particular natural effects, nor artificial instruments; and if any one can show me a better and surer ground or principle than this, I shall most willingly and joyfully embrace it.

32 Of the Celestial Parts of this World; and Whether They Be Alterable?

It may be questioned, whether the celestial parts of the world never alter or change by their corporeal figurative motions, but remain constantly the same without any change or alteration?¹⁴ I answer: concerning the general and particular kinds or sorts of creatures of this world, human sense and reason doth observe, that they do not change, but are continued by a perpetual supply and succession of particulars

¹³Boyle, *New Experiments and Observations Touching Cold* (1665), Title 17: "Since common salt in artificial glaciations, is found to cooperate as powerfully, as saltpeter itself, . . . I see no great reason, why we may not as well esteem that kind of salt among the catholic efficientes of cold. . . . But to all this I must add, that I doubt whether any of those saline or terrestrial exspirations, either single or conjoined, be the adequate causes of cold, since, for ought I know, there may be other ways of producing it, besides the introduction of frigorific, whether atoms or corpuscles."

¹⁴In *Sidereus Nuncius* (1610), Galileo challenged Aristotle's claim that heavenly bodies were unchanging, observing the craters of the moon through a telescope and concluding that its surface was akin to that of the earth; see also Hooke, *Micrographia* (1665), Observation 60.

without any general alteration or dissolution; but as for the singulars or particulars of those kinds and sorts of creatures, it is most certain, that they are subject to perpetual alterations, generations and dissolutions; for example, human sense and reason perceives, that the parts of the earth do undergo continual alterations; some do change into minerals, some into vegetables, some into animals, etc. and these change again into several other figures, and also some into earth again, and the elements are changed one into another; when as yet the globe of the earth itself remains the same without any general alteration or dissolution; neither is there any want or decay of general kinds of creatures, but only a change of their particulars; And though our perception is but finite, and must contain itself within its own compass or bounds, so that it cannot judge of all particulars that are in nature: Nevertheless, I see no reason, why the celestial parts of the world should not be subject to alteration, as well as those of the terrestrial globe; for if nature be full of self-motion, no particular can be at rest, or without action; but the chief actions of nature are composition and division, and changes of parts: Wherefore, although to our human perception, the stars and planets do not change from their general nature, as from being such or such composed figures, but appear the same to us, without any general or remarkable change of their exterior figures; yet we cannot certainly affirm, that the parts thereof be either moveless or unalterable, they being too remote from our perception, to discern all their particular motions: For put the case, the moon, or any other of the planets, were inhabited by animal creatures, which could see as much of this terrestrial globe, as we see of the moon, although they would perceive perhaps the progressive motion of the whole figure of this terrestrial globe, in the same manner as we do perceive the motion of the moon, yet they would never be able to discern the particular parts thereof, viz. trees, animals, stones, water, earth, etc. much less their particular changes and alterations, generations and dissolutions. In the like manner do the celestial orbs appear to us; for none that inhabit this globe will ever be able to discern the particular parts of which the globe of the moon consists, much less their changes and motions. Indeed, it is with the celestial orbs, as it is with other composed parts or figures of nature, which have their interior, as well as exterior; general, as well as particular motions; for it is impossible, that nature, consisting of infinite different parts, should have but one kind of motion; and therefore as a man, or any other animal, has first his exterior motions or actions, which belong to his whole composed figure, next his internal figurative motions by which he grows, decays, and dissolves, etc. Thirdly, as every several part and particle of his body has its interior and exterior actions; so it may be said of the stars and planets, which are no more than other parts of nature, as being composed of the same matter which all the rest consists of, and partaking of the

same self-motion; for although our sight cannot discern more than their progressive, and shining or twinkling motion; nevertheless, they being parts of nature, must of necessity have their interior and exterior, particular and general motions; so that the parts of their bodies may change as much as the parts of this globe, the figure of the whole remaining still the same; for as I said before, they being too far from our perception, their particular motions cannot be observed; nay, were we able to perceive the exterior actions of their parts, yet their interior motions are no ways perceptible by human sight; we may observe the effects of some interior motions of natural creatures; for example, of man, how he changes from infancy to youth, from youth to old age, etc. but how these actions are performed inwardly, no microscope is able to give us a true information thereof. Nevertheless, mankind is as lasting, as the sun, moon and stars; nay, not only mankind, but also several other kinds and species of creatures, as minerals, vegetables, elements, and the like; for though particulars change, yet the species do not; neither can the species be impaired by the changes of their particulars; for example, the sea is no less salt, for all there is so much salt extracted out of salt-water, besides that so many fresh rivers and springs do mingle and intermix with it; Neither doth the earth seem less for all the productions of vegetables, minerals and animals, which derive their birth and origin from thence: Nor doth the race of mankind seem either more or less now than it was in former ages; for every species of creatures is preserved by a continued succession or supply of particulars; so that when some die or dissolve from being such natural figures, others are generated and supply the want of them. And thus it is with all parts of nature, both what we call celestial and terrestrial; nor can it be otherwise, since nature is self-moving, and all her parts are perpetually active.

34 Of Telescopes

Many ingenious and industrious artists take much labor and pains in studying the natures and figures of celestial objects, and endeavor to discover the causes of their appearances by telescopes, and such like optic instruments; but if art be not able to inform us truly of the natures of those creatures that are near us, how may it delude us in the search and enquiry we make of those things that are so far from us? We see how multiplying-glasses do present numerous pictures of one object, which he that has not the experience of the deceitfulness of such glasses, would really think to be so many objects. The like deceits may be in other optic instruments for ought man knows. 'Tis true, we may perhaps through a telescope see a steeple a matter of 20 or 30 miles off; but the same can a natural eye do, if it be not defective, nor the medium obstructed, without the help of any such instrument; especially if one stand

upon a high place: But put the case, a man should be upon the Alps, he would hardly see the city of Paris from thence, although he looked through a telescope never so perfect, and had no obstruction to hinder his sight: and truly the stars and planets are far more distant from us than Paris from the Alps. It is well known, that the sense of sight requires a certain proportion of distance betwixt the eye and the object; which being exceeded, it cannot perform its office; for if the object be either too near, or too far off, the sight cannot discern it: and as I have made mention in my *Philosophical Letters* of the nature of those guns, that according to the proportion of the length of the barrel, shoot either further or shorter; for the barrel must have its proportioned length; which being exceeded, the gun will shoot so much shorter as the barrel is made longer¹⁵; so may prospective-glasses perhaps direct the sense of seeing within a certain compass of distance; which distance, surely the stars and planets do far exceed; I mean so, as to discern their figures as we do of other objects that are near us; for concerning their exterior progressive motions, we may observe them with our natural eyes as well as through artificial tubes: We can see the sun's rising and setting, and the progressive motion of the moon, and other planets; but yet we cannot see their natural figures, what they are, nor what makes them move; for we cannot perceive progressive local motion otherwise, than by change of distance, that is, by composition and division of parts, which is commonly, (though improperly) called change of place, and no glasses or tubes can do more. Some affirm, they have discovered many new stars, never seen before, by the help of telescopes¹⁶; but whether this be true, or not, or whether it be only a delusion of the glasses, I will not dispute; for I having no skill, neither in the art of optics, nor in astronomy, may chance to err, and therefore I will not eagerly affirm what I do not certainly know; I only endeavor to deliver my judgment as reason directs me, and not as sense informs, or rather deludes me; and I chose rather to follow the guidance of regular reason, than of deluding art.

¹⁵Cavendish, *Philosophical Letters* (1664), Section 4, Letter 23.

¹⁶Hooke, *Micrographia* (1665), Observation 59.

Further Observations upon Experimental Philosophy, Reflecting Withal upon Some Principal Subjects in Contemplative Philosophy

1 Ancient Learning Ought Not to Be Exploded, nor the Experimental Part of Philosophy Preferred Before the Speculative

In this present age those are thought the greatest wits that rail most against the ancient philosophers, especially Aristotle, who is beaten by all; but whether he deserve such punishment, others may judge. In my opinion, he was a very subtle philosopher, and an ingenious man; 'tis true, he was subject to errors as well as other men are, (for there is no creature so perfect but may err, nay, not nature her self; but God only who is omnipotent) but if all that err should be accounted fools, and destitute of regular reason, then those deserve it most who think themselves wiser than they are, and upon that account few in this age would escape this censure. But concerning the opinions of ancient philosophers, condemned by many of our modern writers, I for my particular, do very much admire them; for although there is no absolute perfection in them, yet if we do but rightly consider them, we shall find, that in many things, they come nearer to truth than many of our moderns; for surely the ancients had as good and regular rational and sensitive perceptions, and as profitable arts and sciences as we have; and the world was governed as well, and they lived as happily in ancient times, as we do now, nay more. As for example; how well was the world governed, and how did it flourish in Augustus's time?¹⁷ How many proud and stately buildings and palaces could ancient Rome show to the world, when she was in her flower? The cedars, gold, and many other curiosities which Solomon used in the structure of that magnificent temple, (the like whereof our age cannot show) were as safely fetched and brought to him out of foreign places, as those commodities which we have out of other countries either by sea or land¹⁸: Besides, I doubt not but they had as profitable and useful arts and knowledges, and as skillful and ingenious artists as our age can boast of; if not the very same, yet the like, and perhaps better, which by the injury of time have been lost, to our great disadvantage; it may be they had no microscopes or telescopes, but I think they were the happier for the want of them, employing their time in more profitable studies: What learned and witty people the

¹⁷Augustus, grand-nephew and chosen heir of Julius Caesar, was the first emperor of the Roman Empire, ruling from 27 BCE to 14 CE.

¹⁸1 Kings 5: 6–10.

Egyptians were, is sufficiently known out of ancient histories, which may inform us of many more. But I perceive the knowledge of several ages and times, is like the increase and decrease of the moon; for in some ages art and learning flourishes better than in others, and therefore it is not only an injury, but a sign of ill-nature, to exclaim against ancient learning, and call it pedantry; for if the ancients had not been, I question whether we should have arrived to that knowledge we boast of at this present; for they did break the ice, and showed us the way in many things, for which we ought to be thankful, rather than reward them with scorn. Neither ought artists, in my opinion, to condemn contemplative philosophy, nay, not to prefer the experimental part before her; for all that artists have, they are beholden for it to the conceptions of the ingenious student, except some few arts which ascribe their original to chance; and therefore speculation must needs go before practice; for how shall a man practice, if he does not know what or which way to practice? Reason must direct first how sense ought to work, and so much as the rational knowledge is more noble than the sensitive, so much is the speculative part of philosophy more noble than the mechanical. But our age being more for deluding experiments than rational arguments, which some call a “tedious babble,”¹⁹ doth prefer sense before reason, and trusts more to the deceiving sight of their eyes, and deluding glasses, than to the perception of clear and regular reason; nay, many will not admit of rational arguments, but the bare authority of an experimental philosopher is sufficient to them to decide all controversies, and to pronounce the truth without any appeal to reason; as if they only had the infallible truth of nature, and engrossed all knowledge to themselves. Thus reason must stoop to sense, and the conceptor to the artist, which will be the way to bring in ignorance, instead of advancing knowledge; for when the light of reason begins to be eclipsed, darkness of understanding must needs follow.

2 Whether Artificial Effects May Be Called Natural, and In What Sense

In my former discourses I have declared that art produces hermaphroditical effects, that is, such as are partly natural, and partly artificial; but the question is, whether those hermaphroditical effects may not be called natural effects as well as others, or whether they be effects quite different and distinct from natural? My answer is, when I call artificial effects hermaphroditical, or such as are not natural; I do

¹⁹Possibly a reference to Glanvill’s “Address to the Royal Society” (preceding his *Scepsis Scientifica* [1665]), which contrasted that society’s “impartial search” and “wary procedure” with “the sloth, haste, and babble of talking disputants.”

not speak of nature in general, as if they were something else besides nature; for art itself is natural, and an effect of nature, and cannot produce anything that is beyond, or not within nature; wherefore artificial effects can no more be excluded from nature, than any ordinary effect or creature of nature; But when I say they are not natural, I understand the particular nature of every creature, according to its own kind of species; for as there is infinite nature which may be called general nature, or nature in general, which includes and comprehends all the effects and creatures that lie within her, and belong to her, as being parts of her own self-moving body; so there are also particular natures in every creature, which are the innate, proper and inherent interior and substantial forms and figures of every creature, according to their own kind or species, by which each creature or part of nature is discerned or distinguished from the other; as for example, although an animal and a vegetable be fellow creatures, and both natural, because material, yet their interior particular natures are not the same, because they are not of the same kind, but each has its own particular nature quite different from the other; and these particular natures are nothing else but a change of corporeal figurative motions, which make this diversity of figures; for were the same interior and natural motions found in an animal as are in a vegetable, an animal would be a vegetable, and a vegetable an animal without any difference; and after this rate there would be no variety at all in nature; but self-motion acting diversely and variously, not only in every kind and species, but in every particular creature and part of nature, causes that wonderful variety which appears every where even to our admiration in all parts of nature. But to return to artificial effects, it is known that nature has her own ways in her actions, and that there are constant productions in every kind and sort of natural creatures, which nature observes in the propagation and increase of them; whose general manner and way is always the same; (I say, general, because there are many variations in the particular motions belonging to the production of every particular creature.) For example, all mankind is produced after one and the same manner or way, to wit, by the copulation of two persons of each sex; and so are other sorts of creatures produced other ways: also a perfect creature is produced in the same shape, and has the same interior and exterior figure as is proper to it according to the nature of its kind and species to which it belongs, and this is properly called a natural production: But when the figurative motions in particular productions do not move after this ordinary way, as in the productions of monsters, it is called a praeternatural or irregular production, proceeding from the irregularity of motions; not praeternatural in respect to general nature, but in respect to the proper and particular nature of the figure. And in this regard I call artificial effects hermaphroditical, that is, partly natural, and partly artificial; Natural, because art cannot produce anything without natural matter, nor

without the assistance of natural motions, but artificial, because it works not after the way of natural productions; for art is like an emulating ape, and will produce such figures as nature produces, but it doth not, nor cannot go the same way to work as nature doth; for nature's ways are more subtle and mysterious, than that art, or any one particular creature should know, much less trace them; and this is the true construction of my sense concerning natural and artificial production; whereby it is manifest that I am not of the opinion of that experimental writer who thinks it no improbability to say that all natural effects may be called artificial, nay, that nature herself may be called the art of God²⁰; for art is as much inferior to nature, as a part is inferior to the whole, and all artificial effects are irregular in comparison to natural; wherefore to say God or nature works artificially, would be as much as to say they work irregularly.

4 Nature Cannot Be Known by Any of Her Parts

I am not of *Plinius's* opinion, that "nature in her whole power is never more wholly seen than in her smallest works"²¹; For how can nature be seen in a part, when as infinite cannot be known neither in nor by any part, much less a small part? Nay, were nature a great finite body, it could not be perceived entirely in and by a small or minute part, no more than a human eye can see all this world celestial and terrestrial at once. 'Tis true, reason being joined to sense, may make a better discovery than if they were separated; but as the human optic sense is not capable to perceive the greatest, so neither the smallest creature's exterior, much less their interior parts, although assisted by art; for art, (as I mentioned before) many times deludes rather than informs, making hermaphroditical figures; and nature has more variety and curiosity in the several forms, and figurative corporeal motions of one of the smallest creatures, than the most observing and clearest optic sense can perceive. But mistake me not; I do not say, that arts are not profitable, but that they are not truly and thoroughly intelligent or knowing of all nature's works; for several arts are like several other creatures, which have their particular natures, faculties and proprieties, beyond which they cannot go, and one creature is not able to comprehend or know all other creatures, no not any one single creature perfectly, which if so, then none can inform what it doth not know. Nay, not only one particular creature is not able to know it, but not one particular kind or sort of creatures: as for example; all man-kind that ever have lived, or are at present living in this world, could never find out the truth

²⁰Power, *Experimental Philosophy* (1664), 192–193.

²¹Pliny the Elder, *Natural History*, Book 11, Chapter 1; probably quoted from Boyle, *Some Considerations Touching the Usefulness of Experimental Natural Philosophy* (1663), 16.

of nature, even in the least of her parts, nay, not in themselves: For what man is he that knows the figurative corporeal motions, which make him to be such a creature as man, or that make any part of him? And what man or art can inform us truly of the figurative motions that make the nature of blood, flesh, bones, etc. or can give a reason why the heart is triangular, and the head spherical, and so for every differently-shaped part of his body? I will not say, but that man may guess at it, but not infallibly know it by any art; wherefore reason will more truly discover so much of nature as is discoverable to one kind or sort of creatures, than art can do; for art must attend reason as the chief mistress of information, which in time may make her a more prudent and profitable servant than she is; for in this age she is become rather vain than profitable, striving to act beyond her power, as I do undertake to write beyond my experience, for which, 'tis probable artists will condemn me; but if I err, I ask their pardon, and pray them to consider the nature of our sex, which makes us, for the most part, obstinate and willful in our opinions, and most commonly impertinently foolish: And if the art of micrography can but find out the figurative corporeal motions that make or cause us to be thus, it will be an art of great fame, for by that artists may come to discover more hidden causes and effects; but yet I doubt they will hardly find out the interior nature of our sex by the exterior form of their faces or countenances, although very curious, and full of variety of several beauties; nay, I dare on the contrary say, had a young beautiful lady such a face as the microscope expresses, she would not only have no lovers, but be rather a monster of art, than a picture of nature, and have an aversion, at least a dislike to her own exterior figure and shape; and perchance if a louse or flea, or such like insect, should look through a microscope, it would be as much affrighted with its own exterior figure, as a young beautiful lady when she appears ill-favored by art. I do not say this, as if optic glasses could not present the true figure of an original; for if they do not exceed the compass of natural dimensions, they may; but when they endeavor to go beyond them, and do more than nature has done, they rather present monstrous, than truly natural figures. Wherefore those, in my opinion, are the best artists, that keep nearest to nature's rules, and endeavor not to know more than what is possible for a finite part or creature to know; for surely there is no better way to be rightly and truly informed of nature's works, than by studying nature's corporeal figurative motions, by the means of which study, they will practice arts (as far as art is able to be practiced) more easily and successfully than they will do without it. But to conclude this discourse, some parts of nature are more endued with regular reason than others, which is the cause that some creatures of one and the same sort or kind, as for example, mankind, are more wise and ingenious than others; and therefore it is not art, but regular sense and reason, that makes some more knowing, and some

more wise and ingenious than others; and the irregular motions of sense and reason that make some more ignorant or more extravagant in their opinions than others.

Excerpts, notes, and modernized text by [Trevor Pearce](#).

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