

## VIII. Of Mathematics, Pure and Mixed

(1) Nevertheless, there remaineth yet another part of natural philosophy, which is commonly made a principal part, and holdeth rank with physic special and metaphysic, which is mathematic; but I think it more agreeable to the nature of things, and to the light of order, to place it as a branch of metaphysic. For the subject of it being quantity, not quantity indefinite, which is but a relative, and belongeth to *philosophia prima* (as hath been said), but quantity determined or proportionable, it appeareth to be one of the essential forms of things, as that that is causative in Nature of a number of effects; insomuch as we see in the schools both of Democritus and of Pythagoras that the one did ascribe figure to the first seeds of things, and the other did suppose numbers to be the principles and originals of things. And it is true also that of all other forms (as we understand forms) it is the most abstracted and separable from matter, and therefore most proper to metaphysic; which hath likewise been the cause why it hath been better laboured and inquired than any of the other forms, which are more immersed in matter. For it being the nature of the mind of man (to the extreme prejudice of knowledge) to delight in the spacious liberty of generalities, as in a champaign region, and not in the inclosures of particularity, the mathematics of all other knowledge were the goodliest fields to satisfy that appetite. But for the placing of this science, it is not much material: only we have endeavoured in these our partitions to observe a kind of perspective, that one part may cast light upon another.

(2) The mathematics are either pure or mixed. To the pure mathematics are those sciences belonging which handle quantity determinate, merely severed from any axioms of natural philosophy; and these are two, geometry and arithmetic, the one handling quantity continued, and the other dis severed. Mixed hath for subject some axioms or parts of natural philosophy, and considereth quantity determined, as it is auxiliary and incident unto them. For many parts of Nature can neither be invented with sufficient subtlety, nor demonstrated with sufficient perspicuity, nor accommodated unto use with sufficient dexterity, without the aid and intervening of the mathematics, of which sort are perspective, music, astronomy, cosmography, architecture, engineery, and divers others. In the mathematics I can report no deficiency, except it be that men do not sufficiently understand this excellent use of the pure mathematics, in that they do remedy and cure many defects in the wit and faculties intellectual. For if the wit be too dull, they sharpen it; if too wandering, they fix it; if too inherent in the sense, they abstract it. So that as tennis is a game of no use in itself, but of great use in respect it maketh a quick eye and a body ready to put itself into all postures, so in the mathematics that use which is collateral and intervenient is no less worthy than that which is principal and intended. And as for the mixed mathematics, I may only make this prediction, that there cannot fail to be more kinds of them as Nature grows further disclosed. Thus much of natural science, or the part of Nature speculative.

(3) For natural prudence, or the part operative of natural philosophy, we will divide it into three parts—experimental, philosophical, and magical; which three parts active have a correspondence and analogy with the three parts speculative, natural history, physic, and metaphysic. For many operations have been invented, sometimes by a casual incidence and occurrence, sometimes by a purposed experiment; and of those which have been found by an intentional experiment, some have been found out by varying or extending the same experiment, some by transferring and compounding divers experiments the one into the other, which kind of invention an empiric may manage. Again, by the knowledge of physical causes there cannot fail to follow many indications and designations of new particulars, if men in their speculation will keep one eye upon use and practice. But these are but coastings along the shore, *premedo littus iniquum*; for it seemeth to me there can hardly be

discovered any radical or fundamental alterations and innovations in Nature, either by the fortune and essays of experiments, or by the light and direction of physical causes. If, therefore, we have reported metaphysic deficient, it must follow that we do the like of natural magic, which hath relation thereunto. For as for the natural magic whereof now there is mention in books, containing certain credulous and superstitious conceits and observations of sympathies and antipathies, and hidden proprieties, and some frivolous experiments, strange rather by disguisement than in themselves, it is as far differing in truth of Nature from such a knowledge as we require as the story of King Arthur of Britain, or Hugh of Bourdeaux, differs from Cæsar's Commentaries in truth of story; for it is manifest that Cæsar did greater things *de vero* than those imaginary heroes were feigned to do. But he did them not in that fabulous manner. Of this kind of learning the fable of Ixion was a figure, who designed to enjoy Juno, the goddess of power, and instead of her had copulation with a cloud, of which mixture were begotten centaurs and chimeras. So whosoever shall entertain high and vaporous imaginations, instead of a laborious and sober inquiry of truth, shall beget hopes and beliefs of strange and impossible shapes. And, therefore, we may note in these sciences which hold so much of imagination and belief, as this degenerate natural magic, alchemy, astrology, and the like, that in their propositions the description of the means is ever more monstrous than the pretence or end. For it is a thing more probable that he that knoweth well the natures of weight, of colour, of pliant and fragile in respect of the hammer, of volatile and fixed in respect of the fire, and the rest, may superinduce upon some metal the nature and form of gold by such mechanic as longeth to the production of the natures afore rehearsed, than that some grains of the medicine projected should in a few moments of time turn a sea of quicksilver or other material into gold. So it is more probable that he that knoweth the nature of arefaction, the nature of assimilation of nourishment to the thing nourished, the manner of increase and clearing of spirits, the manner of the depredations which spirits make upon the humours and solid parts, shall by ambages of diets, bathings, anointings, medicines, motions, and the like, prolong life, or restore some degree of youth or vivacity, than that it can be done with the use of a few drops or scruples of a liquor or receipt. To conclude, therefore, the true natural magic, which is that great liberty and latitude of operation which dependeth upon the knowledge of forms, I may report deficient, as the relative thereof is. To which part, if we be serious and incline not to vanities and plausible discourse, besides the deriving and deducing the operations themselves from metaphysic, there are pertinent two points of much purpose, the one by way of preparation, the other by way of caution. The first is, that there be made a calendar, resembling an inventory of the estate of man, containing all the inventions (being the works or fruits of Nature or art) which are now extant, and whereof man is already possessed; out of which doth naturally result a note what things are yet held impossible, or not invented, which calendar will be the more artificial and serviceable if to every reputed impossibility you add what thing is extant which cometh the nearest in degree to that impossibility; to the end that by these optatives and potentials man's inquiry may be the more awake in deducing direction of works from the speculation of causes. And secondly, that these experiments be not only esteemed which have an immediate and present use, but those principally which are of most universal consequence for invention of other experiments, and those which give most light to the invention of causes; for the invention of the mariner's needle, which giveth the direction, is of no less benefit for navigation than the invention of the sails which give the motion.

(4) Thus have I passed through natural philosophy and the deficiencies thereof; wherein if I have differed from the ancient and received doctrines, and thereby shall move contradiction, for my part, as I affect not to dissent, so I purpose not to contend. If it be truth,

the voice of Nature will consent, whether the voice of man do or no. And as Alexander Borgia was wont to say of the expedition of the French for Naples, that they came with chalk in their hands to mark up their lodgings, and not with weapons to fight; so I like better that entry of truth which cometh peaceably with chalk to mark up those minds which are capable to lodge and harbour it, than that which cometh with pugnacity and contention.

(5) But there remaineth a division of natural philosophy according to the report of the inquiry, and nothing concerning the matter or subject: and that is positive and considerative, when the inquiry reporteth either an assertion or a doubt. These doubts or *non liquets* are of two sorts, particular and total. For the first, we see a good example thereof in Aristotle's Problems which deserved to have had a better continuance; but so nevertheless as there is one point whereof warning is to be given and taken. The registering of doubts hath two excellent uses: the one, that it saveth philosophy from errors and falsehoods; when that which is not fully appearing is not collected into assertion, whereby error might draw error, but reserved in doubt; the other, that the entry of doubts are as so many suckers or sponges to draw use of knowledge; insomuch as that which if doubts had not preceded, a man should never have advised, but passed it over without note, by the suggestion and solicitation of doubts is made to be attended and applied. But both these commodities do scarcely countervail and inconvenience, which will intrude itself if it be not debarred; which is, that when a doubt is once received, men labour rather how to keep it a doubt still, than how to solve it, and accordingly bend their wits. Of this we see the familiar example in lawyers and scholars, both which, if they have once admitted a doubt, it goeth ever after authorised for a doubt. But that use of wit and knowledge is to be allowed, which laboureth to make doubtful things certain, and not those which labour to make certain things doubtful. Therefore these calendars of doubts I commend as excellent things; so that there be this caution used, that when they be thoroughly sifted and brought to resolution, they be from thenceforth omitted, discarded, and not continued to cherish and encourage men in doubting. To which calendar of doubts or problems I advise be annexed another calendar, as much or more material which is a calendar of popular errors: I mean chiefly in natural history, such as pass in speech and conceit, and are nevertheless apparently detected and convicted of untruth, that man's knowledge be not weakened nor embased by such dross and vanity. As for the doubts or *non liquets* general or in total, I understand those differences of opinions touching the principles of nature, and the fundamental points of the same, which have caused the diversity of sects, schools, and philosophies, as that of Empedocles, Pythagoras, Democritus, Parmenides, and the rest. For although Aristotle, as though he had been of the race of the Ottomans, thought he could not reign except the first thing he did he killed all his brethren; yet to those that seek truth and not magistrality, it cannot but seem a matter of great profit, to see before them the several opinions touching the foundations of nature. Not for any exact truth that can be expected in those theories; for as the same phenomena in astronomy are satisfied by this received astronomy of the diurnal motion, and the proper motions of the planets, with their eccentrics and epicycles, and likewise by the theory of Copernicus, who supposed the earth to move, and the calculations are indifferently agreeable to both, so the ordinary face and view of experience is many times satisfied by several theories and philosophies; whereas to find the real truth requireth another manner of severity and attention. For as Aristotle saith, that children at the first will call every woman mother, but afterward they come to distinguish according to truth, so experience, if it be in childhood, will call every philosophy mother, but when it cometh to ripeness it will discern the true mother. So as in the meantime it is good to see the several glosses and opinions upon Nature, whereof

it may be everyone in some one point hath seen clearer than his fellows, therefore I wish some collection to be made painfully and understandingly *de antiquis philosophiis*, out of all the possible light which remaineth to us of them: which kind of work I find deficient. But here I must give warning, that it be done distinctly and severedly; the philosophies of everyone throughout by themselves, and not by titles packed and faggoted up together, as hath been done by Plutarch. For it is the harmony of a philosophy in itself, which giveth it light and credence; whereas if it be singled and broken, it will seem more foreign and dissonant. For as when I read in Tacitus the actions of Nero or Claudius, with circumstances of times, inducements, and occasions, I find them not so strange; but when I read them in Suetonius Tranquillus, gathered into titles and bundles and not in order of time, they seem more monstrous and incredible: so is it of any philosophy reported entire, and dismembered by articles. Neither do I exclude opinions of latter times to be likewise represented in this calendar of sects of philosophy, as that of Theophrastus Paracelsus, eloquently reduced into an harmony by the pen of Severinus the Dane; and that of Tilesius, and his scholar Donius, being as a pastoral philosophy, full of sense, but of no great depth; and that of Fracastorius, who, though he pretended not to make any new philosophy, yet did use the absoluteness of his own sense upon the old; and that of Gilbertus our countryman, who revived, with some alterations and demonstrations, the opinions of Xenophanes; and any other worthy to be admitted.

(6) Thus have we now dealt with two of the three beams of man's knowledge; that is *radius directus*, which is referred to nature, *radius refractus*, which is referred to God, and cannot report truly because of the inequality of the medium. There resteth *radius reflexus*, whereby man beholdeth and contemplateth himself.

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