# *E S S A Y S*

O N

# PHILOSOPHICAL SUBJECTS.

B Y

The late ADAM SMITH, LL. D.

FELLOW OF THE ROYAL SOCIETIES OF LONDON AND EDINBURGH, *&c. &c.*

*TO WHICH IS PREFIXED,*

An ACCOUNT of the LIFE and WRITINGS of the AUTHOR;

By *DUGALD STEWART*, F. R. S. E.

L O N D O N:

Printed for T. CADELL Jun. and W. DAVIES (Succeffors to Mr. CADELL) in the Strand; and W. CREECH, Edinburgh.

1795.

*The History of Astronomy*

*The History of the Ancient Physics*

*The History of the Ancient Logics and Metaphysics*

# Introduction

To the inquiring layman, Adam Smith was the author of the *Wealth of Nations*; to the philosopher, of a comparable classic, the *Theory of Moral Sentiments*; these were the only books published in his lifetime. Within five years of his death (1790), however, appeared under the editorship of his two friends, Joseph Black and James Hutton, a substantial volume entitled *Essays on Philosophical Subjects ... to which is prefixed an Account of the Life and Writings of the Author by Dugald Stewart.* Though far less celebrated than the two major works the EPS nevertheless appeared during the next hundred years in at least eight editions, including one from Revolutionary Paris and one from Basel (see Bibliographical Note, Nos. 3, 4). In the present century the book has acquired a renewed interest, attention having been drawn principally to the first three essays, consideration of which has formed the basis of a significant secondary literature. The subject of each of these essays is the history of a branch of science, namely, of Astronomy, of the Ancient Physics, and of the Ancient Logics and Metaphysics. Of these the first alone is of any considerable length; the other two are hardly more than fragments. To none of them would a modern scholar turn for enlightenment on the history of the sciences; at most he could expect to discover what an outstanding mind living in the second half of the eighteenth century *believed* to represent the histories of these subjects. Wherein then lies the attraction to writers during recent decades? It lies in the full titles of the three essays: *The Principles which lead and direct Philosophical Enquiries; illustrated by the History of Astronomy*; the preamble is repeated before each of the other two histories. It might be conjectured from this that the first three essays are to be taken rather as chapters in a book than as separate pieces; that such a conjecture might be correct is supported by the Advertisement of the editors in which they emphasize that though immediately before his death Smith had destroyed many other manuscripts, he had left these 'in the hands of his friends to be disposed of as they thought proper', and that on inspection 'the greater number of them appeared to be parts of a plan he once had formed, for giving a connected history of the liberal sciences and elegant arts' but that he had long since 'found it necessary to abandon that plan as far too extensive'. Though there is now no trace of the manuscripts on which the collection was based, we know from other sources that this is hardly an adequate account.

If the allegedly projected *history* was to embrace the 'elegant arts' why was the telling preamble to the first three essays omitted from the remainder? To the modern reader it seems evident that whereas the former, inadequate though they may now appear, do conform to a unitary and highly significant plan, the remainder, though not without their interesting features, are neither treated historically nor do they illustrate the 'principles which lead and direct philosophical enquiry'. The editors, though in other respects men of high eminence, were not noted for scholarship as such. We must turn to other sources to discover what part the composition of these essays played in the author's intellectual scheme of things.

Fortunately we do not have to look beyond the volume itself: the *Essays* were preceded by a long and detailed 'Account of the Life and Writings of Adam Smith', read to the Royal Society of Edinburgh in 1793 and subsequently published in their *Transactions*. The author was Dugald Stewart, Professor of Moral Philosophy in the University of Edinburgh from 1785 to 1810, and the editor of the first *Collected Works* of Smith published in 1811–12. Towards the end of this 'Account' is cited Smith's earliest reference to the EPS of which we have any knowledge; it was contained in letter (137) to David Hume dated 'Edinburgh, 16th. April 1773' when Smith was preparing to go to London where he expected to remain some time. In the expectation that Hume would in the event of his own earlier death act as his literary executor, Smith insisted that of all the papers he was about to leave behind 'there are none worth the publishing but a fragment of a great work which contains a history of the Astronomical Systems that were successively in fashion down to the time of Des Cartes. Whether that might not be published as a fragment of an intended juvenile work, I leave entirely to your judgment; tho I begin to suspect myself that there is more refinement than solidity in some parts of it.' There is neither here nor anywhere else reference to other 'fragments' such as the Ancient Physics and Ancient Logics that ultimately came to be published in the same volume as the Astronomy; the possible significance of this omission will be discussed later (below, 26–7).

In 1773 Smith was already fifty; it is unlikely, therefore, that he would have referred to any work as 'juvenile' except such as had been written many years earlier. This supposition receives some support from his asking (Astronomy, II.12) 'Why has the chemical philosophy in all ages crept along in obscurity, and been so disregarded by the generality of mankind . . . ?' How Smith could have formed such a judgement nearly a century after the prominence of Robert Boyle and Robert Hooke at the Royal Society it is difficult to understand;

but such an opinion would surely have been modified by intercourse with William Cullen with whom Smith is known[1] to have been on intimate terms after he assumed the Glasgow Chair of Logic in 1751. Since by 1748, almost two years after relinquishing the Snell Exhibition at Balliol College, Oxford, he must have been heavily engaged in the preparation and reading of his lectures on belles-lettres at Edinburgh, it has been fairly generally assumed that he at least laid the foundation of the History of Astronomy at Oxford; but from further internal evidence it may be inferred that he did not finish it there. Towards the end of the Astronomy Smith wrote that 'the observations of Astronomers at Lapland and Peru have fully confirmed Sir Isaac's system' (IV.72); Bouguer's account of his observations in Peru confirming Newton's model of the figure of the Earth was published in 1749—three years after Smith left Balliol.

The reader may have noticed a discrepancy between this reference to 'Sir Isaac's [Newton] system' and (in the letter to David Hume) the description of the History as being of the astronomical systems that were successively in fashion down to the time of Descartes: the last ten pages of the original printed text are in fact devoted to establishing 'the superior genius and sagacity of Sir Isaac Newton'. Relevant to this question is the editors' terminal note: 'The Author, at the end of this Essay, left some Notes and Memorandums, from which it appears, that he considered this last part of his History of Astronomy as imperfect, and needing several additions. The Editors, however, chose rather to publish than to suppress it. It must be viewed, not as a History or Account of Sir Isaac Newton's Astronomy, but chiefly as an additional illustration of those Principles in the Human Mind which Mr. Smith has pointed out to be the universal motives of Philosophical Researches.'

This is consistent with the view put forward above that though the Astronomy may well have been largely composed in Oxford the 'last part' of it could have been added after Smith's return to Scotland. That even this 'last part' was written *before* 1758 appears from his statement (Astronomy, IV.74) that Newton's 'followers have, from his principles, ventured even to predict the returns of several of them [sc. comets], particularly of one which is to make its appearance in 1758. We must wait for that time . . .'. Thus the text; a footnote on the same page reads: 'It must be observed, that the whole of this Essay was written previous to the date here mentioned; and that the return of the comet happened agreeably to the prediction.' There is in the

[1] Rae, *Life*, 44, states that before the middle of November [1751] he [Smith] and Cullen were 'already deeply immersed in quite a number of little schemes for the equipment of the College' [Glasgow].

original text no indication as to who added this note; but P. Prevost, the translator of the French edition (see Bibliographical Note 3), describes the note as 'de l'editeur anglais'. Since Prevost was a Fellow of the Royal Society of Edinburgh and claimed to be personally acquainted with Dugald Stewart he may have had first-hand information.

The apparent discrepancy in the letter to Hume disappears if it is recalled that Smith was expressing an opinion as to what of his literary remains might be worthy of publication: the 'Notes and Memorandums' referred to in the editors' final note to the Astronomy, suggest that Smith was more than doubtful as to whether the 'last part' should qualify.

The period 1746–8 when Smith was residing at Kirkcaldy with his mother and before he was committed to the reading of lectures on Rhetoric and Belles-Lettres at Edinburgh would seem as likely as any for laying the foundation of a project on the scale that he is known to have envisaged. Whether the other two 'fragments' were composed during that period is a matter of no special consequence; there would, at any rate, be no inconsistency in his having spoken more than once [and presumably much later] to Dugald Stewart of having 'projected, in the earlier part of his life, a history of the other sciences on the same plan' (Stewart, II.52) and of his editors having referred to a 'plan he had once formed, for giving a connected history of the liberal sciences and elegant arts'. There were, of course, neither then nor for a long time afterwards, any Faculties of Science in the Scottish universities and the boundary between 'arts' and 'sciences' was hardly, if at all, clearly drawn. 'Logics and Metaphysics' are still mainly the concern of Faculties of Arts, as would also be the sort of 'ancient physics' that Smith was describing in the essay so entitled.

There is extant one other allusion by Smith which, though somewhat inconsistent with those that have been referred to, cannot be ignored in any attempt to date the composition of the EPS. It occurs in a letter (248) to the Duc de La Rochefoucauld written from Edinburgh in November 1785 but not published until 1895; the relevant section runs as follows:

> I have likewise two other great works upon the anvil; the one is a sort of Philosophical History of all the different branches of Literature, of Philosophy, Poetry and Eloquence; the other is a sort of theory and History of Law and Government. The materials of both are in a great measure collected, and some Part of both is put into tollerable good order. But the indolence of old age, tho' I struggle violently against it, I feel coming fast upon me, and whether I shall ever be able to finish either is extremely uncertain.

Now whereas the description of the former of these 'other great works' could well refer to the Histories of Astronomy, Ancient Physics, and Logics and Metaphysics included in the *Essays on Philosophical Subjects*, the remaining essays, though falling under the generous heading of 'Literature, Philosophy, Poetry and Eloquence', are almost wholly devoid of any reference to any historical development. Moreover, the limited range of topics hardly warrants the claim that the 'materials' were 'in a great measure collected'. In the fitful light of such evidence as is now available it seems difficult to avoid the conclusion that after the exacting labour of the *Wealth of Nations* with its successive revisions Smith's 'great work on a sort of philosophical history' existed more in the hope of realizing a youthful ambition than in any adequate progress towards its achievement.[2] Fortunately the impossibility of any precise dating of its components does not preclude further fruitful consideration of the part this ambition continued to play in Smith's intellectual development.

In 1755, four years after Smith had been appointed to the Glasgow Chair, he wrote the two well-known letters to the *Edinburgh Review*. In the second of these letters Smith evidently considered himself so much a master of the state of the sciences in Europe as to include a critical review of 'the new French Encyclopedia' (below, 245–8); and though the modern reader will detect a certain degree of superficiality—not to say even contradiction—in his judgements he had clearly a wide-ranging knowledge relevant to the task. Among the contributors he refers to—'many of them already known to foreign nations by the valuable works which they have published' (Letter, §6)—he singles out 'Mr. Alembert' and 'Mr. Diderot' and refers to the former's famous *Discours préliminaire*.

A perusal of d'Alembert's *Discours* reveals a strong resemblance to Smith's approach to the 'principles which lead and direct philosophical enquiries'. In his stress on what he called Smith's 'Theoretical or Conjectural History' Dugald Stewart (II.49) expressed the view that the 'mathematical sciences, both pure and mixed, afford, in many of their branches, very favourable subjects for theoretical history'; and he went on to note d'Alembert's recommendation of this historical approach for teaching. More striking still, he follows this reference by instancing a passage in Montucla's *Histoire des mathématiques* (Paris, 1758) which included long sections on 'mixed' mathematics (viz. astronomy, mechanics, optics, and their applications) where an attempt is made to 'exhibit the gradual progress of philosophical

[2] That Smith himself was far from being consistent in referring to his literary achievements and aims will appear in connection with the dating of the Imitative Arts (172 below).

speculation, from the first conclusions suggested by a general survey of the heavens, to the doctrines of Copernicus. It is somewhat remarkable, that a theoretical history of this very science ... was one of Mr. Smith's earliest compositions'. Since Stewart shared with Smith the habit of almost total lack of *significant* documentation, we do not know where he read d'Alembert's reference to Montucla, but it obviously could not have been in the first (1751) edition of the *Encyclopédie*, which we know to have been in Smith's hands before 1755.

Although we can beyond all reasonable doubt reject any charge of plagiarism, there is nevertheless one feature in Smith's appreciation of the *Encyclopédie* that must strike us as rather odd: in acclaiming the outstanding quality of d'Alembert's contributions he makes no mention of the strong affinity between the latter's views on the nature, significance, and enlargement of 'philosophy' and those we believe he had already set forth in the 'historical' essays. Smith's review of the *Encyclopédie* was part of the evidence he submitted to the 'Authors' of the newly founded *Edinburgh Review* in support of the proposal that they should enlarge the scope of their *Review* to include not only English but also European letters. Is it not a matter for some surprise that a young man, little more than thirty, recently established as the leading philosophical teacher in a small but ancient university, should not in such circumstances have at least briefly impressed upon the *Review* the universal significance of the *Discours préliminaire*? D'Alembert, though only six years older than Smith, was already accepted as one of the most brilliant analytical and comprehensive of European minds: a mathematician of the first rank, who appreciated both the power of mathematics and its limitations as a mode for 'philosophy' in general, and whose concern for this 'philosophy' was primarily in its significance for human welfare. The broad agreement of the views of such an authority with this 'juvenile' plan would, one might have supposed, have prompted Smith to a more enthusiastic welcome to the *Discours* than that 'Mr. Alembert gives an account of the connection of the different arts and sciences, their genealogy and filiation, as he calls it; which, a few alterations and corrections excepted, is nearly the same with that of my Lord Bacon' (Letter, §6). It is perhaps necessary to emphasize that the 'broad agreement' in the views of Smith and d'Alembert was mainly (as noted above) in respect of their *approach*. A review of the details of their argument would here be out of place; but one especially marked difference in their emphasis may be the clue to the puzzle: it is that whereas Smith sets so much store on 'wonder' and 'surprise' (below, 13–14), d'Alembert, following Bacon, stresses the greater significance of 'need and use' in discovery—a position that the author of the *Wealth of Nations* as dogmatically rejects (Astronomy, III.3). Could it have been that the 'juvenile' author of the *Essays on Philosophical Subjects* held his horses in the hope that an opportunity would later present itself for the systematic refutation of a theory whose wrong-headedness he evidently deplored?

Though this account of the circumstances of time, place, and purpose of the composition of the EPS has been if not wholly negative at least mainly 'conjectural', it may have given some insight into the nature of the undertaking and the reason for its continued interest to scholars. Reference to d'Alembert's *Discours* has shown that Smith's attempt at 'conjectural history' was no isolated phenomenon; Dugald Stewart claims that the 'expression . . . coincides pretty nearly in its meaning with that of *Natural History*, as employed by Mr. Hume [i.e. *The Natural History of Religion*, 1757], and with what some French writers have called *Histoire Raisonnée*' (Stewart, II.48). Among examples of the latter he names Montesquieu's *Esprit des lois* (1748). The title of that great work is itself indicative of what many writers were doing at that time: Paul Hazard reminds us of the numerous attempts to distil the *Esprit* of this, that, and the other; frequently by means of a search for the origin and growth of the 'science' or 'art' concerned. The *Encyclopédie* was not the first to envisage this task: something of the same sort had appeared in Ephraim Chambers's relatively concise *Cyclopaedia; or an Universal Dictionary of Arts and Sciences* (1728), but never before had it been accomplished in such a penetrating manner or on such an immense scale.

## *The History of Astronomy*

The importance of this essay to modern scholars lies mainly in the preamble and the first three sections; these contain a statement and elaboration of the chief 'principles' that Smith believed to 'lead and direct philosophical enquiries'. The History of Astronomy *sensu stricto*, that begins only in Section IV, is of interest partly as an indication of contemporary knowledge of the subject, but mainly for the incidental remarks made by the author in pursuance of his central aim. Though acceptable to a modern historian in its main lines, it contains so many errors of detail and not a few serious omissions as to be no longer more than a museum specimen of its kind. This is not to deny its high merit for an age when systematic study of the history of the sciences was in its infancy. But by 1758 a student would have been better advised to read Jean-Étienne Montucla's *Histoire des mathématiques* (written incidentally in the enlightened spirit characteristic of the young Adam Smith) which by 1802 had been revised and extended by Jérôme de Lalande. The first history of astronomy still used as an important work of reference was completed by Jean-Baptiste-Joseph Delambre in 1827.

In any attempt to assess the success of Smith's enterprise we are met at the outset by his inconsistent and ill-defined terminology 'philosophy is the science ... Philosophy ... may be regarded as one of those arts ...' (both in Astronomy, II.12). In fact the terms philosophy, physics, arts, sciences, and natural philosophy are used almost indiscriminately. In this of course he was not alone: Hume (*Treatise of Human Nature*, Introduction) speaks of 'philosophy and the sciences', which seems to promise a distinction more in line with modern usage; but by including Natural Religion and Criticism among the 'sciences' he introduced a possible source of confusion. The actual words 'natural science' in the sense of an 'inquiry by reason alone into all things in the natural kingdom of God' were first used by Thomas Hobbes in *Leviathan*; but 'natural philosophy' was preferred (though not in the restricted sense still current in the Scottish universities) throughout the seventeenth and eighteenth centuries. The first demarcation between 'science' and 'art' is attributed by the *Oxford English Dictionary* to Richard Kirwan: 'Previous to the year 1780 mineralogy tho' tolerably understood as an art could scarcely be termed a science' (1796). James Hutton about the same time wrote that 'philosophy must proceed in generalising those truths which are the objects of particular sciences'. In respect of the recent blossoming of the so-called 'social sciences' the failure of English to distinguish the species *Naturwissenschaft* from the genus *Wissenschaft* has become even more embarrassing than heretofore.

Had Smith consistently used 'philosophy' to *include* natural philosophy, leaving it to the context to indicate whether the general term or the specific application was concerned, there could, in relation to the period, be no quarrel. When he writes (Astronomy, IV.18) 'Philosophers, long before the days of Hipparchus [*c.* 140 B.C.], seem to have abandoned the study of nature ...' and to have regarded 'all mathematicians, among whom they counted astronomers' with 'supercilious and ignorant contempt' his *usage* (whatever we may think of his judgement) was in general accord with ancient and medieval practice.

In the Middle Ages the interpretation of 'philosophy' varied from one university to another. Roughly speaking when the trivium was enlarged under the term *studia humanitatis* (and in many cases the quadrivium, as such, disappeared in practice), 'philosophy' meant moral philosophy. Mathematics and astronomy, together with 'natural philosophy' (more often called 'physics'), became mainly the concern of the Faculty of Medicine; this was especially the case in the Italian universities. But Smith's judgement cited above follows a brief account of the epicyclic and eccentric systems of planetary motion by which 'those philosophers (IV.9) imagined they could account for the apparently unequal velocities of all those bodies'. Who are 'those philosophers'? It was, we are told, Apollonius (IV.8) who 'invented' the system and Hipparchus who 'afterwards perfected' it. Apollonius was a mathematician of the calibre of Eudoxus and Euclid; Hipparchus pioneered the branch of mathematics that came long afterwards to be known as spherical trigonometry and he was also among the greatest observers of all time. Most of the astronomical works of each were irretrievably lost; but to neither is any interest in 'philosophy' attributed—a fact at which Smith himself hints in another context (Astronomy, IV.25) where he speaks of 'the philosophy of Aristotle, and the astronomy of Hipparchus'. The precise distinction made by the Greeks themselves will be cited in the Introduction to the essay on 'The Ancient Physics'.

It would of course be absurd to demand precisely demarcated categories which would only stifle attempts to reveal latent relationships. But that in relation to the age of Adam Smith there are traps easily fallen into is shown by a recent comment[3] that Smith referred to Isaac Newton 'as a philosopher not scientist'. From Smith's use of the term in this context nothing can be inferred, since the word 'scientist' did not exist before 1839. The use of such expressions as 'Adam Smith's philosophy of science' may similarly be a source of confusion; better to risk a charge of repetitiveness and pedantry than that of circularity; each reference must be explicated on its own merits.

This caveat has an indirect bearing on the introductory sections of the Astronomy. Smith's aim in this and the succeeding essays was to show how these histories illustrate 'the principles which lead and direct philosophical enquiries'. Having in the first three paragraphs given the barest hint of the relevance of 'surprise' and 'wonder' to these 'principles' he reviews at what may seem inordinate length the influence of the sentiments of surprise and wonder on the emotions of joy, grief, panic, frenzy, etc. The modern reader, especially one unfamiliar with the pervasive significance accorded to the 'passions' by Smith and his contemporaries, may feel puzzled to know what all this has to do with the clearly expressed aim of the essays. Smith might have been wise to recall Bacon's words that such observations are 'well inquired and collected in metaphysic, but in physic they are

[3] H. F. Thomson, 'Adam Smith's Philosophy of Science', *Quarterly Journal of Economics*, lxxix (1965), 218.

impertinent' (*Advancement of Learning* II.vii.7). But after a dozen pages the rhetorical fog lifts: the 'surprise' excited in the observer by the motion of a piece of iron 'without any visible impulse, in consequence of the motion of a loadstone at some little distance from it' and the 'wonder' how it came to be 'conjoined to an event with which, according to the ordinary train of things, he could have so little suspected it to have any connection' (II.6) establish the thesis in the clearest possible manner. The further deployment of the thesis, even if unnecessarily prolonged, displays Smith's elegant and imaginative style at its best. Had he but set his own words 'philosophy is the science of the connecting principles of nature' at the beginning instead of near the end, and then avoided the trap in the ill-defined term 'philosophy', this section might well have ranked as the most fundamental in the whole work. Though not free from confusion, the concluding pages of this section reveal in greater emphasis Smith's 'principles of philosophical enquiries'. Central among these is an interpretation of causal investigation as a search for a 'bridge'; the examples here are much more convincing. The special characteristics of this 'bridge' or 'chain' are analogy to more familiar objects, coherence, and—of special significance for the modern scholar—'without regarding their absurdity or probability, their agreement or inconsistency with truth and reality' (II.12). This remarkable passage is our justification for caution in speaking about what has been called 'Smith's philosophy of science'. For Smith himself who, as we have seen, defines 'philosophy' as 'the science of the connecting principles of nature' the term could have no clear connotation; nor could it for anyone until the term 'science' was restricted to what Smith is here calling 'philosophy'. There is still no general agreement as to the range of the 'philosophy of science'; but that it is essentially *meta*-science, or talk *about* science, would probably not be contested. Of this there could not in Smith's time be any explicit recognition. No doubt the study of his enterprise will shed light on the nature of the problems to be talked about; but in respect of its 'systems' his inquiry was less about their truth than about 'how far each of them was fitted to sooth(e) the imagination, and to render the theatre of nature a more coherent, and therefore a more magnificent spectacle, than otherwise it would have appeared to be' (ibid.). This has certainly a modern ring about it; but a modern 'philosophy of science' that thus ignored the problem of truth would get rather a cold reception. It is thus less the philosophy of science than the history of the *idea* of the 'philosophy of science' that Smith's enterprise is likely to illuminate.[4]

[4] For a further elaboration, see the present writer's 'Adam Smith and the History of Ideas' in *Essays on Adam Smith*. The essay was designed to be read in conjunction with this introduction.

The dubious historiography and scrappy exposition of Section III—'Of the Origin of Philosophy'—are characteristic of the 'Age of Reason': imaginative liveliness creates a colourful stage upon which the drama of Western culture is to take its rise. Regrettably 'imagination'[5] aided and abetted but not controlled by 'reason' takes command; and what was in the circumstances inevitably no more than a 'likely story' is presented with a degree of naïve dogmatism and assurance that would be beguiling if it had not engendered distorted attitudes in the long shadows of which we are still living. The danger of 'conjectural history' is thus made only too plain; justification of this rather critical assessment may most suitably wait on textual commentary.

In Section IV we are plunged rather abruptly into 'The History of Astronomy' proper: abruptly, since Smith has already stated that it is from Plato and Aristotle that he will 'begin to give her history in any detail'. The highly complex and mathematically beautiful system of Eudoxus is thus made to appear fully formed like Pallas from the head of Zeus. For his purpose Smith is perhaps justified in thus proceeding; but not to emphasize the extreme unlikelihood of such a creation without a long preparation of accurate observation and critical correlation is to risk begging the whole question of the genesis of philosophical inquiry. Once launched, however, on the exposition of the 'first regular system of Astronomy' (Astronomy, IV.4) he moves, not indeed with complete mastery, but with a remarkable degree of precision and understanding. Since among the readers of this edition there may be some wholly unfamiliar with the rationale of this system it may be as well to give a necessarily somewhat simplified but also more concise account of it than Smith provides; to facilitate cross-reference this will be set out in a somewhat schematic form.

The celestial phenomena (appearances) were either relatively transitory (e.g. meteors) or eternal; comets, remaining visible for months, were the subjects of some controversy.

The 'eternal' bodies, with seven notable exceptions, were fixed in space relative to each other. The exceptions—Sun, Moon, Mercury, Venus, Mars, Jupiter, and Saturn (to give them their Latinized names)—were all called 'planets' or 'wandering stars', since their positions varied continuously both with respect to each other and to the pattern of the 'fixed' stars.

All the visible objects were seen to move in circles round the Earth in a time constituting a 'day'. The various minor discrepancies among

[5] On Smith's attitude to the 'faculty' of imagination see below, 20.

the planets were accounted for by assuming additional circular motions superimposed upon the uniform daily rotation. The 'fixed' stars were thus regarded as being carried round by the rotation of the 'celestial sphere' whose axis, since many of them periodically 'rose' in the east and 'set' in the west, was held to be variously inclined to the surface of the Earth. Contrary to the belief still held in some quarters, the 'flat Earth' had been generally abandoned about a century earlier, and, though reintroduced to conform to biblical cosmology, was probably never again seriously considered among men having any pretension to astronomical knowledge.

Since the Sun and Moon are seen to make a circuit of the stellar sphere once in roughly 365 and 29 days respectively, the motion of each was regarded as being compounded of that of the stellar sphere and that of a second sphere whose axis was inclined to that of the stellar; in the case of the Sun the 'equator' of the second sphere was called the 'ecliptic', and the latter's 'obliquity' represents the observed progressive changes in the Sun's altitude in the course of the year. A third sphere had to be added to account for a further minor irregularity in the observed motion. The Moon's observed motion resisted any adequate representation; it was one of the few problems that gave Newton a headache 2,000 years later.

The motions of the remaining 'planets' were partially accounted for by supposing them to share the daily and (approximate) annual motion of the Sun's two spheres—the third was peculiar to the Sun. But these five bodies—and very obviously those that were believed to be always further from the Earth than is the Sun—possessed a characteristic irregularity of apparently coming to a halt, and then roughly retracing their paths to a second point before once more proceeding in the general direction. These meaningless 'stations' and 'retrogradations' of each of these planets were 'saved' by the ingenious device of 'fixing' each planet on a sphere, the poles of whose axis were also 'fixed' on the surface of the surrounding sphere to whose axis their axes were inclined; and at the same time supposing them to rotate in the opposite sense, each at a characteristic rate different from that of the surrounding sphere. The process could be repeated, and the inclinations and relative rates of rotation varied, to give the closest possible approximation to the 'appearances'.

All this is set out by Smith with only relatively minor historical inaccuracies; but he does not here make clear that the 'constant and equable motions' reported by reliable commentators to have been demanded by Plato were in fact uniform angular motion in perfectly circular paths. Nor, though he has his own view as to the human urge to see coherence and a continuous chain in natural phenomena, does he comment on Plato's postulates in flat opposition to the evidence of the senses, except in respect of the daily revolution. Plato discussed these questions in several dialogues, and his final 'vision' of the cosmos (if he did in fact ever arrive at one) is still a matter of controversy. But his guiding principle, from which he made no fundamental departure, was that the 'visible' heavens have the same relation to 'things divine' as they really exist as do geometrical figures to those 'truths of reason' that they are made to represent.

In proceeding from the concentric systems of Eudoxus to the excentric (and epicyclic) systems that permanently superseded it among the Greeks, Smith missed two points of fundamental importance to his 'principles that lead and direct' philosophical investigation. The first was that Aristotle's addition of twenty-two spheres had nothing to do with the 'insufficiency' of the spheres to represent the motions; the reason was what we should call a philosophical demand for a physical coherence: the additional spheres were so intercalated as to prevent the characteristic motion of each of the planets from being transmitted to the remainder. Another serious physical discrepancy apparently first observed by Autolycus of Pitane but not by Aristotle, was the fact that no system of spheres concentric with the Earth could conceivably account for the marked changes in the apparent size of e.g. Mars and Venus, implying variation in their distances from the Earth. The contrast between 'astronomy' and 'physics' sketched by Aristotle, well known to the Middle Ages and Renaissance through the *Commentaries* of Simplicius, but apparently lost sight of later until stressed by Paul Duhem in his *Σώζειν τὰ φαινόμενα*, will be discussed more at large in the Introduction to the Ancient Physics.

The first step towards the epicyclic (and incidentally towards the Copernican) theory of planetary motion was taken by Heracleides of Pontus, who, noting the fact that neither Mercury nor Venus is ever seen far from the Sun as the latter makes its annual circuit of the heavens, put forward the hypothesis that the circular paths of the former bodies were centred at the Sun, not the Earth. A century later, when Alexandria had replaced Athens as the centre of 'Greek' culture, this hypothesis was extended by Aristarchus of Samos to include *all* the planets, of which he regarded the Earth instead of the Sun to be one. This revolutionary hypothesis, in which the diurnal rotation of the Earth (already assumed by Heracleides) was also adopted, was summarily rejected by his contemporaries. Nevertheless, since their imaginative leaps achieved the essential basis of that of Copernicus, the omission by Smith of any mention of these two men is quite unaccountable.

Though no motion of the Earth was acceptable to astronomers until the time of Copernicus, and even then but tardily, the concept of epicyclic motion (i.e. the circular motion of a body about another body itself describing a circle about a third) rapidly achieved a dominating influence and received a definitive form in the *Almagest* of Ptolemy (*c.* A.D. 150). Stripped down to the barest essentials this system was based on the following postulates:

(i) The Earth is the 'centre' of the world.
(ii) The Sun moves at a uniform rate on a circle (the 'eccentric') whose centre is somewhat distant from the Earth.
(iii) The remaining planets (except the Moon) move on circles (epicycles) whose centres move on larger circles ('deferents') centred at the eccentric; but the planets themselves are represented as moving at a uniform rate round a separate point ('equant') on the side of the eccentric remote from the Earth.
(iv) The Moon's motion is especially anomalous.

The eccentric and epicycle had been elaborated by earlier astronomers, notably Hipparchus (*c.* 170 B.C.), but the equant point, concerned not with the shape but with the rate of planetary movement, was the creation of Ptolemy himself. Since their concern was to provide a mathematical model for forecasting celestial events, the Alexandrian (Hellenistic) astronomers took no account of the existence of 'spheres'. The later Islamic astronomers, strongly influenced by Aristotelian and later 'physics', devised means of harmonizing epicyclic and eccentric motion with concentric celestial spheres. This mode of thought achieved its ultimate refinement in the theory of Georg (of) Peurbach. The so-called 'Copernican Revolution' was in fact a retrogression to 'ancient' principles buttressed by superior mathematical technique and the less 'parochial' world-view characteristic of the Renaissance. Far from being technically 'modern', the system of Copernicus was in some respects retrograde in the pejorative sense; this judgement does not detract from the dedication and intellectual courage of the man himself.

By one of those paradoxes that the history of science displays from time to time, Tycho Brahe, 'the great restorer of the science of the heavens' as Smith describes him, spent his life and fortune (aided by royal patronage on a lavish scale) in assembling the data enabling Ioannes Kepler to demolish both his own extension of the system of Heracleides and the details of the Copernican system. Tycho's model, postulating a heliocentric system of all the planets, the Sun and Moon alone describing circles about the Earth, was mathematically equivalent to that of Copernicus, at the same time avoiding any affront to the physical prejudices of the age, still predominantly Aristotelian. Endowed with a spirit in which intense religious feeling, high poetic fancy, and unswerving intellectual integrity were combined to a degree probably unsurpassed in any man before or since, Kepler made the first and final break with the Platonic postulates of 'equable circular motion' for celestial bodies. It is the Sun, not the Earth, around which the planets describe the only discoverable simple curve—not a circle, but an ellipse; and it is the Sun that determines, in a degree corresponding to the harmonics of the diatonic scale, the speed with which they move in the paths appointed by God. Stripped of the overtones that Kepler himself regarded as his supreme act of praise to the living God, his three[6] 'laws' are the basis of the modern astronomy of the solar system.

Within the limits of the available knowledge Smith's account of the revolution in astronomical thought effected by Copernicus, Tycho Brahe, and Kepler displays remarkable understanding; there is however one misleading feature in his exposition—the statements (Astronomy, IV.29,32) that the Copernican system has no need of epicycles. It is indeed true that each of these statements is made in the context of the apparent shape of the planetary motions, but not many paragraphs later it is made clear that in order to rid his system of the 'incoherence' of the equant point (IV.53) Copernicus had in fact been compelled to employ a number of epicycles. One of Kepler's earliest discoveries was that the motion of the Earth demanded just such an equant point: it is of course a mathematical dodge to represent the hitherto 'unthinkable' fact that the planets move faster when near the Sun than when more remote. Smith's account is further notable for having stressed the possibly decisive nature of Galileo's telescopic observations—the 'rough' surface of the Moon, the satellites of Jupiter, sunspots, and the phases of Venus—all phenomena that could 'appeal to a wide audience', thus enlisting a wider support for the Copernican hypothesis than Copernicus's own dry mathematical exposition would have done. Smith's claim that the latter 'was adopted . . . by astronomers only' (IV.36), though qualified on the next page, gives a misleading impression of the situation. This and some relatively minor points are more conveniently dealt with in footnotes to the text.

The confused state of astronomy during the first half of the seventeenth century was just such as to give point to Smith's 'principle' that discovery is the fruit of a search for a 'connecting

[6] Really four: the first, the demonstration that the planets' orbits, including the Earth's, are co*planar* with the Sun is unaccountably omitted from the 'text-books'. Kepler himself never set out the laws in any systematic form.

chain of intermediate objects to link together . . . discordant qualities' (IV.60)—in this case the immensity of the celestial bodies and the hardly conceivable speeds with which they are hurled round the Sun. The 'gap' left in the 'imagination' by a purely mathematical model, however subtle and however accurately representative of the facts, received expression in the full title of Kepler's *Astronomia Nova.* The 'physical or if you will metaphysical' element in his system was supplied by a supposed magnetic 'radiation' emitted by the Sun as it rotated, thus maintaining the revolutions of the planets at varying speeds. 'That doctrine,' wrote Smith, 'like almost all those of the philosophy in fashion during his time, bestowed a name upon this invisible chain, called it an immaterial virtue, but afforded no determinate idea of what was its nature.' (Astronomy, IV.60.) In an age dominated by Newton's proper rejection of 'occult causes' such a reaction was inevitable. But it is not the whole story. Kepler's 'magnetic virtue' was more than a name; in fact magnetism was not, in the distinction made by Newton, an 'occult' but a 'manifest' quality. The fact that it is a different 'manifest' quality—gravitation—that was later shown to be the controlling factor between Sun and planets does not detract from Kepler's recognition that a 'chain' must exist. In his second letter to Richard Bentley, Newton emphasized that 'the cause of gravity is what I do not pretend to know'. Smith and his clear-sighted contemporaries failed to realize that the greatest creative advances in the search for the 'invisible chain' have seldom been free from the wildest guesses.

The 'first who attempted to ascertain, precisely, wherein this invisible chain consisted, and to afford the imagination a train of intermediate events, . . .' was, Smith justly states, Descartes (Astronomy, IV.61). The details of the Cartesian system fortunately do not concern us. But Smith shows remarkable sagacity in emphasizing that it was he (and not, as is still occasionally stated, Galileo) who stated three propositions that jointly imply 'Newton's' First Law of Motion; that his notion of God's conservation of the quantity of motion in the universe (IV. 61) made a notable advance towards Newton's Second Law; and that he was 'among the first of the moderns, who . . . took away the boundaries of the Universe'. Not surprisingly Smith nowhere shows any knowledge of the wide-ranging mathematical speculation of the fifteenth-century Cardinal Nicholas of Cues (whom Kepler called 'divine'), nor of the limited publication of Thomas Digges's theory of stellar distribution in depth; but his omission of any reference to the ill-supported but widely publicized 'plurality of worlds' affirmed by Giordano Bruno is less easy to excuse.

His lengthy treatment of Descartes in a history of astronomy, Smith claims, is justified less by his theory of the heavens that by the time Smith was writing was almost entirely abandoned, than by his demonstration that a coherent 'system of the world' could be based on simple mechanical principles applicable to both celestial and terrestrial bodies. This was a radical departure from the 'natural philosophy' still dominant in the schools: Samuel Pepys was so 'vexed' to discover that his younger brother, John's, knowledge of 'physiques' was based on Descartes instead of Aristotle that he decided to find out 'what it is that he has studied since his going to the University'. So far as 'physiques' were concerned both Samuel and John were wasting their time; for in the same year a young sizar of Trinity College in the same university of Cambridge was also giving less than satisfaction in his undergraduate studies. But within three years he was to think of 'extending gravity to the orbe of the Moon'. Cambridge was slow to appreciate the tremendous revolution that the young Lucasian Professor of Mathematics proceeded to hatch within its walls; but a few years after its publication (1687—under the imprimatur of Samuel Pepys P.R.S.!) the elements of Newton's *Philosophiae Naturalis Principia Mathematica* were being introduced to the students of the University of Edinburgh by David Gregory.

Despite the lack of any break in the narrative, it seems most probable that it was at this point (Astronomy, IV.67) that Smith's original manuscript ended and the remainder was added at some later date (above, 7–8).

About Smith's account of the Newtonian system, which, despite his doubts, stands least in need of correction at the present day, little need be said. It is clearly written and includes all the 'verifications' available by the middle of the eighteenth century. It is doubtful whether he had ever studied the *Principia* at that time. Voltaire's *Elemens de la philosophie de Neuton* had been published in London by 1737, and, if this section was in fact written some years after the rest of the essay, Colin Maclaurin's *Account of Sir Isaac Newton's Philosophical Discoveries* would have been available to him after 1748; of course he may have been sufficiently well grounded in the qualitative aspects before leaving Glasgow. The only disconcerting feature of his account, taken as a contribution to the 'principles of philosophical investigation', is the facile manner in which he accepts gravitation as an adequate *explanation* of the mutually determined motions of the celestial bodies, simply on the grounds that it has always been 'familiar' to men on the Earth. Taken in conjunction with his remarks (Astronomy, IV.61) in hailing Descartes as having been the first to attempt to 'ascertain, precisely, wherein this invisible chain consisted', this must be regarded as a serious deficiency. It betrays a strange lack of awareness of the fact that what he saw as 'so familiar a principle of connection, which completely removed all the difficulties the imagination had hitherto felt in attending to them [sc. planetary motions]' (IV.67), many continental 'philosophers', notably Leibniz, regarded as either a miracle or a blasphemy. The root of their objections was that celestial gravitation, unlike the 'familiar' form, must be held to act instantaneously across immense distances. Moreover, since the planets showed no sign of slowing down as a result of external resistance, there could be no material medium to transmit the gravitational influence. Such an 'action at a distance' must be regarded as either an inexplicable miracle or an 'occult' property of matter itself. Neither 'solution' was acceptable: not the former, since it removed the question entirely from the realm of natural philosophy; nor the latter, since it reintroduced the 'specific occult qualities' postulated by the Aristotelians, which as Newton himself later remarked 'put a stop to the improvement of natural philosophy' (*Opticks*, Q.30). This fundamental dilemma, and much else of a more technical nature, was ventilated in the famous *Leibniz–Clarke Correspondence* first published in 1707. Newton, on whose behalf (and at the instigation of Princess Caroline) Clarke replied to Leibniz, showed his recognition of the difficulties by adding to the second edition of the *Principia* (1713) the famous General Scholium containing the even more famous (and misunderstood) phrase 'Hypotheses non fingo', and by his letters to the Master of Trinity, Richard Bentley, in one of which he explicitly denied that gravity is 'essential and inherent to matter'. Newton was fully aware of the lack of finality in his 'System of the World' and returned to the question several times; but since Smith was apparently unaware of this, it would be inappropriate to enter into the inevitably long and difficult discussion here.

### *The History of the Ancient Physics and the History of the Ancient Logics and Metaphysics*

The History of Astronomy, though naturally imperfect, was in a sense complete. After the second edition of Newton's *Principia* there was no fundamental change or addition to the 'system of the world', that was Smith's main concern, until long after his death. The mathematical theory was under constant refinement; and Smith shows his continuing interest in the progress of physical astronomy when in the *Edinburgh Review* article he refers to James Bradley's important discovery of the aberration of light. But the titles of the two subsequent essays suggest that the restriction to the 'ancient' period expressed the fact that he had said all that he intended to say.

The two essays now to be considered, though like that on the History of Astronomy both written with an eye to 'philosophical investigation', are in a different class from the first. The title of each reveals a subtle change of aim: the histories of these 'sciences' are to be restricted to their 'ancient' development. For this and other reasons that will appear during the discussion it is convenient to introduce them under a single heading. To a greater extent than in the 'history' of astronomy his account of the 'facts' of pre-Socratic 'physics' is not only without adequate historical foundation but lacks any historical coherence other than that imposed by Smith's own 'likely story', namely that 'from arranging and methodizing the System of the Heavens, Philosophy descended to the consideration of the inferior parts of Nature' (Ancient Physics, 1). There neither is, nor ever was, as far as we know, any evidence for this order of inquiry; on the contrary, Aristotle rightly referred to his predecessors as φυσιολόγοι—those who strove to 'account for nature', which for them was the whole cosmos. Their speculations about the objects above the Earth in fact lacked any 'arrangement or methodizing': they remained crude and ill-supported by reason. The views on the 'elements' (ἀρχαί, Aristotle calls them), on the other hand, put forward separately by the Ionian pioneers embodied a profound insight into the problem of the relation between change and the permanent ground of being. Only later did the Italian, Empedocles, order the elements in such a manner as to make possible the even later 'square of opposite properties' introduced by Aristotle.

As has been hinted already, Smith never made explicit the cardinal distinction between 'physics' and 'astronomy'—a distinction that in fact 'guided and directed philosophical enquiry' from Aristotle onwards, and which, in somewhat altered terms, is still a living issue in the philosophy of science, notably in the interpretation of quantum mechanics. The basic formulation has never been more clearly put than by the sixth-century Neoplatonist, Simplicius, in his commentary on Aristotle's *Physics*, and in which he claims to be quoting the actual words of Geminus summarizing the views of the Stoic Poseidonius, both of them having lived much nearer to the time of Aristotle. After a long and detailed preamble he emphasized that while 'the physicist will in many cases, reach the cause by looking to creative force', 'it is no part of the business of the astronomer to know what is by nature suited to a position of rest and what sort of bodies are apt to move, but he introduces hypotheses under which some bodies remain fixed while others move, and then considers to which hypotheses the phenomena actually observed in the heaven will correspond'.[7] The astronomer, in other words, is satisfied if, given certain physical postulates, such as 'equable motion', he can devise a mathematical scheme from which the motions of the heavenly bodies can be deduced; the question of 'truth' has for him, *qua* astronomer, no relevance. In the History of Astronomy (notably in the introductory Section II) Smith shows his appreciation of this aspect of 'philosophical investigation'. But his failure to explicate the notion of *cause*, latent in the various pre-Socratic speculations and dominating Aristotle's whole philosophy, reduces his Ancient Physics, despite its elegant and persuasive presentation of certain aspects, to a much lower level of cogency. Detailed justification for this judgement would here be out of place; suffice it to say that the reader of the text will find no hint of the pervasive notion of final causation and the grades of 'animation' (the Latin *anima* replaced ψυχή in the transmission of the Aristotelian corpus) in living beings.

Having momentarily forgotten his most promising hypothesis that 'philosophical enquiries' stem from 'surprise and wonder' Smith opens the essay on the 'History of the Ancient Logics and Metaphysics' with a liberal application of the term 'evident' to assumptions that to thinkers in another tradition seem far from evident. This apart, however, he rightly insists that 'philosophy, . . . in considering the general nature of Water, takes no notice of those particularities which are peculiar to this Water, but confines itself to those things which are common to all water'. From which it follows that 'Species, or Universals, and not Individuals, are the objects of Philosophy' (§ 1). In the succeeding passage, amounting to little more than twenty lines, Smith condenses all that he has to say on the relation between the 'ancient' sciences of 'logics' and 'metaphysics'. Restricted to such a compass his account of what came to be regarded as 'logic' and 'metaphysics' might do well enough, though the exclusive emphasis on classification is hardly warranted. But viewed as a stage in the achievement of his historical aim it is quite inadequate. In claiming with some justice that these two sciences 'seem, before the time of Aristotle, to have been regarded as one' and, with less justice, 'to have made up between them that ancient Dialectic of which we hear so much, and of which we understand so little' (Ancient Logics, 1) Smith gives no hint that λογική and its derivatives covered a huge range of meaning as much to do with 'words' as with 'reasoning'; nor that the term 'metaphysics' came only long after Aristotle's death to refer to those of his books which

[7] Quoted from T. Heath, *Greek Astronomy* (1932), 124–5.

embodied a consideration of 'those causes and principles the knowledge of which constitutes Wisdom'—'First philosophy' as Aristotle himself described it. The throw-away comment on the 'ancient Dialectic' may have been prompted by Smith's native caution: the subtle and even inconsistent use of the term by Plato and Aristotle is still the subject of scholarly debate. The inappropriateness of the remark becomes even more remarkable in the light of the following *definition* proposed by the Stranger from Elea: 'Dividing according to kinds, not taking the same Form for a difference or a different one for the same—is not that the business of the science of Dialectic?' (Plato, *Sophist*, 253 D.) This 'division by kinds' is precisely the method that Smith himself regarded as being the essence of the 'ancient logics' and one of which he himself makes frequent use. This account of dialectic differs from the more basic requirement stipulated by Socrates (i.e. the effort to attain truth by correction of agreed hypotheses rather than the confutation of an adversary) but is not inconsistent with it. Equally regrettable is Smith's failure to make clear, as Aristotle had, that the pre-Socratic φυσιολόγοι (as Aristotle calls them) were asking 'metaphysical' questions but for the most part (Parmenides being clearly an exception) giving 'physical' answers.

The part of the essay devoted to an exposition of Plato's attitude to Nature and its relation to the general theory of 'Ideas', though disproportionately long, is almost the only part that carries conviction that the author had adequately prepared himself for the ambitious task he had undertaken. But even here he fails to drive home the lesson, so important for his own thesis, that what Plato was for the most part concerned with, even in the dialogue that looks like natural philosophy, the *Timaeus*, is perhaps not even metaphysics, but rather natural theology as it was perhaps understood in the original scheme for the Gifford Lectures. This was far from being without influence on the development of natural philosophy and subsequently of the natural sciences; but by placing 'cause and principle' of nature as it were outwith nature and providing only a 'likely story' of how it (δημιουργός) might have operated, Plato effectively closed the door on further investigation on the lines initiated by the φυσιολόγοι. Or rather he would have closed it, had not his independent-minded pupil, Aristotle, put his foot in the doorway—at least for the sublunary world!

At this stage some readers may reasonably protest that it is an editor's function at most to comment on the text and not to argue with its author. To leave without qualification the rather disparaging remarks which this editor has felt it necessary to make would amount to a failure to view the matter in that historical perspective for the lack of which Smith has been censured. Well versed in the classical tongues as the young Adam Smith undoubtedly was, he cannot be blamed for having failed to transcend the limitations set by the materials available to him. And these were meagre indeed, for though we may think of the eighteenth century as one in which classical scholarship was most highly appreciated and familiarity with the classical authors more widely spread than perhaps at any other time, it is apt to be forgotten that both scholarship and familiarity were almost wholly restricted to grammatical and stylistic aspects; it is probable that Smith's contemporaries were far less conversant with the *matter* of the Greek classics than had been the humanists of three centuries earlier. In his valuable *Greek Studies in England, 1700–1830* (1945) (which in fact includes a knowledgeable chapter on Scotland) M. L. Clarke states that 'the undergraduates at Oxford and Cambridge read only a few isolated dialogues of Plato and learned nothing of his philosophical theories'. Before 1759 there was no English translation, except of the *Phaedo*, to which the Scottish scholar, Spens, added the *Republic* only in 1763. Aristotle was in like case. Smith's dismissal (Astronomy, III.6) of the Ionian φυσιολόγοι on the ground that the extant accounts 'represent the doctrines of those sages as full of the most inextricable confusion' is of a piece with Clarke's judgement that 'of the remarkable speculations of the pre-Socratics there was no appreciation' (op. cit., 114); he would have had to rely upon Aristotle's biased views put forward in the *Metaphysics*. In respect of 'Logics' he was presumably the victim of the 'trivialization' of Aristotle's logic, unavoidable if it was to be taught to the lower end of the teenage stream! His point of view (putting 'objects' into the 'right' classes) seems to be based on the *Topics*, even perhaps mediated through Ramism; but of the structure of inference as expounded by Aristotle himself in the two *Analytics* he gives no hint. If this 'conditioning' was effected at Glasgow it would not have been unique; it is only in our time (by Jan Łukasiewicz and others) that the 'modernity' of Aristotle's canon has been made generally known. Smith was also unlucky in setting forth on this immensely ambitious endeavour at a time when Giambattista Vico's principles of critical historiography based on critical philology (*Scienza Nuova*, 1725-44) were still wholly unappreciated outside Italy. Nevertheless, when all allowance has been made for the handicaps under which Smith must have laboured when composing these 'juvenile' historical pieces, there remains an air of brashness about the two (presumably) later ones that provokes the question whether the author of the *Theory of Moral Sentiments* and the *Wealth of Nations* would have countenanced their publication in the form in which he had left them. It is true that as late as November 1785, in the letter (248) to Rochefoucauld referred to above, the 'sort of Philosophical History' he mentions as still being 'upon the anvil' must have been at least based on the 'great work' mentioned in the letter to Hume twelve years earlier. But in that letter he expressly stated that none of his papers were worth publishing except a fragment—the history of the astronomical systems—and even that one he suspected contained 'more refinement than solidity'. How much more apposite would this judgement be of the two subsequent essays! In view of his repeated request—as he neared his end—for assurance that his papers had been destroyed, it seems more than a little doubtful whether his editors were not doing his memory a disservice in making public these two essays without a more extensive caveat than the rather fulsome and misleading last sentence of their Advertisement.

# *Bibliographical Note*

The survey on which this Note has been based was restricted to the following institutions: British Library (BL), National Library of Scotland (NLS), Bodleian (O), Cambridge University (C), Trinity College, Dublin (D), and the four Scottish universities existing before the recent expansion: St. Andrews (StA), Glasgow (G), Aberdeen (A—see, however, No. 6 below), Edinburgh (E). Eight editions prior to 1900 have been established, at least one copy of each having been examined. Only NLS has a copy of every edition, two of these being accessions from the library of Lauriston Castle near Edinburgh. Thanks are due to members of the library staff at NLS, C, StA, and D for information about their holdings.

The full title-page of the First Edition is provided together with brief descriptions of the remaining editions. Only 'sample' collations have been carried out; no substantial differences in the texts have been discovered.

1. London 1795 4to. First edition. BL, NLS, O, C. StA, G, A, E.
2. Dublin 1795 8vo. Some spelling mistakes have been corrected. BL, NLS, O, C, D. Mr. M. Pollard of Trinity College Library states that the copy of this edition was purchased only in 1962; it contains the bookplate of Eliz. Anne Levinge with the signature 'Elizth. Anne Parkyns 1808' on the title-page. Mr. Pollard emphasizes that reprint by Dublin printers was perfectly legal provided that the books were not offered for sale in England.
3. *Essais philosophiques*; par feu ADAM SMITH, Docteur en droit, de la société royale de Londres, de celle d'Edimbourg, etc. etc. Précédés d'un précis de sa vie et de ses écrits; Par DUGALD STEWART, de la société royale d'Edimbourg. Traduits de l'anglais par P. Prevost, professeur de philosophie à Genève de l'académie de Berlin, de la société des Curieux de la Nature, et de la société royale d'Edimbourg. PREMIERE PARTIE. A Paris, Chez H. AGASSE, imprimeur-librairie, rue des Poitevins, no° 18. An V de la République (1797, vieux style.)

   Fine portrait bust of Adam Smith ('B.L. Prevost *sculp.*') opposite title-page.

   Of this, in some respects the most adequate, edition a rather fuller description seems to be justified. It is unique among editions before 1900 in containing Adam Smith's long letter to the

*Edinburgh Review* (1756), here in French translation, numerous notes of varying lengths by the translator and mainly relating to the later essays, also a fairly detailed Table of Contents of the whole, the *Seconde Partie* of which is separately signed and paged. The Notes are described (presumably by the publisher) as 'très intéressantes' (ii.316). Of special interest is the translator's statement (i.277) that the note on Halley's comet is de 'l'editeur anglais' (*sic*). BL, NLS.

4. Basel 1799 8vo. *Essays on Philosophical Subjects* by the late ADAM SMITH LL.D.... To which is affixed an account of the Life and Writings of the Author by DUGALD STEWART F.R.S.E. Basil: printed for the Editor of the Collection of English Classics sold by James Decker, Printer and Bookseller 1799. BL, NLS. The only point of interest in this edition is the omission of any reference to the original editors, Joseph Black and James Hutton.
5. Volume v of Adam Smith's *Works* edited by Dugald Stewart and dated 1811 (as is vol. iv, vols. i–iii being 1812). Vol. v also contains the essay entitled *Considerations concerning the first Formation of Languages.* BL, NLS, O.
6. *Essays on Philosophical Subjects* by Adam Smith LL.D., F.R.S. etc. London 1822. A new edition.
   This apparently very rare edition was printed (title-page verso) by A. Allardice, Leith, for Allardice, Edinburgh; R. Griffin, Glasgow; and several London houses. The copy examined is inscribed 'Biblioth. Classis Physicae in Acad. Mariscallana' and stamped 'Nat. Phil. Clas. Library 1860 University of Aberdeen', i.e. on the union of King's and Marischal Colleges, previously separate universities. NLS. A.
7. London 1869 8vo. *Essays.* The volume is in fact a reprint of both TMS (followed, as usual, by Languages) and EPS. The 'Biographical Notice' is drastically abridged. BL, O, C, StA.
8. London 1880 8vo. *Essays Philosophical and Literary.* Stated in BL catalogue to be a 'duplicate' of No. 7. BL, NLS, O, C, StA.
9. The Essays are included in *The Early Writings of Adam Smith* edited by J. R. Lindgren (Augustus M. Kelley, New York 1967). This edition includes the *Edinburgh Review* articles, the Preface to William Hamilton's *Poems on Several Occasions* (1748), and the Languages. It is not introduced or annotated.

### *Note on the Text*

The present volume follows the text of the first edition (published by Cadell and Davies in 1795, five years after Smith's death), but with printer's errors corrected. Since the essay is designed to illustrate 'the principles which lead and direct philosophical enquiries' rather than to provide a history of astronomy *per se*, no attempt has been made to achieve that completeness of documentation which would be appropriate in a definitive classic.

# THE PRINCIPLES WHICH LEAD AND DIRECT PHILOSOPHICAL ENQUIRIES; ILLUSTRATED BY THE HISTORY of ASTRONOMY

# ADVERTISEMENT

## By the EDITORS

The much lamented Author of these Essays left them in the hands of his friends to be disposed of as they thought proper, having immediately before his death destroyed many other manuscripts which he thought unfit for being made public.[1] When these were inspected, the greater number of them appeared to be parts of a plan he once had formed, for giving a connected history of the liberal sciences and elegant arts. It is long since he found it necessary to abandon that plan as far too extensive; and these parts of it lay beside him neglected until his death. His friends are persuaded however, that the reader will find in them that happy connection, that full and accurate expression, and that clear illustration which are conspicuous in the rest of his works; and that though it is difficult to add much to the great fame he so justly acquired by his other writings, these will be read with satisfaction and pleasure.

JOSEPH BLACK
JAMES HUTTON

[1] Details of the executry are given in Stewart, V.8 and note; Rae, *Life*, chap. 32.

# THE HISTORY OF ASTRONOMY

1 Wonder, Surprise, and Admiration, are words which, though often confounded, denote, in our language, sentiments that are indeed allied, but that are in some respects different also, and distinct from one another. What is new and singular, excites that sentiment which, in strict propriety, is called Wonder; what is unexpected, Surprise; and what is great or beautiful, Admiration.

2 We wonder at all extraordinary and uncommon objects, at all the rarer phaenomena of nature, at meteors, comets, eclipses, at singular plants and animals, and at every thing, in short, with which we have before been either little or not at all acquainted; and we still wonder, though forewarned of what we are to see.

3 We are surprised at those things which we have seen often, but which we least of all expected to meet with in the place where we find them; we are surprised at the sudden appearance of a friend, whom we have seen a thousand times, but whom we did not imagine we were to see then.

4 We admire the beauty of a plain or the greatness of a mountain, though we have seen both often before, and though nothing appears to us in either, but what we had expected with certainty to see.

5 Whether this criticism upon the precise meaning of these words be just, is of little importance. I imagine it is just, though I acknowledge, that the best writers in our language have not always made use of them according to it. Milton, upon the appearance of Death to Satan, says, that

> The Fiend what this might be admir'd;
> Admir'd, not fear'd.[1]——

But if this criticism be just, the proper expression should have been *wonder'd*.—Dryden, upon the discovery of Iphigenia sleeping, says, that

> The fool of nature stood with stupid eyes
> And gaping mouth, that testified surprise.[2]

[1] [*Paradise Lost*, ii.677–8, but Milton wrote 'Th' undaunted Fiend . . .'.]
[2] ['Cymon and Iphigenia', 107–8.]

But what Cimon must have felt upon this occasion could not so much be Surprise, as Wonder and Admiration. All that I contend for is, that the sentiments excited by what is new, by what is unexpected, and by what is great and beautiful, are really different, however the words made use of to express them may sometimes be confounded. Even the admiration which is excited by beauty, is quite different (as will appear more fully hereafter) from that which is inspired by greatness, though we have but one word to denote them.

6 These sentiments, like all others when inspired by one and the same object, mutually support and enliven one another: an object with which we are quite familiar, and which we see every day, produces, though both great and beautiful, but a small effect upon us; because our admiration is not supported either by Wonder or by Surprise: and if we have heard a very accurate description of a monster, our Wonder will be the less when we see it; because our previous knowledge of it will in a great measure prevent our Surprise.

7 It is the design of this Essay to consider particularly the nature and causes of each of these sentiments, whose influence is of far wider extent than we should be apt upon a careless view to imagine. I shall begin with Surprise.

## SECTION I

### *Of the Effect of Unexpectedness, or of Surprise*

1 When an object of any kind, which has been for some time expected and foreseen, presents itself, whatever be the emotion which it is by nature fitted to excite, the mind must have been prepared for it, and must even in some measure have conceived it before-hand; because the idea of the object having been so long present to it, must have before-hand excited some degree of the same emotion which the object itself would excite: the change, therefore, which its presence produces comes thus to be less considerable, and the emotion or passion which it excites glides gradually and easily into the heart, without violence, pain, or difficulty.[1]

2 But the contrary of all this happens when the object is unexpected; the passion is then poured in all at once upon the heart, which is thrown, if it is a strong passion, into the most violent and convulsive emotions, such as sometimes cause immediate death; sometimes, by the suddenness of the extacy, so entirely disjoint the whole frame of the imagination, that it never after returns to its former tone and composure, but falls either into a frenzy or habitual lunacy; and such

[1] Cf. Hume, *Treatise of Human Nature*, I.i.4, 'Of the connexion or association of ideas'.

as almost always occasion a momentary loss of reason, or of that attention to other things which our situation or our duty requires.

3 How much we dread the effects of the more violent passions, when they come suddenly upon the mind, appears from those preparations which all men think necessary when going to inform any one of what is capable of exciting them. Who would choose all at once to inform his friend of an extraordinary calamity that had befallen him, without taking care before-hand, by alarming him with an uncertain fear, to announce, if one may say so, his misfortune, and thereby prepare and dispose him for receiving the tidings?

4 Those panic terrors which sometimes seize armies in the field, or great cities, when an enemy is in the neighbourhood, and which deprive for a time the most determined of all deliberate judgments, are never excited but by the sudden apprehension of unexpected danger. Such violent consternations, which at once confound whole multitudes, benumb their understandings, and agitate their hearts, with all the agony of extravagant fear, can never be produced by any foreseen danger, how great soever. Fear, though naturally a very strong passion, never rises to such excesses, unless exasperated both by Wonder, from the uncertain nature of the danger, and by Surprise, from the suddenness of the apprehension.

5 Surprise, therefore, is not to be regarded as an original emotion of a species distinct from all others. The violent and sudden change produced upon the mind, when an emotion of any kind is brought suddenly upon it, constitutes the whole nature of Surprise.

6 But when not only a passion and a great passion comes all at once upon the mind, but when it comes upon it while the mind is in the mood most unfit for conceiving it, the Surprise is then the greatest. Surprises of joy when the mind is sunk into grief, or of grief when it is elated with joy, are therefore the most unsupportable. The change is in this case the greatest possible. Not only a strong passion is conceived all at once, but a strong passion the direct opposite of that which was before in possession of the soul. When a load of sorrow comes down upon the heart that is expanded and elated with gaiety and joy, it seems not only to damp and oppress it, but almost to crush and bruise it, as a real weight would crush and bruise the body. On the contrary, when from an unexpected change of fortune, a tide of gladness seems, if I may say so, to spring up all at once within it, when depressed and contracted with grief and sorrow, it feels as if suddenly extended and heaved up with violent and irresistible force, and is torn with pangs of all others most exquisite, and which almost always occasion faintings, deliriums, and sometimes instant death. For it may be worth while to observe, that though grief be a more violent

passion than joy, as indeed all uneasy sensations seem naturally more pungent than the opposite agreeable ones, yet of the two, Surprises of joy are still more insupportable than Surprises of grief. We are told[2] that after the battle of Thrasimenus, while a Roman lady, who had been informed that her son was slain in the action, was sitting alone bemoaning her misfortunes, the young man who escaped came suddenly into the room to her, and that she cried out and expired instantly in a transport of joy. Let us suppose the contrary of this to have happened, and that in the midst of domestic festivity and mirth, he had suddenly fallen down dead at her feet, is it likely that the effects would have been equally violent? I imagine not. The heart springs to joy with a sort of natural elasticity, it abandons itself to so agreeable an emotion, as soon as the object is presented; it seems to pant and leap forward to meet it, and the passion in its full force takes at once entire and complete possession of the soul. But it is otherways with grief; the heart recoils from, and resists the first approaches of that disagreeable passion, and it requires some time before the melancholy object can produce its full effect. Grief comes on slowly and gradually, nor ever rises at once to that height of agony to which it is increased after a little time. But joy comes rushing upon us all at once like a torrent. The change produced therefore by a Surprise of joy is more sudden, and upon that account more violent and apt to have more fatal effects, than that which is occasioned by a Surprise of grief; there seems too to be something in the nature of Surprise, which makes it unite more easily with the brisk and quick motion of joy, than with the slower and heavier movement of grief. Most men who can take the trouble to recollect, will find that they have heard of more people who died or became distracted with sudden joy, than with sudden grief. Yet from the nature of human affairs, the latter must be much more frequent than the former. A man may break his leg, or lose his son, though he has had no warning of either of these events, but he can hardly meet with an extraordinary piece of good fortune, without having had some foresight of what was to happen.

7 Not only grief and joy but all the other passions, are more violent, when opposite extremes succeed each other. Is any resentment so keen as what follows the quarrels of lovers, or any love so passionate as what attends their reconcilement?

8 Even the objects of the external senses affect us in a more lively manner, when opposite extremes succeed to, or are placed beside each other. Moderate warmth seems intolerable heat if felt after extreme cold. What is bitter will seem more so when tasted after what is very sweet; a dirty white will seem bright and pure when placed by

[2] [Livy, XXII.7.13.]

a jet black. The vivacity in short of every sensation, as well as of every sentiment, seems to be greater or less in proportion to the change made by the impression of either upon the situation of the mind or organ; but this change must necessarily be the greatest when opposite sentiments and sensations are contrasted, or succeed immediately to one another. Both sentiments and sensations are then the liveliest; and this superior vivacity proceeds from nothing but their being brought upon the mind or organ when in a state most unfit for conceiving them.

9 As the opposition of contrasted sentiments heightens their vivacity, so the resemblance of those which immediately succeed each other renders them more faint and languid. A parent who has lost several children immediately after one another, will be less affected with the death of the last than with that of the first, though the loss in itself be, in this case, undoubtedly greater; but his mind being already sunk into sorrow, the new misfortune seems to produce no other effect than a continuance of the same melancholy, and is by no means apt to occasion such transports of grief as are ordinarily excited by the first calamity of the kind; he receives it, though with great dejection, yet with some degree of calmness and composure, and without any thing of that anguish and agitation of mind which the novelty of the misfortune is apt to occasion. Those who have been unfortunate through the whole course of their lives are often indeed habitually melancholy, and sometimes peevish and splenetic, yet upon any fresh disappointment, though they are vexed and complain a little, they seldom fly out into any more violent passion, and never fall into those transports of rage or grief which often, upon the like occasions, distract the fortunate and successful.

10 Upon this are founded, in a great measure, some of the effects of habit and custom. It is well known that custom deadens the vivacity of both pain and pleasure, abates the grief we should feel for the one, and weakens the joy we should derive from the other. The pain is supported without agony, and the pleasure enjoyed without rapture: because custom and the frequent repetition of any object comes at last to form and bend the mind or organ to that habitual mood and disposition which fits them to receive its impression, without undergoing any very violent change.

## SECTION II

### *Of Wonder, or of the Effects of Novelty*

1 It is evident that the mind takes pleasure in observing the resemblances that are discoverable betwixt different objects. It is by

means of such observations that it endeavours to arrange and methodise all its ideas, and to reduce them into proper classes and assortments. Where it can observe but one single quality, that is common to a great variety of otherwise widely different objects, that single circumstance will be sufficient for it to connect them all together, to reduce them to one common class, and to call them by one general name. It is thus that all things endowed with a power of self-motion, beasts, birds, fishes, insects, are classed under the general name of Animal; and that these again, along with those which want that power, are arranged under the still more general word Substance: and this is the origin of those assortments of objects and ideas which in the schools are called Genera and Species, and of those abstract and general names, which in all languages are made use of to express them.[1]

2 The further we advance in knowledge and experience, the greater number of divisions and subdivisions of those Genera and Species we are both inclined and obliged to make. We observe a greater variety of particularities amongst those things which have a gross resemblance; and having made new divisions of them, according to those newly-observed particularities, we are then no longer to be satisfied with being able to refer an object to a remote genus, or very general class of things, to many of which it has but a loose and imperfect resemblance. A person, indeed, unacquainted with botany may expect to satisfy your curiosity, by telling you, that such a vegetable is a weed, or, perhaps in still more general terms, that it is a plant. But a botanist will neither give nor accept of such an answer. He has broke and divided that great class of objects into a number of inferior assortments, according to those varieties which his experience has discovered among them; and he wants to refer each individual plant to some tribe of vegetables, with all of which it may have a more exact resemblance, than with many things comprehended under the extensive genus of plants. A child imagines that it gives a satisfactory answer when it tells you, that an object whose name it knows not is a thing, and fancies that it informs you of something, when it thus ascertains to which of the two most obvious and comprehensive classes of objects a particular impression ought to be referred; to the class of realities or solid substances which is calls *things*, or to that of appearances which it calls *nothings*.

3 Whatever, in short, occurs to us we are fond of referring to some species or class of things, with all of which it has a nearly exact resemblance; and though we often know no more about them than

[1] [Similar points are made in Languages, 1–2; cf. LRBL i.17–19 (ed. Lothian, 7–8).]

about it, yet we are apt to fancy that by being able to do so, we show ourselves to be better acquainted with it, and to have a more thorough insight into its nature. But when something quite new and singular is presented, we feel ourselves incapable of doing this. The memory cannot, from all its stores, cast up any image that nearly resembles this strange appearance. If by some of its qualities it seems to resemble, and to be connected with a species which we have before been acquainted with, it is by others separated and detached from that, and from all the other assortments of things we have hitherto been able to make. It stands alone and by itself in the imagination, and refuses to be grouped or confounded with any set of objects whatever. The imagination and memory exert themselves to no purpose, and in vain look around all their classes of ideas in order to find one under which it may be arranged. They fluctuate to no purpose from thought to thought, and we remain still uncertain and undetermined where to place it, or what to think of it. It is this fluctuation and vain recollection, together with the emotion or movement of the spirits[2] that they excite, which constitute the sentiment properly called *Wonder*, and which occasion that staring, and sometimes that rolling of the eyes, that suspension of the breath, and that swelling of the heart, which we may all observe, both in ourselves and others, when wondering at some new object, and which are the natural symptoms of uncertain and undetermined thought. What sort of a thing can that be? What is that like? are the questions which, upon such an occasion, we are all naturally disposed to ask. If we can recollect many such objects which exactly resemble this new appearance, and which present themselves to the imagination naturally, and as it were of their own accord, our Wonder is entirely at an end. If we can recollect but a few, and which it requires too some trouble to be able to call up, our Wonder is indeed diminished, but not quite destroyed. If we can recollect none, but are quite at a loss, it is the greatest possible.

4 With what curious attention does a naturalist examine a singular plant, or a singular fossil, that is presented to him? He is at no loss to refer it to the general genus of plants or fossils; but this does not satisfy him, and when he considers all the different tribes or species of either with which he has hitherto been acquainted, they all, he thinks, refuse to admit the new object among them. It stands alone in

[2] The notion of 'spirits' associated with material bodies has a long and highly complex history (see, e.g., W. Pagel, *Das medizinische Weltbild des Paracelsus* (1962), under 'Geist' and 'Spiritus' in index). Smith seems here to be assuming some kind of para-material stuff such as Descartes had supposed to flow in the 'hollow' nerves and to 'interact with' the 'extensionless soul' in the unpaired pineal gland in the brain. Cf. Hume, *Treatise*, I.ii.5 (ed. L. A. Selby-Bigge, 61): 'these spirits always excite the idea ...'.

his imagination, and as it were detached from all the other species of that genus to which it belongs. He labours, however, to connect it with some one or other of them. Sometimes he thinks it may be placed in this, and sometimes in that other assortment; nor is he ever satisfied, till he has fallen upon one which, in most of its qualities, it resembles. When he cannot do this, rather than it should stand quite by itself, he will enlarge the precincts, if I may say so, of some species, in order to make room for it; or he will create a new species on purpose to receive it, and call it a Play of Nature, or give it some other appellation, under which he arranges all the oddities that he knows not what else to do with. But to some class or other of known objects he must refer it, and betwixt it and them he must find out some resemblance or other, before he can get rid of that Wonder, that uncertainty and anxious curiosity excited by its singular appearance, and by its dissimilitude with all the objects he had hitherto observed.

5 As single and individual objects thus excite our Wonder when, by their uncommon qualities and singular appearance, they make us uncertain to what species of things we ought to refer them; so a succession of objects which follow one another in an uncommon train or order, will produce the same effect, though there be nothing particular in any one of them taken by itself.

6 When one accustomed object appears after another, which it does not usually follow, it first excites, by its unexpectedness, the sentiment properly called Surprise, and afterwards, by the singularity of the succession, or order of its appearance, the sentiment properly called Wonder. We start and are surprised at feeling it there, and then wonder how it came there. The motion of a small piece of iron along a plain table is in itself no extraordinary object, yet the person who first saw it begin, without any visible impulse, in consequence of the motion of a loadstone at some little distance from it, could not behold it without the most extreme Surprise; and when that momentary emotion was over, he would still wonder how it came to be conjoined to an event with which, according to the ordinary train of things, he could have so little suspected it to have any connection.

7 [3]When two objects, however unlike, have often been observed to follow each other, and have constantly presented themselves to the senses in that order, they come to be so connected together in the fancy, that the idea of the one seems, of its own accord, to call up and introduce that of the other. If the objects are still observed to succeed each other as before, this connection, or, as it has been called, this

[3] The phraseology of this paragraph follows more closely that of Hume; see note 1 to Section I above.

association of their ideas, becomes stricter and stricter, and the habit of the imagination to pass from the conception of the one to that of the other, grows more and more rivetted and confirmed. As its ideas move more rapidly than external objects, it is continually running before them, and therefore anticipates, before it happens, every event which falls out according to this ordinary course of things. When objects succeed each other in the same train in which the ideas of the imagination have thus been accustomed to move, and in which, though not conducted by that chain of events presented to the senses, they have acquired a tendency to go on of their own accord, such objects appear all closely connected with one another, and the thought glides easily along them,[4] without effort and without interruption. They fall in with the natural career of the imagination; and as the ideas which represented such a train of things would seem all mutually to introduce each other, every last thought to be called up by the foregoing, and to call up the succeeding; so when the objects themselves occur, every last event seems, in the same manner, to be introduced by the foregoing, and to introduce the succeeding. There is no break, no stop, no gap, no interval. The ideas excited by so coherent a chain of things seem, as it were, to float through the mind of their own accord, without obliging it to exert itself, or to make any effort in order to pass from one of them to another.

8 But if this customary connection be interrupted, if one or more objects appear in an order quite different from that to which the imagination has been accustomed, and for which it is prepared, the contrary of all this happens. We are at first surprised by the unexpectedness[5] of the new appearance, and when that momentary emotion is over, we still wonder how it came to occur in that place. The imagination no longer feels the usual facility of passing from the event which goes before to that which comes after. It is an order or law of succession to which it has not been accustomed, and which it therefore finds some difficulty in following, or in attending to. The fancy is stopped and interrupted in that natural movement or career, according to which it was proceeding. Those two events seem to stand at a distance from each other; it endeavours to bring them together, but they refuse to unite; and it feels, or imagines it feels, something like a gap or interval betwixt them. It naturally hesitates, and, as it were, pauses upon the brink of this interval; it endeavours

[4] [A similar expression is used in Ancient Physics, 2. The idea is derived from Hume; see especially *Treatise*, I.iv.2.]

[5] Smith's approach to the problem of scientific knowledge has an interesting—perhaps vital—bearing on 'inductivism' and its denial by Sir Karl Popper and his disciples; cf. A. N. Whitehead, 'Sometimes we see an elephant and sometimes we do not', *Process and Reality* (1929), 5.

to find out something which may fill up the gap,[6] which, like a bridge, may so far at least unite those seemingly distant objects, as to render the passage of the thought betwixt them smooth, and natural, and easy. The supposition of a chain of intermediate, though invisible, events, which succeed each other in a train similar to that in which the imagination has been accustomed to move, and which link together those two disjointed appearances, is the only means by which the imagination can fill up this interval, is the only bridge which, if one may say so, can smooth its passage from the one object to the other. Thus, when we observe the motion of the iron, in consequence of that of the loadstone, we gaze and hesitate, and feel a want of connection betwixt two events which follow one another in so unusual a train. But when, with Des Cartes, we imagine certain invisible effluvia[7] to circulate round one of them, and by their repeated impulses to impel the other, both to move towards it, and to follow its motion, we fill up the interval betwixt them, we join them together by a sort of bridge, and thus take off that hesitation and difficulty which the imagination felt in passing from the one to the other. That the iron should move after the loadstone seems, upon this hypothesis, in some measure according to the ordinary course of things. Motion after impulse is an order of succession with which of all things we are the most familiar. Two objects which are so connected seem no longer to be disjoined,[8] and the imagination flows smoothly and easily along them.

9 Such is the nature of this second species of Wonder, which arises from an unusual succession of things. The stop which is thereby given to the career of the imagination, the difficulty which it finds in passing along such disjointed objects, and the feeling of something like a gap or interval betwixt them, constitute the whole essence of this emotion. Upon the clear discovery of a connecting chain of intermediate events, it vanishes altogether. What obstructed the movement of the imagination is then removed. Who wonders at the machinery of the opera-house who has once been admitted behind the scenes? In the Wonders of nature, however, it rarely happens that we can discover so clearly this connecting chain. With regard to a few

[6] [Smith is again adapting the thought of Hume in *Treatise*, I.iv.2 (ed. Selby-Bigge, 198). A similar idea that a 'gap' in a narration can be a source of discomfort is mentioned in LRBL ii.36 (ed. Lothian, 95–6).]

[7] Descartes's natural philosophy was based on the denial of empty space in the cosmos. Action at a distance was similarly ruled out, hence the necessity for postulating a 'medium'. The term 'effluvium' had already been used by W. Gilbert for the supposed 'exhalation' uniting 'electrics' (such as amber) to other bodies: he did not apply this concept to magnetic attraction. *De Magnete* (1600), Book II.

[8] To 'explain' a 'change' is to discover a means of showing that no *real* change has taken place—what E. Meyerson called 'l'identification de l'antécédent et du conséquent' (*Identité et réalité*, ed.3 (1926), xviii).

even of them, indeed, we seem to have been really admitted behind the scenes, and our Wonder accordingly is entirely at an end. Thus the eclipses of the sun and moon, which once, more than all the other appearances in the heavens, excited the terror and amazement of mankind, seem now no longer to be wonderful, since the connecting chain has been found out which joins them to the ordinary course of things. Nay, in those cases in which we have been less successful, even the vague hypotheses of Des Cartes, and the yet more indetermined notions of Aristotle, have, with their followers, contributed to give some coherence to the appearances of nature, and might diminish, though they could not destroy, their Wonder. If they did not completely fill up the interval betwixt the two disjointed objects, they bestowed upon them, however, some sort of loose connection which they wanted before.

10 That the imagination feels a real difficulty in passing along two events which follow one another in an uncommon order, may be confirmed by many obvious observations. If it attempts to attend beyond a certain time to a long series of this kind, the continual efforts it is obliged to make, in order to pass from one object to another, and thus follow the progress of the succession, soon fatigue it, and if repeated too often, disorder and disjoint its whole frame. It is thus that too severe an application to study sometimes brings on lunacy and frenzy, in those especially who are somewhat advanced in life, but whose imaginations, from being too late in applying, have not got those habits which dispose them to follow easily the reasonings in the abstract sciences. Every step of a demonstration, which to an old practitioner is quite natural and easy, requires from them the most intense application of thought. Spurred on, however, either by ambition, or by admiration for the subject, they still continue till they become, first confused, then giddy, and at last distracted. Could we conceive a person of the soundest judgment, who had grown up to maturity, and whose imagination had acquired those habits, and that mold, which the constitution of things in this world necessarily impress upon it, to be all at once transported alive to some other planet, where nature was governed by laws quite different from those which take place here; as he would be continually obliged to attend to events, which must to him appear in the highest degree jarring, irregular, and discordant, he would soon feel the same confusion and giddiness begin to come upon him, which would at last end in the same manner, in lunacy and distraction. Neither, to produce this effect, is it necessary that the objects should be either great or interesting, or even uncommon, in themselves. It is sufficient that they follow one another in an uncommon order. Let any one attempt

to look over even a game of cards, and to attend particularly to every single stroke, and if he is unacquainted with the nature and rules of the game; that is, with the laws which regulate the succession of the cards; he will soon feel the same confusion and giddiness begin to come upon him, which, were it to be continued for days and months, would end in the same manner, in lunacy and distraction. But if the mind be thus thrown into the most violent disorder, when it attends to a long series of events which follow one another in an uncommon train, it must feel some degree of the same disorder, when it observes even a single event fall out in this unusual manner: for the violent disorder can arise from nothing but the too frequent repetition of this smaller uneasiness.

11 That it is the unusualness alone of the succession which occasions this stop and interruption in the progress of the imagination, as well as the notion of an interval betwixt the two immediately succeeding objects, to be filled up by some chain of intermediate events, is not less evident. The same orders of succession, which to one set of men seem quite according to the natural course of things, and such as require no intermediate events to join them, shall to another appear altogether incoherent and disjointed, unless some such events be supposed: and this for no other reason, but because such orders of succession are familiar to the one, and strange to the other. When we enter the work-houses of the most common artizans; such as dyers, brewers, distillers; we observe a number of appearances, which present themselves in an order that seems to us very strange and wonderful. Our thought cannot easily follow it, we feel an interval betwixt every two of them, and require some chain of intermediate events, to fill it up, and link them together. But the artizan himself, who has been for many years familiar with the consequences of all the operations of his art, feels no such interval. They fall in with what custom has made the natural movement of his imagination: they no longer excite his Wonder, and if he is not a genius superior to his profession, so as to be capable of making the very easy reflection, that those things, though familiar to him, may be strange to us, he will be disposed rather to laugh at, than sympathize with our Wonder. He cannot conceive what occasion there is for any connecting events to unite those appearances, which seem to him to succeed each other very naturally. It is their nature, he tells us, to follow one another in this order, and that accordingly they always do so.[9] In the same manner bread has, since the world began, been the common

[9] [Cf. Imitative Arts, I.17: 'After a little use and experience, all looking-glasses cease to be wonders altogether; and even the ignorant become so familiar with them, as not to think that their effects require any explication.']

nourishment of the human body, and men have so long seen it, every day, converted into flesh and bones, substances in all respects so unlike it, that they have seldom had the curiosity to inquire by what process of intermediate events this change is brought about. Because the passage of the thought from the one object to the other is by custom become quite smooth and easy, almost without the supposition of any such process. Philosophers, indeed, who often look for a chain of invisible objects to join together two events that occur in an order familiar to all the world, have endeavoured to find out a chain of this kind betwixt the two events I have just now mentioned; in the same manner as they have endeavoured, by a like intermediate chain, to connect the gravity, the elasticity, and even the cohesion of natural bodies, with some of their other qualities. These, however, are all of them such combinations of events as give no stop to the imaginations of the bulk of mankind, as excite no Wonder, nor any apprehension that there is wanting the strictest connection between them. But as in those sounds, which to the greater part of men seem perfectly agreeable to measure and harmony, the nicer ear of a musician will discover a want, both of the most exact time, and of the most perfect coincidence: so the more practised thought of a philosopher, who has spent his whole life in the study of the connecting principles of nature, will often feel an interval betwixt two objects, which, to more careless observers, seem very strictly conjoined. By long attention to all the connections which have ever been presented to his observation, by having often compared them with one another, he has, like the musician, acquired, if one may say so, a nicer ear, and a more delicate feeling with regard to things of this nature. And as to the one, that music seems dissonance which falls short of the most perfect harmony; so to the other, those events seem altogether separated and disjoined, which fall short of the strictest and most perfect connection.

12 Philosophy is the science of the connecting principles of nature.[10] Nature, after the largest experience that common observation can acquire, seems to abound with events which appear solitary and incoherent with all that go before them, which therefore disturb the easy movement of the imagination; which make its ideas succeed each other, if one may say so, by irregular starts and sallies; and which thus tend, in some measure, to introduce those confusions and distractions we formerly mentioned. Philosophy, by representing the invisible chains which bind together all these disjointed objects, endeavours to introduce order into this chaos of jarring and

[10] [Cf. Ancient Logics, 1. A similar definition of moral philosophy in particular is given in WN V.i.f.25.] For a discussion of Smith's indiscriminate use of 'philosophy', etc., see the editor's Introduction, 12–14. [Also T. D. Campbell, *Adam Smith's Science of Morals* (1971), chap. 1.]

discordant appearances, to allay this tumult of the imagination, and to restore it, when it surveys the great revolutions of the universe, to that tone of tranquillity and composure, which is both most agreeable in itself, and most suitable to its nature. Philosophy, therefore, may be regarded as one of those arts which address themselves to the imagination; and whose theory and history, upon that account, fall properly within the circumference of our subject. Let us endeavour to trace it, from its first origin, up to that summit of perfection to which it is at present supposed to have arrived, and to which, indeed, it has equally been supposed to have arrived in almost all former times. It is the most sublime of all the agreeable arts, and its revolutions have been the greatest, the most frequent, and the most distinguished of all those that have happened in the literary world. Its history, therefore, must, upon all accounts, be the most entertaining and the most instructive. Let us examine, therefore, all the different systems of nature, which, in these western parts of the world, the only parts of whose history we know any thing,[11] have successively been adopted by the learned and ingenious; and, without regarding their absurdity or probability, their agreement or inconsistency with truth and reality, let us consider them only in that particular point of view which belongs to our subject; and content ourselves with inquiring how far each of them was fitted to sooth the imagination, and to render the theatre of nature a more coherent, and therefore a more magnificent spectacle, than otherwise it would have appeared to be. According as they have failed or succeeded in this, they have constantly failed or succeeded in gaining reputation and renown to their authors; and this will be found to be the clew that is most capable of conducting us through all the labyrinths of philosophical history: for, in the mean time, it will serve to confirm what has gone before, and to throw light upon what is to come after, that we observe, in general, that no system, how well soever in other respects supported, has ever been able to gain any general credit on the world, whose connecting principles were not such as were familiar to all mankind. Why has the chemical philosophy in all ages crept along in obscurity,[12] and been so disregarded by the generality of mankind, while other systems, less useful, and not more agreeable to experience, have possessed universal admiration for whole centuries together? The connecting principles of the chemical philosophy are such as the generality of mankind know nothing about, have rarely seen, and

[11] An exaggeration. Western natural philosophy owed a great deal to Eastern thinkers who wrote in Arabic—a fact well known at that time. Cf. IV.21–3 below.

[12] Smith could hardly have written this in Glasgow, where William Cullen in 1748 began his epoch-making 'popularization' of chemistry in relation to industry and agriculture as well as medicine. It appears to be further evidence for the relatively early composition of this essay.

have never been acquainted with; and which to them, therefore, are incapable of smoothing the passage of the imagination betwixt any two seemingly disjointed objects. Salts, sulphurs, and mercuries, acids, and alkalis, are principles[13] which can smooth things to those only who live about the furnace; but whose most common operations seem, to the bulk of mankind, as disjointed as any two events which the chemists would connect together by them. Those artists, however, naturally explained things to themselves by principles that were familiar to themselves. As Aristotle observes,[14] that the early Pythagoreans, who first studied arithmetic, explained all things by the properties of numbers; and Cicero tells us,[15] that Aristoxenus, the musician, found the nature of the soul to consist in harmony. In the same manner, a learned physician lately gave a system of moral philosophy upon the the principles of his own art,[16] in which wisdom and virtue were the healthful state of the soul; the different vices and follies, the different diseases to which it was subject; in which the causes and symptoms of those diseases were ascertained; and, in the same medical strain, a proper method of cure prescribed. In the same manner also, others have written parallels of painting and poetry, of poetry and music, of music and architecture, of beauty and virtue, of all the fine arts; systems which have universally owed their origin to the lucubrations of those who were acquainted with the one art, but ignorant of the other; who therefore explained to themselves the phaenomena, in that which was strange to them, by those in that which was familiar; and with whom, upon that account, the analogy, which in other writers gives occasion to a few ingenious similitudes, became the great hinge upon which every thing turned.[17]

[13] Modern chemical nomenclature became possible only after Lavoisier's *Traité élémentaire de chimie* (1789; translated into English by Robert Kerr in 1790). The plural 'sulphurs' and 'mercuries' reveal the persistence of alchemical and Paracelsian modes of thought, the former being the 'principle of combustibility', the latter that of 'metallicity'. Smith should have been aware that 'acids and alkalis' had never been regarded as 'principles'; at that time they were regarded as varieties of 'salts'. Nevertheless, his exemplification of Francis Bacon's 'Idols' (*Novum Organum*, aphorism xxxviii ff.) shows an important general insight.

[14] [*Metaphysics*, A, $985^{b}32$–$986^{a}6$.]

[15] [*Tusculan Disputations*, I.10.19, I.18.41.]

[16] [Probably J. O. de La Mettrie, *Discours sur le bonheur* (1748, 1750, 1751, with different titles for substantially the same work). This comes closer to Smith's description than does *Observations on Man* (1749) by David Hartley, likewise a physician turned philosopher. La Mettrie's book, which arose from his translation of Seneca, *De Beata Vita*, is both critical and appreciative of Stoic ethics, and may well have attracted Smith's attention for that reason.]

[17] [In IV.50 below Smith writes of Kepler's 'excessive' tendency to explain by analogy.]

## SECTION III

### *Of the Origin of Philosophy*

1 Mankind, in the first ages of society, before the establishment of law, order, and security, have little curiosity to find out those hidden chains of events which bind together the seemingly disjointed appearances of nature.[1] A savage, whose subsistence is precarious, whose life is every day exposed to the rudest dangers, has no inclination to amuse himself with searching out what, when discovered, seems to serve no other purpose than to render the theatre of nature a more connected spectacle to his imagination. Many of these smaller incoherences, which in the course of things perplex philosophers, entirely escape his attention. Those more magnificent irregularities, whose grandeur he cannot overlook, call forth his amazement. Comets, eclipses, thunder, lightning, and other meteors, by their greatness, naturally overawe him, and he views them with a reverence that approaches to fear. His inexperience and uncertainty with regard to every thing about them, how they came, how they are to go, what went before, what is to come after them, exasperate his sentiment into terror and consternation. But our passions, as Father Malbranche observes, all justify themselves;[2] that is, suggest to us opinions which justify them. As those appearances terrify him, therefore, he is disposed to believe every thing about them which can render them still more the objects of his terror. That they proceed from some intelligent, though invisible causes, of whose vengeance and displeasure they are either the signs or the effects, is the notion of all others most capable of enhancing this passion, and is that, therefore, which he is most apt to entertain. To this too, that cowardice and pusillanimity, so natural to man in his uncivilized state, still more disposes him; unprotected by the laws of society, exposed, defenceless, he feels his weakness upon all occasions; his strength and security upon none.

2 But all the irregularities of nature are not of this awful or terrible kind. Some of them are perfectly beautiful and agreeable. These, therefore, from the same impotence of mind, would be beheld with love and complacency, and even with transports of gratitude; for whatever is the cause of pleasure naturally excites our gratitude. A

[1] [Cf. IV.21 below, where Smith connects a breakdown of law, order, and security with the neglect of natural science.]

[2] *Recherche de la vérité*, V.11. [TMS III.4.3 cites the same phrase from Malebranche, as did Smith's teacher, Francis Hutcheson, in *Inquiry concerning Moral Good and Evil*, II.4.]

child caresses the fruit that is agreeable to it, as it beats the stone that hurts it.[3] The notions of a savage are not very different. The ancient Athenians, who solemnly punished the axe which had accidentally been the cause of the death of a man,[4] erected altars, and offered sacrifices to the rainbow. Sentiments not unlike these, may sometimes, upon such occasions, begin to be felt even in the breasts of the most civilized, but are presently checked by the reflection, that the things are not their proper objects. But a savage, whose notions are guided altogether by wild nature and passion, waits for no other proof that a thing is the proper object of any sentiment, than that it excites it. The reverence and gratitude, with which some of the appearances of nature inspire him, convince him that they are the proper objects of reverence and gratitude, and therefore proceed from some intelligent beings, who take pleasure in the expressions of those sentiments. With him, therefore, every object of nature, which by its beauty or greatness, its utility or hurtfulness, is considerable enough to attract his attention, and whose operations are not perfectly regular, is supposed to act by the direction of some invisible and designing power. The sea is spread out into a calm, or heaved into a storm, according to the good pleasure of Neptune. Does the earth pour forth an exuberant harvest? It is owing to the indulgence of Ceres. Does the vine yield a plentiful vintage? It flows from the bounty of Bacchus. Do either refuse their presents? It is ascribed to the displeasure of those offended deities. The tree, which now flourishes, and now decays, is inhabited by a Dryad, upon whose health or sickness its various appearances depend. The fountain, which sometimes flows in a copious, and sometimes in a scanty stream, which appears sometimes clear and limpid, and at other times muddy and disturbed, is affected in all its changes by the Naiad who dwells within it. Hence the origin of Polytheism, and of that vulgar superstition which ascribes all the irregular events of nature to the favour or displeasure of intelligent, though invisible beings, to gods, daemons, witches, genii, fairies. For it may be observed, that in all Polytheistic religions, among savages, as well as in the early ages of Heathen antiquity, it is the irregular events of nature only that are ascribed to the agency and power of their gods. Fire burns, and water refreshes; heavy bodies descend, and lighter substances fly upwards, by the necessity of their own nature; nor was the invisible hand of Jupiter[5] ever apprehended to be employed in those matters. But

[3] [Cf. TMS II.iii.1.1: 'We are angry, for a moment, even at the stone that hurts us. A child beats it . . .']

[4] [Cf. LJ(A) ii.119, LJ(B) 188 (ed. Cannan, 141).]

[5] [For comment on this phrase and its connection with Smith's later use of 'invisible hand',

(continued)

thunder and lightning, storms and sunshine, those more irregular events, were ascribed to his favour, or his anger. Man, the only designing power with which they were acquainted, never acts but either to stop, or to alter the course, which natural events would take, if left to themselves. Those other intelligent beings, whom they imagined, but knew not, were naturally supposed to act in the same manner; not to employ themselves in supporting the ordinary course of things, which went on of its own accord, but to stop, to thwart, and to disturb it. And thus, in the first ages of the world, the lowest and most pusillanimous superstition supplied the place of philosophy.

3 But when law has established order and security, and subsistence ceases to be precarious, the curiosity of mankind is increased, and their fears are diminished. The leisure which they then enjoy renders them more attentive to the appearances of nature, more observant of her smallest irregularities, and more desirous to know what is the chain which links them all together.[6] That some such chain subsists betwixt all her seemingly disjointed phaenomena, they are necessarily led to conceive; and that magnanimity, and cheerfulness, which all generous natures acquire who are bred in civilized societies, where they have so few occasions to feel their weakness, and so many to be conscious of their strength and security, renders them less disposed to employ, for this connecting chain, those invisible beings whom the fear and ignorance of their rude forefathers had engendered.[7] Those of liberal fortunes, whose attention is not much occupied either with business or with pleasure, can fill up the void of their imagination, which is thus disengaged from the ordinary affairs of life, no other way than by attending to that train of events which passes around them. While the great objects of nature thus pass in review before them, many things occur in an order to which they have not been accustomed. Their imagination, which accompanies with ease and delight the regular progress of nature, is stopped and embarrassed by those seeming incoherences; they excite their wonder, and seem to require some chain of intermediate events, which, by connecting them with something that has gone before, may thus render the

see A. L. Macfie, 'The Invisible Hand of Jupiter', *Journal of the History of Ideas*, xxxii (1971), 595–9.]

[6] [Cf. Hume, who says of a republic: 'From law arises security: from security curiosity: and from curiosity knowledge.' 'Of the Rise and Progress of the Arts and Sciences', in *Essays Moral, Political and Literary*, ed. Green and Grose, i.180.]

[7] [For Smith's views on the relation between scientific and religious explanation, cf. WN V.i.f.24: 'Superstition first attempted to satisfy this curiosity by referring all those wonderful appearances to the immediate agency of the gods. Philosophy afterwards endeavoured to account for them, from more familiar causes ...' But also Ancient Physics, 9, below: 'as ignorance begot superstition, science gave birth to the first theism that arose among those nations, who were not enlightened by divine Revelation.']

whole course of the universe consistent and of a piece. Wonder, therefore, and not any expectation of advantage from its discoveries, is the first principle which prompts mankind to the study of Philosophy, of that science which pretends to lay open the concealed connections that unite the various appearances of nature; and they pursue this study for its own sake, as an original pleasure or good in itself, without regarding its tendency to procure them the means of many other pleasures.[8]

4 Greece, and the Greek colonies in Sicily, Italy, and the Lesser Asia, were the first countries which, in these western parts of the world, arrived at a state of civilized society. It was in them, therefore, that the first philosophers, of whose doctrine we have any distinct account, appeared. Law and order seem indeed to have been established in the great monarchies of Asia and Egypt, long before they had any footing in Greece: yet, after all that has been said concerning the learning of the Chaldeans and Egyptians, whether there ever was in those nations any thing which deserved the name of science, or whether that despotism which is more destructive of security and leisure than anarchy itself, and which prevailed over all the East, prevented the growth of Philosophy, is a question which, for want of monuments, cannot be determined with any degree of precision.[9]

5 The Greek colonies having been settled amid nations either altogether barbarous, or altogether unwarlike, over whom, therefore, they soon acquired a very great authority, seem, upon that account, to have arrived at a considerable degree of empire and opulence before any state in the parent country had surmounted that extreme poverty, which, by leaving no room for any evident distinction of ranks, is necessarily attended with the confusion and misrule which flows from a want of all regular subordination.[10] The Greek islands being secure from the invasion of land armies, or from naval forces, which were in those days but little known, seem, upon that account too, to have got before the continent in all sorts of civility and improvement. The first philosophers, therefore, as well as the first poets, seem all to have been natives, either of their colonies, or of their

[8] This explanation of the origin of philosophy is commonly attributed to Plato. The *locus classicus* is 'The sense of wonder is the mark of the philosopher' (*Theaetetus*, 155 D), but the context suggests 'puzzlement' rather than the conventional sense. [For the complete thought of Smith's sentence cf. Aristotle, *Metaphysics*, A, $982^b11$–24.]

[9] With the knowledge then available Smith's cautious statement could hardly have been improved upon. Modern research, based on authentic documents (papyrus, steles, etc.), reveals the high sophistication of Egyptian and especially 'Babylonian' mathematics, astronomy, and medicine *sensu lato*. The debt of Greece to these forerunners becomes progressively apparent; nevertheless, the Greek innovation of rigour and abstraction introduced a new dimension.

[10] [Smith comments extensively on the proposition that 'Civil government supposes a certain subordination' in WN V.i.b.3 ff. ('Part II, Of the Expence of Justice'). On the social utility of the 'distinction of ranks' cf. TMS I.iii.2.3, VI.ii.1.20, VI.iii.30.]

islands. It was from thence that Homer, Archilochus, Stesichorus, Simonides, Sappho, Anacreon, derived their birth. Thales and Pythagoras, the founders of the two earliest sects of philosophy, arose, the one in an Asiatic colony, the other in an island; and neither of them established his school in the mother country.[11]

6 What was the particular system of either of those two philosophers, or whether their doctrine was so methodized as to deserve the name of a system, the imperfection, as well as the uncertainty of all the traditions that have come down to us concerning them, makes it impossible to determine. The school of Pythagoras, however, seems to have advanced further in the study of the connecting principles of nature, than that of the Ionian philosopher. The accounts which are given of Anaximander, Anaximenes, Anaxagoras, Archelaus, the successors of Thales, represent the doctrines of those sages as full of the most inextricable confusion. Something, however, that approaches to a composed and orderly system, may be traced in what is delivered down to us concerning the doctrine of Empedocles, of Archytas, of Timaeus, and of Ocellus the Lucanian, the most renowned philosophers of the Italian school.[12] The opinions of the two last coincide pretty much; the one, with those of Plato; the other, with those of Aristotle; nor do those of the two first seem to have been very different, of whom the one was the author of the doctrine of the Four Elements, the other the inventor of the Categories;[13] who, therefore, may be regarded as the founders, the one, of the ancient Physics; the other, of the ancient Dialectic; and, how closely these were connected,

[11] [Cf. WN IV.vii.b.4 ('Causes of the Prosperity of new Colonies'): 'The schools of the two oldest Greek philosophers, those of Thales and Pythagoras, were established, it is remarkable, not in antient Greece, but the one in an Asiatick, the other in an Italian colony.' Smith elaborates the point in LRBL ii.117–19 (ed. Lothian, 132–3), stating that Thales taught in Miletus, Pythagoras in Italy, and Empedocles in Sicily, before 'the Persian expedition' brought commerce and the arts to the mainland of Greece.]

[12] The work on natural philosophy by 'Ocellus the Lucanian' is now (*Oxford Classical Dictionary*, 1970) regarded as supposititious and as dating from *c.*150 B.C., i.e. post-Aristotelian. [See R. Mondolfo's note in his Italian translation of E. Zeller, *History of Greek Philosophy*, ii.384–5.

As regards Timaeus, Smith is making two assumptions usual at that time. (1) He takes Plato's dialogue figure Timaeus to be a historical person. On this, see F. M. Cornford, *Plato's Cosmology* (1937), 2–3. (2) He does not doubt the genuineness of the surviving treatise, ascribed to Timaeus, 'On the World-Soul'. But see A. E. Taylor, *Commentary on Plato's Timaeus* (1928), Appendix II, 655–64, and other literature there cited.

The 'Italian School' refers to the Pythagoreans at Croton in Southern Italy. It is mentioned again in Ancient Physics, 3 ff.]

[13] [Here again Smith's judgement is based on a too ready acceptance of pseudonymous writings. Some genuine fragments of works by Archytas of Tarentum have been preserved; but the logical works acribed to him, with such titles as *On general propositions, On opposites*, are now commonly regarded as productions of much later neo-Pythagoreans. Admittedly, Simplicius and other ancient commentators on Aristotle's *Categories* accepted them as genuine. E. Zeller, *Philosophie der Griechen*, ed. 4, vol. iii b, 114–26; Diels-Kranz, *Fragmente der Vorsokratiker*, ed. 6, i.439.]

will appear hereafter.[14] It was in the school of Socrates, however, from Plato and Aristotle, that Philosophy first received that form, which introduced her, if one may say so, to the general acquaintance of the world. It is from them, therefore, that we shall begin to give her history in any detail. Whatever was valuable in the former systems, which was at all consistent with their general principles, they seem to have consolidated into their own. From the Ionian Philosophy, I have not been able to discover that they derived any thing. From the Pythagorean school, both Plato and Aristotle seem to have derived the fundamental principles of almost all their doctrines. Plato, too, appears to have borrowed something from two other sects of philosophers, whose extreme obscurity seems to have prevented them from acquiring themselves any extensive reputation: the one was that of Cratylus and Heraclitus; the other was that of Xenophanes, Parmenides, Melissus, and Zeno.[15] To pretend to rescue the system of any of those antesocratic sages, from that oblivion which at present covers them all, would be a vain and useless attempt. What seems, however, to have been borrowed from them, shall sometimes be marked as we go along.

7 There was still another school of philosophy, earlier than Plato, from which, however, he was so far from borrowing any thing, that he seems to have bent the whole force of his reason to discredit and expose its principles.[16] This was the Philosophy of Leucippus, Democritus, and Protagoras,[17] which accordingly seems to have submitted to his eloquence, to have lain dormant, and to have been almost forgotten for some generations, till it was afterwards more successfully revived by Epicurus.

## SECTION IV

### *The History of Astronomy*

1 Of all the phaenomena of nature, the celestial appearances are, by their greatness and beauty, the most universal objects of the curiosity

[14] [Ancient Logics, 1.]

[15] [Cratylus was a pupil of Heracleitus. For his influence on Plato, see Aristotle, *Metaphysics*, A, 987a32 ff., and Sir David Ross, *Aristotle's Metaphysics*, vol. i, xlvii. In these remarks, Smith greatly underrates the influence of Parmenides upon his immediate successors and upon Plato.]

[16] [This statement is too sweeping. It is likely that Plato knew *something* of the system of Leucippus (see F. M. Cornford, *Plato's Theory of Knowledge* (1935), 231); but when he attacks materialism, as at *Sophist*, 246 A–D, and *Laws*, X, 889 B ff., it is in quite general terms. Protagoras is criticized specifically by Plato, but see next note.]

[17] The inclusion of Protagoras, the Sophist, in the 'school' of the atomists is unwarranted.

of mankind.[1] Those who surveyed the heavens with the most careless attention, necessarily distinguished in them three different sorts of objects; the Sun, the Moon, and the Stars. These last, appearing always in the same situation, and at the same distance with regard to one another, and seeming to revolve every day round the earth in parallel circles,[2] which widened gradually from the poles to the equator,[3] were naturally thought to have all the marks of being fixed, like so many gems, in the concave side of the firmament, and of being carried round by the diurnal revolutions of that solid body: for the azure sky, in which the stars seem to float, was readily apprehended, upon account of the uniformity of their apparent motions, to be a solid body, the roof or outer wall of the universe, to whose inside all those little sparkling objects were attached.

2 The Sun and Moon, often changing their distance and situation, in regard to the other heavenly bodies, could not be apprehended to be attached to the same sphere with them. They assigned, therefore, to each of them, a sphere of its own; that is, supposed each of them to be attached to the concave side of a solid and transparent body, by whose revolutions they were carried round the earth. There was not indeed, in this case, the same ground for the supposition of such a sphere as in that of the Fixed Stars; for neither the Sun nor the Moon appear to keep always at the same distance with regard to any one of the other heavenly bodies. But as the motion of the Stars had been accounted for by an hypothesis of this kind, it rendered the theory of the heavens more uniform, to account for that of the Sun and Moon in the same manner. The sphere of the Sun they placed above that of the Moon; as the Moon was evidently seen in eclipses to pass betwixt the Sun and the Earth. Each of them was supposed to revolve by a motion of its own, and at the same time to be affected by the motion of the Fixed Stars. Thus, the Sun was carried round from east to west by the communicated movement of this outer sphere, which produced his diurnal revolutions, and the vicissitudes of day and night; but at the same time he had a motion of his own, contrary to this, from west

[1] [Cf. Ancient Physics, 1. Also WN V.i.f.24 ('Of the Expence of the Institutions for the Education of Youth'): 'The great phenomena of nature, the revolutions of the heavenly bodies, eclipses, comets, thunder, lightning, and other extraordinary meteors; the generation, the life, growth, and dissolution of plants and animals; are objects which, as they necessarily excite the wonder, so they naturally call forth the curiosity of mankind to enquire into their causes.'

In LRBL ii.18–19*v* (ed. Lothian, 87), Smith says: 'The more lively and striking the impression is which any phaenomenon makes on the mind, the greater curiosity does it excite to know its causes, tho perhaps the phaenomenon may not be intrinsically half so grand or important as another less striking. Thus it is we have a greater curiosity to pry into the cause of thunder and lightning and of the celestial motions, than of gravity, because these naturally make a greater impression on us.']

[2] [See § 51 below on the use of the circle in early astronomical theories.]

[3] For technical terms employed in the 'Ancient Astronomy' see the editor's Introduction, 15–16.

to east, which occasioned his annual revolution, and the continual shifting of his place with regard to the Fixed Stars. This motion was more easy, they thought, when carried on edgeways, and not in direct opposition to the motion of the outer sphere, which occasioned the inclination of the axis of the sphere of the Sun, to that of the sphere of the Fixed Stars; this again produced the obliquity of the ecliptic, and the consequent changes of the seasons. The moon, being placed below the sphere of the Sun, had both a shorter course to finish, and was less obstructed by the contrary movement of the sphere of the Fixed Stars, from which she was farther removed. She finished her period, therefore, in a shorter time, and required but a month, instead of a year, to complete it.

3 The Stars, when more attentively surveyed, were some of them observed to be less constant and uniform in their motions than the rest, and to change their situations with regard to the other heavenly bodies; moving generally eastwards, yet appearing sometimes to stand still, and sometimes even to move westwards. These, to the number of five, were distinguished by the name of Planets, or wandering Stars, and marked with the particular appellations of Saturn, Jupiter, Mars, Venus, and Mercury. As, like the Sun and Moon, they seem to accompany the motion of the Fixed Stars from east to west, but at the same time to have a motion of their own, which is generally from west to east; they were each of them, as well as those two great lamps of heaven, apprehended to be attached to the inside of a solid concave and transparent sphere, which had a revolution of its own, that was almost directly contrary to the revolution of the outer heaven, but which, at the same time, was hurried along by the superior violence and rapidity of this last.

4 This is the system of concentric Spheres, the first regular system of Astronomy, which the world beheld, as it was taught in the Italian school[4] before Aristotle and his two contemporary philosophers, Eudoxus and Callippus,[5] had given it all the perfection which it is capable of receiving. Though rude and inartificial,[6] it is capable of

[4] [No objection can be raised to this account of the science of the 'Italian school', since it is not unlike what classical scholars would have said until quite recent times. Today, however, it seems by no means certain that the Pythagoreans deserve the place in the early history of mathematics and astronomy which tradition has given them. It is safer to regard Eudoxus as the originator of the system of concentric spheres.]

[5] [On Eudoxus and Callippus, see Sir T. L. Heath, *Aristarchus of Samos* (1913), chap. 16, 190–224, and G. L. Huxley in *Dictionary of Scientific Biography*, vol. iv (1971); also D. J. Allan, article 'Plato', ibid., vol. xi (1975), 22–31. As Smith says in §7 below, Eudoxus was the friend and auditor of Plato. We learn on good authority that he propounded his system in answer to a problem posed by Plato. Our knowledge of the system comes from Aristotle, *Metaphysics*, Λ, 8, $1073^{b}1$ ff., and the Commentary of Simplicius (5th–6th century A.D.) on Aristotle, *De Caelo*, II.12, $293^{a}4$. Smith was obviously acquainted with the former, probably with the latter also.]

[6] Far from being 'rude and inartificial', the system of Eudoxus is a remarkable piece of

(*continued*)

connecting together, in the imagination, the grandest and the most seemingly disjointed appearances in the heavens. The motions of the most remarkable objects in the celestial regions, the Sun, the Moon, and the Fixed Stars, are sufficiently connected with one another by this hypothesis. The eclipses of these two great luminaries are, though not so easily calculated, as easily explained, upon this ancient, as upon the modern system. When these early philosophers explained to their disciples the very simple causes of those dreadful phaenomena, it was under the seal of the most sacred secrecy, that they might avoid the fury of the people, and not incur the imputation of impiety, when they thus took from the gods the direction of those events, which were apprehended to be the most terrible tokens of their impending vengeance. The obliquity of the ecliptic, the consequent changes of the seasons, the vicissitudes of day and night, and the different lengths of both days and nights, in the different seasons, correspond too, pretty exactly, with this ancient doctrine. And if there had been no other bodies discoverable in the heavens besides the Sun, the Moon, and the Fixed Stars, this old hypothesis might have stood the examination of all ages, and have gone down triumphant to the remotest posterity.

5 If it gained the belief of mankind by its plausibility, it attracted their wonder and admiration; sentiments that still more confirmed their belief, by the novelty and beauty of that view of nature which it presented to the imagination. Before this system was taught in the world, the earth was regarded as, what it appears to the eye, a vast, rough, and irregular plain, the basis and foundation of the universe, surrounded on all sides by the ocean, and whose roots extended themselves through the whole of that infinite depth which is below it. The sky was considered as a solid hemisphere, which covered the earth, and united with the ocean at the extremity of the horizon. The Sun, the Moon, and all the heavenly bodies rose out of the eastern, climbed up the convex side of the heavens, and descended again into the western ocean, and from thence, by some subterraneous passages, returned to their first chambers in the east. Nor was this notion confined to the people, or to the poets who painted the opinions of the people: it was held by Xenophanes, the founder of the Eleatic philosophy, after that of the Ionian and Italian schools, the earliest that appeared in Greece. Thales of Miletus too, who, according to Aristotle,[7] represented the Earth as floating upon an immense ocean of water, may have been nearly of the same opinion; notwithstanding

mathematical analysis, virtually a geometrical equivalent of Joseph Fourier's algebraic resolution of a complex curvilinear motion into simpler components.

[7] [*De Caelo*, II.13, 294$^{a}$28.]

what we are told by Plutarch[8] and Apuleius[9] concerning his astronomical discoveries, all of which must plainly have been of a much later date. To those who had no other idea of nature, besides what they derived from so confused an account of things, how agreeable must that system have appeared, which represented the Earth as distinguished into land and water, self-balanced and suspended in the centre of the universe, surrounded by the elements of Air and Ether, and covered by eight polished and cristalline Spheres, each of which was distinguished by one or more beautiful and luminous bodies, and all of which revolved round their common centre, by varied, but by equable and proportionable motions. It seems to have been the beauty of this system that gave Plato[10] the notion of something like an harmonic proportion, to be discovered in the motions and distances of the heavenly bodies; and which suggested to the earlier Pythagoreans, the celebrated fancy of the Musick of the Spheres:[11] a wild and romantic idea, yet such as does not ill correspond with that admiration, which so beautiful a system, recommended too by the graces of novelty, is apt to inspire.

6 Whatever are the defects which this account of things labours under, they are such, as to the first observers of the heavens could not readily occur. If all the motions of the Five Planets cannot, the greater part of them may, be easily connected by it; they and all their motions are the least remarkable objects in the heavens; the greater part of mankind take no notice of them at all; and a system, whose only defect lies in the account which it gives of them, cannot thereby be much disgraced in their opinion. If some of the appearances too of the Sun and Moon, the sometimes accelerated and again retarded motions of those luminaries but ill correspond with it; these too, are such as cannot be discovered but by the most attentive observation, and such therefore as we cannot wonder that the imaginations of the first enquirers should slur over, if one may say so, and take little notice of.

7 It was, however, to remedy those defects, that Eudoxus, the friend and auditor of Plato, found it necessary to increase the number of the Celestial Spheres.[12] Each Planet is sometimes observed to advance forward in that eastward course which is peculiar to itself, sometimes to retire backwards, and sometimes again to stand still. To suppose

[8] [*De Pythicae Oraculis*, 18, 402 E–F.]

[9] [*Florilegium*, 18; English translation in Heath, *Aristarchus of Samos*. 22.]

[10] [*Republic*, X.616–17; Heath, op. cit., 148–58.]

[11] [Aristotle, *De Caelo*, II.9, 290$^b$12–29; Cicero, *Somnium Scipionis*, 5. See W. K. C. Guthrie, *History of Greek Philosophy* (1962), i.295–301; W. Bürkert, *Weisheit und Wissenschaft* (1962), 328–35.]

[12] [See notes 4–5 above. The phrase is incorrect if Eudoxus was the originator of the spheres.]

that the Sphere of the Planet should by its own motion, if one may say so, sometimes roll forwards, sometimes roll backwards, and sometimes do neither the one nor the other, is contrary to all the natural propensities of the imagination, which accompanies with ease and delight any regular and orderly motion, but feels itself perpetually stopped and interrupted, when it endeavours to attend to one so desultory and uncertain. It would pursue, naturally and of its own accord, the direct or progressive movement of the Sphere, but is every now and then shocked, if one may say so, and turned violently out of its natural career by the retrograde and stationary appearances of the Planet, betwixt which and its more usual motion, the fancy feels a want of connection, a gap or interval, which it cannot fill up, but by supposing some chain of intermediate events to join them.[13] The hypothesis of a number of other spheres revolving in the heavens, besides those in which the luminous bodies themselves were infixed, was the chain with which Eudoxus endeavoured to supply it. He bestowed four of these Spheres upon each of the Five Planets; one in which the luminous body itself revolved, and three others above it. Each of these had a regular and constant, but a peculiar movement of its own, which it communicated to what was properly the Sphere of the Planet, and thus occasioned that diversity of motions observable in those bodies. One of these Spheres, for example, had an oscillatory motion,[14] like the circular pendulum of a watch. As when you turn round a watch, like a Sphere upon its axis, the pendulum will, while turned round along with it, still continue to oscillate, and communicate to whatever body is comprehended within it, both its own oscillations and the circular motion of the watch; so this oscillating Sphere, being itself turned round by the motion of the Sphere above it, communicated to the Sphere below it, that circular, as well as its own oscillatory motion; produced by the one, the daily revolutions; by the other, the direct, stationary, and retrograde appearances of the Planet, which derived from a third Sphere that revolution by which it performed its annual period. The motions of all these Spheres were in themselves constant and equable, such as the imagination could easily attend to and pursue, and which connected together that otherwise incoherent diversity of movements observable in the Sphere of the Planet. The motions of the Sun and Moon being more regular than those of the Five Planets, by assigning three Spheres to

[13] [The account that follows is based on Aristotle, *Metaphysics*, Λ, 8 (see note 5 above): spheres of the planets, 1073$^b$22; of Sun and Moon, 1073$^b$17; system of Callippus, 1073$^b$32 ff.]

[14] Smith seems to have misunderstood the nature of the 'oscillation', since the currently accepted characteristics—'constant' and 'equable'—contradict it. He may have failed to recognize that the 'oscillation' is only relative to the observer.

each of them, Eudoxus imagined he could connect together all the diversity of movements discoverable in either. The motion of the Fixed Stars being perfectly regular, one Sphere he judged sufficient for them all. So that, according to this account, the whole number of Celestial Spheres amounted to twenty-seven. Callippus, though somewhat younger, the cotemporary of Eudoxus, found that even this number was not enough to connect together the vast variety of movements which he discovered in those bodies, and therefore increased it to thirty-four.[15] Aristotle, upon a yet more attentive observation, found that even all these Spheres would not be sufficient, and therefore added twenty-two more, which increased their number to fifty-six.[16] Later observers discovered still new motions, and new inequalities, in the heavens. New Spheres were therefore still to be added to the system, and some of them to be placed even above that of the Fixed Stars. So that in the sixteenth century, when Fracostorio,[17] smit with the eloquence of Plato and Aristotle, and with the regularity and harmony of their system, in itself perfectly beautiful, though it corresponds but inaccurately with the phaenomena, endeavoured to revive this ancient Astronomy, which had long given place to that of Ptolemy and Hipparchus,[18] he found it necessary to multiply the number of Celestial Spheres to seventy-two; neither were all these enough.

8 This system had now become as intricate and complex as those appearances themselves, which it had been invented to render uniform and coherent. The imagination, therefore, found itself but little relieved from that embarrassment, into which those appearances had thrown it, by so perplexed an account of things. Another system, for this reason, not long after the days of Aristotle, was invented by Apollonius,[19] which was afterwards perfected by Hipparchus, and has since been delivered down to us by Ptolemy, the more artificial system of Eccentric Spheres and Epicycles.[20]

9 In this system, they first distinguished betwixt the real and

[15] [Aristotle says that Callippus found it necessary, in order to explain the phenomena, to assign two additional spheres each to the Sun and Moon, and one each to Mars, Venus, and Mercury. Thus his total was 27+4+3.]

[16] This elaboration of the system is described in Aristotle's *De Caelo*. See the editor's Introduction, 17.

[17] i.e. Girolamo Fracastoro (1483–1553), an outstanding figure linking the humanistic (literary) Renaissance with the so-called 'Scientific Revolution'. The theory referred to by Smith was set out in Fracastoro's *Homocentrica* (1583). [See *Dictionary of Scientific Biography*, vol. v (1972), 104–7.]

[18] [Hipparchus (*fl.* 146–127 B.C.) of course preceded Ptolemy, who is one of the prime sources of our information about him.]

[19] [Apollonius of Perga (3rd century B.C.), 'the Great Geometer'. His theory of planetary motion is known from Ptolemy's *Almagest*.]

[20] [See T. L. Heath, *Manual of Greek Mathematics* (1931), 376, 396–7; W. W. Tarn and G. T. Griffith, *Hellenistic Civilization*, ed. 3 (1952), 296–9, and literature there quoted.]

apparent motion of the heavenly bodies. These, they observed, upon account of their immense distance, must necessarily appear to revolve in circles concentric with the globe of the Earth, and with one another: but that we cannot, therefore, be certain that they really revolve in such circles, since, though they did not, they would still have the same appearance. By supposing, therefore, that the Sun and the other Planets revolved in circles, whose centres were very distant from the centre of the Earth; that consequently, in the progress of their revolution, they must sometimes approach nearer, and sometimes recede further from it, and must, therefore, to its inhabitants appear to move faster in the one case, and slower in the other, those philosophers imagined they could account for the apparently unequal velocities of all those bodies.

10 By supposing, that in the solidity of the Sphere of each of the Five Planets there was formed another little Sphere, called an Epicycle, which revolved round its own centre, at the same time that it was carried round the centre of the Earth by the revolution of the great Sphere, betwixt whose concave and convex sides it was inclosed; in the same manner as we might suppose a little wheel inclosed within the outer circle of a great wheel, and which whirled about several times upon its own axis, while its centre was carried round the axis of the great wheel, they imagined they could account for the retrograde and stationary appearances of those most irregular objects in the heavens. The Planet, they supposed, was attached to the circumference, and whirled round the centre of this little Sphere,[21] at the same time that it was carried round the Earth by the movement of the great Sphere. The revolution of this little Sphere, or Epicycle, was such, that the Planet, when in the upper part of it; that is, when furthest off and least sensible to the eye; was carried round in the same direction with the centre of the Epicycle, or with the Sphere in which the Epicycle was inclosed: but when in the lower part, that is, when nearest and most sensible to the eye; it was carried round in a direction contrary to that of the centre of the Epicycle: in the same manner as every point in the upper part of the outer circle of a coach-wheel revolves forward in the same direction with the axis, while every point, in the lower part, revolves backwards in a contrary direction to the axis. The motions of the Planet, therefore, surveyed from the Earth appeared direct, when in the upper part of the Epicycle, and retrograde, when in the lower. When again it either descended from the upper part to the lower, or ascended from the lower to the upper, it necessarily appeared stationary.

[21] The system of Ptolemy took no account of 'spheres'; these were later introduced into it by the Muslim astronomers under the influence of Aristotelian 'physics'.

11 But, though, by the eccentricity of the great Sphere, they were thus able, in some measure, to connect together the unequal velocities of the heavenly bodies, and by the revolutions of the little Sphere, the direct, stationary, and retrograde appearances of the Planets, there was another difficulty that still remained. Neither the Moon, nor the three superior Planets, appear always in the same part of the heavens, when at their periods of most retarded motion, or when they are supposed to be at the greatest distance from the Earth. The apogeum therefore, or the point of greatest distance from the Earth, in the Spheres of each of those bodies, must have a movement of its own, which may carry it successively through all the different points of the Ecliptic. They supposed, therefore, that while the great eccentric Sphere revolved eastwards round its centre, that its centre too revolved westwards in a circle of its own, round the centre of the Earth, and thus carried its apogeum through all the different points of the Ecliptic.

12 But with all those combined and perplexed circles; though the patrons of this system were able to give some degree of uniformity to the real directions of the Planets, they found it impossible so to adjust the velocities of those supposed Spheres to the phaenomena, as that the revolution of any one of them, when surveyed from its own centre, should appear perfectly equable and uniform. From that point, the only point in which the velocity of what moves in a circle can be truly judged of, they would still appear irregular and inconstant, and such as tended to embarrass and confound the imagination. They invented, therefore, for each of them, a new Circle, called the Equalizing Circle, from whose centre they should all appear perfectly equable: that is, they so adjusted the velocities of these Spheres, as that, though the revolution of each of them would appear irregular when surveyed from its own centre, there should, however, be a point comprehended within its circumference, from whence its motions should appear to cut off, in equal times, equal portions of the Circle, of which that point was the centre.

13 Nothing can more evidently show, how much the repose and tranquillity of the imagination is the ultimate end of philosophy, than the invention of this Equalizing Circle. The motions of the heavenly bodies had appeared inconstant and irregular, both in their velocities and in their directions. They were such, therefore, as tended to embarrass and confound the imagination, whenever it attempted to trace them. The invention of Eccentric Spheres, of Epicycles, and of the revolution of the centres of the Eccentric Spheres, tended to allay this confusion, to connect together those disjointed appearances, and to introduce harmony and order into the mind's conception of the

movements of those bodies. It did this, however, but imperfectly; it introduced uniformity and coherence into their real directions. But their velocities, when surveyed from the only point in which the velocity of what moves in a Circle can be truly judged of, the centre of that Circle, still remained, in some measure, inconstant as before; and still, therefore, embarrassed the imagination. The mind found itself somewhat relieved from this embarrassment, when it conceived, that how irregular soever the motions of each of those Circles might appear, when surveyed from its own centre, there was, however, in each of them, a point, from whence its revolution would appear perfectly equable and uniform, and such as the imagination could easily follow. Those philosophers transported themselves, in fancy, to the centres of these imaginary Circles, and took pleasure in surveying from thence, all those fantastical motions, arranged, according to that harmony and order, which it had been the end of all their researches to bestow upon them. Here, at last, they enjoyed that tranquillity and repose which they had pursued through all the mazes of this intricate hypothesis; and here they beheld this, the most beautiful and magnificent part of the great theatre of nature, so disposed and constructed, that they could attend, with ease and delight, to all the revolutions and changes that occurred in it.

14 These, the System of Concentric, and that of Eccentric Spheres, seem to have been the two Systems of Astronomy, that had most credit and reputation with that part of the ancient world, who applied themselves particularly to the study of the heavens. Cleanthes,[22] however, and the other philosophers of the Stoical sect who came after him, appear to have had a system of their own, quite different from either. But, though justly renowned for their skill in dialectic, and for the security and sublimity of their moral doctrines, those sages seem never to have had any high reputation for their knowledge of the heavens; neither is the name of any one of them[23] ever counted in the catalogue of the great astronomers, and studious observers of the Stars, among the ancients. They rejected the doctrine of the Solid Spheres; and maintained, that the celestial regions were filled with a fluid ether, of too yielding a nature to carry along with it, by any motion of its own, bodies so immensely great as the Sun, Moon, and Five Planets. These, therefore, as well as the Fixed Stars, did not derive their motion from the circumambient body, but had each of them, in itself, and peculiar to itself, a vital principle of motion, which directed it to move with its own peculiar velocity, and its own peculiar direction. It was by this internal principle, that the Fixed Stars

[22] [Second head of the Stoic school, succeeding its founder, Zeno of Citium, in 263 B.C.]
[23] Poseidonius (*c.*135–51 B.C.) was a notable exception.

revolved directly from east to west in circles parallel to the Equator, greater or less, according to their distance or nearness to the Poles, and with velocities so proportioned, that each of them finished its diurnal period in the same time, in something less than twenty-three hours and fifty-six minutes. It was, by a principle of the same kind, that the Sun moved westwards, for they allowed of no eastward motion in the heavens, but with less velocity than the Fixed Stars, so as to finish his diurnal period in twenty-four hours, and, consequently, to fall every day behind them, by a space of the heavens nearly equal to that which he passes over in four minutes; that is, nearly equal to a degree. This revolution of the Sun, too, was neither directly westwards, nor exactly circular; but after the Summer Solstice, his motion began gradually to incline a little southwards, appearing in his meridian to-day, further south than yesterday; and to-morrow still further south than to-day; and thus continuing every day to describe a spiral line round the Earth, which carried him gradually further and further southwards, till he arrived at the Winter Solstice. Here, this spiral line began to change its direction, and to bring him gradually, every day, further and further northwards, till it again restored him to the Summer Solstice. In the same manner they accounted for the motion of the Moon, and that of the Five Planets, by supposing that each of them revolved westwards, but with directions, and velocities, that were both different from one another, and continually varying; generally, however, in spherical lines, somewhat inclined to the Equator.

15 This system seems never to have had the vogue. The system of Concentric as well as that of Eccentric Spheres gives some sort of reason, both for the constancy and equability of the motion of the Fixed Stars, and for the variety and uncertainty of that of the Planets. Each of them bestow some sort of coherence upon those apparently disjointed phaenomena. But this other system seems to leave them pretty much as it found them. Ask a Stoic, why all the Fixed Stars perform their daily revolutions in circles parallel to each other, though of very different diameters, and with velocities so proportioned, that they all finish their period at the same time, and through the whole course of it preserve the same distance and situation with regard to one another? He can give no other answer, but that the peculiar nature, or if one may say so, the caprice of each Star[24] directs it to move in that peculiar manner. His system affords him no principle of connection, by which he can join together, in his

[24] The notion of the 'caprice of each star' was to play an important part in later natural philosophy and especially medicine.

imagination, so great a number of harmonious revolutions. But either of the other two systems, by the supposition of the solid firmament, affords this easily. He is equally at a loss to connect together the peculiarities that are observed in the motions of the other heavenly bodies; the spiral motion of them all; their alternate progression from north to south, and from south to north; the sometimes accelerated, and again retarded motions of the Sun and Moon; the direct retrograde and stationary appearances of the Planets. All these have, in his system, no bond of union, but remain as loose and incoherent in the fancy, as they at first appeared to the senses, before philosophy had attempted, by giving them a new arrangement, by placing them at different distances, by assigning to each some peculiar but regular principle of motion, to methodize and dispose them into an order that should enable the imagination to pass as smoothly, and with as little embarrassment, along them, as along the most regular, familiar, and coherent appearances of nature.

16 Such were the systems of Astronomy that, in the ancient world, appear to have been adopted by any considerable party. Of all of them, the system of Eccentric Spheres was that which corresponded most exactly with the appearances of the heavens. It was not invented till after those appearances had been observed, with some accuracy, for more than a century together; and it was not completely digested by Ptolemy till the reign of Antoninus,[25] after a much longer course of observations. We cannot wonder, therefore, that it was adapted to a much greater number of the phaenomena, than either of the other two systems, which had been formed before those phaenomena were observed with any degree of attention, which, therefore, could connect them together only while they were thus regarded in the gross, but which, it could not be expected, should apply to them when they came to be considered in the detail. From the time of Hipparchus, therefore, this system seems to have been pretty generally received by all those who attended particularly to the study of the heavens. That astronomer first made a catalogue of the Fixed Stars;[26] calculated, for six hundred years, the revolutions of the Sun, Moon, and Five Planets; marked the places in the heavens, in which, during all that period, each of those bodies should appear; ascertained the times of the eclipses of the Sun and Moon, and the particular places of the Earth in which they should be visible. His calculations were founded

[25] ['Claudius Ptolemy . . . presumably wrote his great work about the middle of the reign of Antoninus Pius (A.D. 138–61)': Heath, *Manual of Greek Mathematics*, 402.]

[26] The catalogue attributed to Hipparchus was based by him on the earlier one of Aristillus and Timocharis, thus making possible his discovery of the precession of the equinoxes. [For Hipparchus' achievements see Heath, *Manual*, 395–9.]

upon this system, and as the events corresponded to his predictions, with a degree of accuracy which, though inferior to what Astronomy has since arrived at, was greatly superior to any thing which the world had then known, they ascertained, to all astronomers and mathematicians, the preference of his system, above all those which had been current before it.

17 It was, however, to astronomers and mathematicians only, that they ascertained this; for, notwithstanding the evident superiority of this system, to all those with which the world was then acquainted, it was never adopted by any one sect of philosophers.

18 Philosophers, long before the days of Hipparchus, seem to have abandoned the study of nature,[27] to employ themselves chiefly in ethical, rhetorical, and dialectical questions.[28] Each party of them too, had by this time completed their peculiar system or theory of the universe, and no human consideration could then have induced them to give up any part of it. That supercilious and ignorant contempt too, with which at this time they regarded all mathematicians, among whom they counted astronomers, seems even to have hindered them from enquiring so far into their doctrines, as to know what opinions they held. Neither Cicero nor Seneca, who have so often occasion to mention the ancient systems of Astronomy, take any notice of that of Hipparchus. His name is not to be found in the writings of Seneca. It is mentioned but once in those of Cicero, in a letter to Atticus,[29] but without any note of approbation, as a geographer, and not as an astronomer. Plutarch, when he counts up, in his second book, concerning the opinions of philosophers, all the ancient systems of Astronomy,[30] never mentions this, the only tolerable one which was known in his time. Those three authors, it seems, conversed only with the writings of philosophers. The elder Pliny[31] indeed, a man whose curiosity extended itself equally to every part of learning, describes the system of Hipparchus, and never mentions its author, which he has occasion to do often, without some note of that high admiration which he had so justly conceived for his merit. Such profound ignorance[32] in those professed instructors of mankind, with

[27] Too sweeping a condemnation; the attitudes of Stoics and Epicureans towards 'Nature' differed from that of the 'astronomers' but were far from negligible.

[28] [Cf. LRBL ii.213–14 (ed. Lothian, 175–6), referring to the time of Cicero: 'Rhetoric and Logic or Dialectic were these undoubtedly which had made the greatest progress amongst the ancients, and indeed, if we except a little of Morals, were the only ones which had been tolerably cultivated. These, therefore, were the fashionable sciences . . .']

[29] [*Letters to Atticus*, II.6.1.]

[30] [Like Copernicus (see §28 and note 51 below), Smith assumes the genuineness of the *Placita Philosophorum* preserved among the writings of Plutarch. On its real origin, see J. Burnet, *Early Greek Philosophy*, ed. 3 (1920), 34.]

[31] [*Natural History*, II, especially 54, 95.]

[32] While Cicero would probably have been incapable of following the mathematical

(*continued*)

regard to so important a part of the learning of their own times, is so very remarkable, that I thought it deserved to be taken notice of, even in this short account of the revolutions of philosophy.

19 Systems in many respects resemble machines.[33] A machine is a little system, created to perform, as well as to connect together, in reality, those different movements and effects which the artist has occasion for. A system is an imaginary machine invented to connect together in the fancy those different movements and effects which are already in reality performed. The machines that are first invented to perform any particular movement are always the most complex, and succeeding artists generally discover that, with fewer wheels, with fewer principles of motion, than had originally been employed, the same effects may be more easily produced.[34] The first systems, in the same manner, are always the most complex, and a particular connecting chain, or principle, is generally thought necessary to unite every two seemingly disjointed appearances: but it often happens, that one great connecting principle is afterwards found to be sufficient to bind together all the discordant phaenomena that occur in a whole species of things. How many wheels are necessary to carry on the movements of this imaginary machine, the system of Eccentric Spheres! The westward diurnal revolution of the Firmament, whose rapidity carries all the other heavenly bodies along with it, requires one. The periodical eastward revolutions of the Sun, Moon, and Five Planets, require, for each of those bodies, another. Their differently accelerated and retarded motions require, that those wheels, or circles, should neither be concentric with the Firmament, nor with one another; which, more than any thing, seems to disturb the harmony of the universe. The retrograde and stationary appearance of the Five Planets, as well as the extreme inconstancy of the Moon's motion, require, for each of them, an Epicycle, another little wheel attached to the circumference of the great wheel, which still more interrupts the uniformity of the system. The motion of the apogeum

arguments, his remarks relating to what we might call 'philosophy of science' (e.g. in *De Natura Deorum, De Divinatione*) have a distinctively modern ring.

[33] [Mechanistic analogies were common in the eighteenth century and Smith used them widely. He writes of the universe as like a machine in Ancient Physics, 9, and in TMS I.i.4.2, VII.ii.1.37; and of society similarly in TMS VII.iii.1.2, VII.iii.3.16.]

[34] [Cf. Languages, 41: 'All machines are generally, when first invented, extremely complex in their principles, and there is often a particular principle of motion for every particular movement which it is intended they should perform. Succeeding improvers observe, that one principle may be so applied as to produce several of those movements; and thus the machine becomes gradually more and more simple, and produces its effects with fewer wheels and fewer principles of motion.' Smith compares with this the development of languages from original complexity to later simplicity but considers that, while the process of simplification makes machines 'more and more perfect', it makes languages 'more and more imperfect'. The whole passage recurs in summary form in LRBL i.34*v*. (ed. Lothian, 11).]

of each of those bodies requires, in each of them, still another wheel, to carry the centres of their Eccentric Spheres round the centre of the Earth. And thus, this imaginary machine, though, perhaps, more simple, and certainly better adapted to the phaenomena than the Fifty-six Planetary Spheres of Aristotle, was still too intricate and complex for the imagination to rest in it with complete tranquillity and satisfaction.

20 It maintained its authority, however, without any diminution of reputation, as long as science was at all regarded in the ancient world. After the reign of Antoninus, and, indeed, after the age of Hipparchus, who lived almost three hundred years before Antoninus, the great reputation which the earlier philosophers had acquired, so imposed upon the imaginations of mankind, that they seem to have despaired of ever equalling their renown. All human wisdom, they supposed, was comprehended in the writings of those elder sages. To abridge, to explain, and to comment upon them, and thus show themselves, at least, capable of understanding some of their sublime mysteries, became now the only probable road to reputation. Proclus and Theon wrote commentaries upon the System of Ptolemy;[35] but, to have attempted to invent a new one, would then have been regarded, not only as presumption, but as impiety to the memory of their so much revered predecessors.

21 The ruin of the empire of the Romans, and, along with it, the subversion of all law and order, which happened a few centuries afterwards, produced the entire neglect of that study of the connecting principles of nature, to which leisure and security can alone give occasion.[36] After the fall of those great conquerors and civilizers of mankind, the empire of the Califfs seems to have been the first state under which the world enjoyed that degree of tranquillity which the cultivation of the sciences requires. It was under the protection of those generous and magnificent princes, that the ancient philosophy and astronomy of the Greeks were restored and established in the East; that tranquillity, which their mild,[37] just, and religious government diffused over their vast empire, revived the curiosity of mankind, to inquire into the connecting principles of nature. The fame of the Greek and Roman learning, which was then recent in the memories of men, made them desire to know, concerning these

[35] [Proclus (A.D. 410–85), the Neoplatonist philosopher. His extant works include 'the *Hypotyposis of Astronomical Hypotheses*, a sort of easy and readable introduction to the astronomical system of Hipparchus and Ptolemy' (Heath, *Manual*, 517).
Theon of Alexandria (4th century A.D.) wrote a commentary on Ptolemy's *Syntaxis*. Heath, ibid., 516, explains its value.]

[36] [Cf. III.1 above.]

[37] Smith gives a somewhat optimistic view of Muslim 'toleration'.

abstruse subjects, what were the doctrines of the so much renowned sages of those two nations.

22 They translated, therefore, into the Arabian language, and studied, with great eagerness, the works of many Greek philosophers, particularly of Aristotle, Ptolemy, Hippocrates, and Galen.[38] The superiority which they easily discovered in them, above the rude essays which their own nation[39] had yet had time to produce, and which were such, we may suppose, as arise every where in the first infancy of science, necessarily determined them to embrace their systems, particularly that of Astronomy: neither were they ever afterwards able to throw off their authority. For, though the munificence of the Abassides, the second race of the Califfs, is said to have supplied the Arabian astronomers with larger and better instruments, than any that were known to Ptolemy and Hipparchus, the study of the sciences seems, in that mighty empire, to have been either of too short, or too interrupted a continuance, to allow them to make any considerable correction in the doctrines of those old mathematicians. The imaginations of mankind had not yet got time to grow so familiar with the ancient systems, as to regard them without some degree of that astonishment which their grandeur and novelty excited; a novelty of a peculiar kind, which had at once the grace of what was new, and the authority of what was ancient. They were still, therefore, too much enslaved to those systems, to dare to depart from them, when those confusions which shook, and at last overturned the peaceful throne of the Califfs, banished the study of the sciences from that empire. They had, however, before this, made some considerable improvements: they had measured the obliquity of the Ecliptic, with more accuracy than had been done before. The tables of Ptolemy had, by the length of time, and by the inaccuracy of the observations upon which they were founded, become altogether wide of what was the real situation of the heavenly bodies, as he himself indeed had foretold they would do. It became necessary, therefore, to form new ones, which was accordingly executed by the orders of the Califf Almamon,[40] under whom, too, was made the first mensuration of the Earth that we know of, after the commencement

[38] [At the period in question, many Greek scientific works, especially those of Galen and Hippocrates, were translated into Syriac as well as into Arabic: see M. Meyerhof, in Sir T. Arnold and A. Guillaume (eds.), *The Legacy of Islam* (1931), 316 ff.; E. Gilson, *La Philosophie au moyen âge* (1944), and R. Walzer, 'On the Arabic versions ... of Aristotle's *Metaphysics*', *Harvard Studies in Classical Philology*, lxiii (1958), 218–21.]

[39] The term 'nation' is inappropriate: many of the greatest were Persians.

[40] i.e. al-Ma'mūn (786–833), 7th Abbasid Caliph from 813 until his death. [On the Tables of al-Ma'mūn, see Baron Carra de Vaux in *The Legacy of Islam*, 380–1, chapter on 'Astronomy and Mathematics'.]

of the Christian Aera, by two Arabian astronomers, who, in the plain of Sennaar,[41] measured two degrees of its circumference.

23 The victorious arms of the Saracens carried into Spain the learning, as well as the gallantry, of the East; and along with it, the tables of Almamon, and the Arabian translations of Ptolemy and Aristotle; and thus Europe received a second time, from Babylon, the rudiments of the science of the heavens. The writings of Ptolemy were translated from Arabic into Latin;[42] and the Peripatetic philosophy was studied in Averroes and Avicenna with as much eagerness, and with as much submission to its doctrines in the West, as it had been in the East.[43]

24 The doctrine of the Solid Spheres had, originally, been invented, in order to give a physical account of the revolutions of the heavenly bodies, according to the system of Concentric Circles, to which that doctrine was very easily accommodated. Those mathematicians who invented the doctrine of Eccentric Circles and Epicycles, contented themselves with showing, how, by supposing the heavenly bodies to revolve in such orbits, the phaenomena might be connected together, and some sort of uniformity and coherence be bestowed upon their real motions. The physical causes of those motions they left to the consideration of the philosophers; though, as appears from some passages of Ptolemy, they had some general apprehension, that they were to be explained by a like hypothesis. But, though the system of Hipparchus[44] was adopted by all astronomers and mathematicians, it never was received, as we have already observed, by any one sect of philosophers among the ancients. No attempt, therefore, seems to have been made amongst them, to accommodate to it any such hypothesis.

25 The schoolmen, who received, at once, from the Arabians, the philosophy of Aristotle, and the astronomy of Hipparchus, were necessarily obliged to reconcile them to one another, and to connect together the revolutions of the Eccentric Circles and Epicycles of the one, by the solid Spheres of the other. Many different attempts of this kind were made by many different philosophers: but, of them all, that of Purbach,[45] in the fifteenth century, was the happiest and the most esteemed. Though his hypothesis is the simplest of any of them, it

[41] [The Biblical Shinar. Other accounts say that the measurements were made by two companies of astronomers.]

[42] [On these developments see C. H. Haskins, *Studies in the History of Medieval Science* (1927), especially chap. 1 on translators from the Arabic in Spain, and chap. 5 on twelfth-century writers on astronomy. For the versions of Ptolemy see 103 ff.]

[43] [See Gilson, op. cit., 344–67, 377–90.]

[44] Here and elsewhere Smith fails to stress that it was *Ptolemy's* system (embodying the equant and based on the unsurpassed observations of Hipparchus) that was adopted in 'learned' circles. But see §26 below.

[45] Georg von Peuerbach or Peurbach (1423–61) was of course a humanist, not a 'schoolman'.

would be in vain to describe it without a scheme; neither is it easily intelligible with one: for, if the system of Eccentric Circles and Epicycles was before too perplexed and intricate for the imagination to rest in it, with complete tranquillity and satisfaction, it became much more so, when this addition had been made to it. The world, justly indeed, applauded the ingenuity of that philosopher, who could unite, so happily, two such seemingly inconsistent systems. His labours, however, seem rather to have increased than to have diminished the causes of that dissatisfaction, which the learned soon began to feel with the system of Ptolemy. He, as well as all those who had worked upon the same plan before him, by rendering this account of things more complex, rendered it still more embarrassing than it had been before.

26 Neither was the complexness of this system the sole cause of the dissatisfaction, which the world in general began, soon after the days of Purbach, to express for it. The tables of Ptolemy having, upon account of the inaccuracy of the observations on which they were founded, become altogether wide of the real situation of the heavenly bodies, those of Almamon,[46] in the ninth century, were, upon the same hypothesis, composed to correct their deviations. These again, a few ages afterwards, became, for the same reason, equally useless. In the thirteenth century, Alphonsus, the philosophical king of Castile,[47] found it necessary to give orders for the composition of those tables, which bear his name. It is he, who is so well known for the whimsical impiety of using to say, that, had he been consulted at the creation of the universe, he could have given good advice; an apophthegm which is supposed to have proceeded from his dislike to the intricate system of Ptolemy. In the fifteenth century, the deviation of the Alphonsine tables began to be as sensible, as those of Ptolemy and Almamon had been before. It appeared evident, therefore, that, though the system of Ptolemy might, in the main, be true, certain corrections were necessary to be made in it before it could be brought to correspond with exact precision to the phaenomena.[48] For the revolution of his Eccentric Circles and Epicycles, supposing them to exist, could not, it was evident, be precisely such as he represented them; since the revolutions of the heavenly bodies deviated, in a short time, so widely from what the most exact calculations, that were founded upon his hypothesis, represented them. It had plainly, therefore, become

[46] [See §22 and note 40 above.]

[47] [Alfonso X (b. 1221), 'the Wise', King of Castile and León, 1252–84. See Haskins, op. cit., 16–17, and literature there cited. The legend of his 'whimsical impiety' is of late authority.]

[48] Additional spheres (ninth and tenth) were introduced to account for two (actually imaginary) anomalies in the rotation of the 'eighth sphere' (of the fixed stars). One of these anomalies was 'trepidation', mentioned by Milton, *Paradise Lost*, iii.483.

necessary to correct, by more accurate observations, both the velocities and directions of all the wheels and circles of which his hypothesis is composed. This, accordingly, was begun by Purbach, and carried on by Regiomontanus,[49] the disciple, the continuator, and the perfecter of the system of Purbach; and one, whose untimely death, amidst innumerable projects for the recovery of old, and the invention and advancement of new sciences, is, even at this day, to be regretted.

27 When you have convinced the world, that an established system ought to be corrected, it is not very difficult to persuade them that it should be destroyed. Not long, therefore, after the death of Regiomontanus, Copernicus began to meditate a new system, which should connect together the celestial appearances, in a more simple as well as a more accurate manner, than that of Ptolemy.

28 The confusion, in which the old hypothesis represented the motions of the heavenly bodies, was, he tells us,[50] what first suggested to him the design of forming a new system, that these, the noblest works of nature, might no longer appear devoid of that harmony and proportion which discover themselves in her meanest productions. What most of all dissatisfied him, was, the motion of the Equalizing Circle, which, by representing the revolutions of the Celestial Spheres, as equable only, when surveyed from a point that was different from their centers, introduced a real inequality into their motions; contrary to that most natural, and indeed fundamental idea, with which all the authors of astronomical systems, Plato, Eudoxus, Aristotle, even Hipparchus and Ptolemy themselves, had hitherto set out, that the real motions of such beautiful and divine objects must necessarily be perfectly regular, and go on, in a manner, as agreeable to the imagination, as the objects themselves are to the senses. He began to consider, therefore, whether, by supposing the heavenly bodies to be arranged in a different order from that in which Aristotle and Hipparchus had placed them, this so much sought for uniformity might not be bestowed upon their motions. To discover this arrangement, he examined all the obscure traditions delivered down to us, concerning every other hypothesis which the ancients had invented, for the same purpose. He found, in Plutarch,[51] that some

[49] [Johannes Müller (1436–76) assumed the name of Regiomontanus as the Latinized form of his birthplace, Königsberg (bei Hassfurt, W.Germany). For his life and achievements, see the article in the *Dictionary of Scientific Biography*, vol. xi (1975), 348–52.]

[50] [Preface to *De Revolutionibus Orbium Coelestium.*]

[51] [See Heath, *Aristarchus of Samos*, 301. The relevant passages are in Copernicus' *De Revolutionibus*, I.5, and in the Preface. Copernicus assumed that in the *Placita Philosophorum* he had before him a genuine work of Plutarch (see note 30 above).

He was apparently well aware that in the third century B.C. Aristarchus of Samos had suggested the heliocentric hypothesis, a fact which is unambiguously stated by Archimedes in *The Sand-Reckoner*; but he suppressed a note in which he made reference to this. Thus, in his

(*continued*)

old Pythagoreans had represented the Earth as revolving in the centre of the universe, like a wheel round its own axis; and that others, of the same sect, had removed it from the centre, and represented it as revolving in the Ecliptic like a star round the central fire. By this central fire, he supposed they meant the Sun; and though in this he was very widely mistaken,[52] it was, it seems, upon this interpretation, that he began to consider how such an hypothesis might be made to correspond to the appearances. The supposed authority of those old philosophers, if it did not originally suggest to him his system, seems, at least, to have confirmed him in an opinion, which, it is not improbable, that he had before-hand other reasons for embracing, notwithstanding what he himself would affirm to the contrary.

29 It then occurred to him, that, if the Earth was supposed to revolve every day round its axis, from west to east, all the heavenly bodies would appear to revolve, in a contrary direction, from east to west. The diurnal revolution of the heavens, upon this hypothesis, might be only apparent; the firmament, which has no other sensible motion, might be perfectly at rest; while the Sun, the Moon, and the Five Planets, might have no other movement beside that eastward revolution, which is peculiar to themselves. That, by supposing the Earth to revolve with the Planets, round the Sun, in an orbit, which comprehended within it the orbits of Venus and Mercury, but was comprehended within those of Mars, Jupiter, and Saturn, he could, without the embarrassment of Epicycles,[53] connect together the apparent annual revolutions of the Sun, and the direct, retrograde, and stationary appearances of the Planets: that while the Earth really revolved round the Sun on one side of the heavens, the Sun would appear to revolve round the Earth on the other; that while she really advanced in her annual course, he would appear to advance eastward in that movement which is peculiar to himself. That, by supposing the axis of the Earth to be always parallel to itself, not to be quite perpendicular, but somewhat inclined to the plane of her orbit, and consequently to present to the Sun, the one pole when on the one side

published work, there remains only the mention of *Pythagoreans* who had anticipated him—to the extent that they assigned a planetary movement, as well as axial rotation, to the earth.
Smith has nowhere mentioned the remarkable achievement of Aristarchus. Either it escaped him, or he has deliberately confined himself in this essay to those ancient systems which enjoyed wide influence.]

[52] A perceptive comment in respect of the Sun and 'central fire'—a distinction not always recognized by later historians. But the term 'ecliptic' is here misleading (see the editor's Introduction, 16).

[53] Smith's expression 'without the embarrassment of epicycles', repeated more than once, must be taken to refer only to the shapes and directions of the apparent motions. In order to avoid the use of Ptolemy's equant, Copernicus in fact employed more epicycles than Ptolemy had done. Smith partially corrects this in §53 below.

of him, and the other when on the other, he would account for the obliquity of the Ecliptic; the Sun's seemingly alternate progression from north to south, and from south to north, the consequent change of the seasons, and different lengths of days and nights in the different seasons.

30 If this new hypothesis thus connected together all these appearances as happily as that of Ptolemy, there were others which it connected together much better. The three superior Planets, when nearly in conjunction with the Sun, appear always at the greatest distance from the Earth, are smallest, and least sensible to the eye, and seem to revolve forward in their direct motion with the greatest rapidity. On the contrary, when in opposition to the Sun, that is, when in their meridian about midnight, they appear nearest the Earth, are largest, and most sensible to the eye, and seem to revolve backwards in their retrograde motion. To explain these appearances, the system of Ptolemy supposed each of the these Planets to be at the upper part of their several Epicycles, in the one case; and at the lower, in the other. But it afforded no satisfactory principle of connection, which could lead the mind easily to conceive how the Epicycles of those Planets, whose spheres were so distant from the sphere of the Sun, should thus, if one may say so, keep time to his motion. The system of Copernicus afforded this easily, and like a more simple machine, without the assistance of Epicycles, connected together, by fewer movements, the complex appearances of the heavens. When the superior Planets appear nearly in conjunction with the Sun, they are then in the side of their orbits, which is almost opposite to, and most distant from the Earth, and therefore appear smallest, and least sensible to the eye. But, as they then revolve in a direction which is almost contrary to that of the Earth, they appear to advance forward with double velocity; as a ship, that sails in a contrary direction to another, appears from that other, to sail both with its own velocity, and the velocity of that from which it is seen. On the contrary, when those Planets are in opposition to the Sun, they are on the same side of the Sun with the Earth, are nearest it, most sensible to the eye, and revolve in the same direction with it; but, as their revolutions round the Sun are slower than that of the Earth, they are necessarily left behind by it, and therefore seem to revolve backwards; as a ship which sails slower than another, though it sails in the same direction, appears from that other to sail backwards. After the same manner, by the same annual revolution of the Earth, he connected together the direct and retrograde motions of the two inferior Planets, as well as the stationary appearances of all the Five.

31 There are some other particular phaenomena of the two inferior

Planets, which correspond still better to this system, and still worse to that of Ptolemy. Venus and Mercury seem to attend constantly upon the motion of the Sun, appearing, sometimes on the one side, and sometimes on the other, of that great luminary; Mercury being almost always buried in his rays, and Venus never receding above forty-eight degrees from him, contrary to what is observed in the other three Planets, which are often seen in the opposite side of the heavens, at the greatest possible distance from the Sun. The system of Ptolemy accounted for this, by supposing that the centers of the Epicycles of these two Planets were always in the same line with those of the Sun and the Earth; that they appeared therefore in conjunction with the Sun, when either in the upper or lower part of their Epicycles, and at the greatest distance from him, when in the sides of them. It assigned, however, no reason why the Epicycles of these two Planets should observe so different a rule from that which takes place in those of the other three, nor for the enormous Epicycle of Venus, whose sides must have been forty-eight degrees distant from the Sun, while its center was in conjunction with him, and whose diameter must have covered more than a quadrant of the Great Circle. But how easily all these appearances coincide with the hypothesis, which represents those two inferior Planets revolving round the Sun in orbits comprehended within the orbit of the Earth, is too obvious to require an explanation.

32 Thus far did this new account of things render the appearances of the heavens more completely coherent than had been done by any of the former systems. It did this, too, by a more simple and intelligible, as well as more beautiful machinery. It represented the Sun, the great enlightener of the universe, whose body was alone larger than all the Planets taken together, as established immoveable in the center, shedding light and heat on all the worlds that circulated around him in one uniform direction, but in longer or shorter periods, according to their different distances. It took away the diurnal revolution of the firmament, whose rapidity, upon the old hypothesis, was beyond what even thought could conceive. It not only delivered the imagination from the embarrassment of Epicycles, but from the difficulty of conceiving these two opposite motions going on at the same time, which the system of Ptolemy and Aristotle bestowed upon all the Planets; I mean, their diurnal westward, and periodical eastward revolutions. The Earth's revolution round its own axis took away the necessity for supposing the first, and the second was easily conceived when by itself. The Five Planets, which seem, upon all other systems, to be objects of a species by themselves, unlike to every thing to which the imagination has been accustomed, when supposed

to revolve along with the Earth round the Sun, were naturally apprehended to be objects of the same kind with the Earth, habitable, opaque, and enlightened only by the rays of the Sun. And thus this hypothesis, by classing them in the same species of things, with an object that is of all others the most familiar to us, took off that wonder and uncertainty which the strangeness and singularity of their appearance had excited; and thus far, too, better answered the great end of Philosophy.

33 Neither did the beauty and simplicity[54] of this system alone recommend it to the imagination; the novelty and unexpectedness of that view of nature, which it opened to the fancy, excited more wonder and surprise than the strangest of those appearances, which it had been invented to render natural and familiar, and these sentiments still more endeared it. For, though it is the end of Philosophy, to allay that wonder, which either the unusual or seemingly disjointed appearances of nature excite, yet she never triumphs so much, as when, in order to connect together a few, in themselves, perhaps, inconsiderable objects, she has, if I may say so, created another constitution of things, more natural indeed, and such as the imagination can more easily attend to, but more new, more contrary to common opinion and expectation, than any of those appearances themselves. As, in the instance before us, in order to connect together some seeming irregularities in the motions of the Planets, the most inconsiderable objects in the heavens, and of which the greater part of mankind have no occasion to take any notice during the whole course of their lives,[55] she has, to talk in the hyperbolical language of Tycho-Brache, moved the Earth from its foundations, stopt the revolution of the Firmament, made the Sun stand still, and subverted the whole order of the Universe.[56]

34 Such were the advantages of this new hypothesis, as they appeared to its author, when he first invented it. But, though that love of paradox, so natural to the learned, and that pleasure, which they are so apt to take in exciting, by the novelty of their supposed discoveries, the amazement of mankind, may, notwithstanding what one of his disciples tells us to the contrary, have had its weight in prompting Copernicus to adopt this system; yet, when he had completed his

[54] 'Simple' only to a first approximation.

[55] It was of course for the more accurate calculations of the positions of the planets that the greater part of astronomy up to and including the Renaissance had been undertaken.

[56] [This appears to be a distorted report at second hand or possibly a confusion between Tycho Brahe and someone else. The supposed quotation is uncharacteristic of Tycho, who is usually respectful to Copernicus, even though he was ready to describe both the Copernican and the Ptolemaic systems as 'absurd'.]

Smith's spelling of the name, here and elsewhere, though representing more nearly the Danish pronunciation, is corrected in the Dublin edition of the same year.

Treatise of Revolutions,[57] and began coolly to consider what a strange doctrine he was about to offer to the world, he so much dreaded the prejudice of mankind against it, that, by a species of continence, of all others the most difficult to a philosopher, he detained it in his closet for thirty years together.[58] At last, in the extremity of old age, he allowed it to be extorted from him,[59] but died as soon as it was printed,[60] and before it was published.

35 When it appeared in the world, it was almost universally disapproved of, by the learned as well as by the ignorant. The natural prejudices of sense, confirmed by education, prevailed too much with both, to allow them to give it a fair examination. A few disciples only, whom he himself had instructed in his doctrine, received it with esteem and admiration. One of them, Reinholdus,[61] formed, upon this hypothesis, larger and more accurate astronomical tables, than what accompanied the Treatise of Revolutions, in which Copernicus had been guilty of some errors in calculation. It soon appeared, that these Prutenic Tables, as they were called, corresponded more exactly with the heavens, than the Tables of Alphonsus. This ought naturally to have formed a prejudice in favour of the diligence and accuracy of Copernicus in observing the heavens. But it ought to have formed none in favour of his hypothesis; since the same observations, and the result of the same calculations, might have been accommodated to the system of Ptolemy, without making any greater alteration in that system than what Ptolemy had foreseen, and had even foretold should be made. It formed, however, a prejudice in favour of both, and the learned begin to examine, with some attention, an hypothesis which afforded the easiest methods of calculation, and upon which the most exact predictions had been made. The superior degree of coherence, which it bestowed upon the celestial appearances, the simplicity and uniformity which it introduced into the real directions and velocities of the Planets, soon disposed many astronomers, first

[57] In fact the *Commentariolus* (not the *De Revolutionibus*), privately circulated in 1514. Only three near-contemporary MSS. of the *Commentariolus* are known, one recently discovered in the University of Aberdeen. It is not to be confused with the *Narratio Prima* written by his disciple Rheticus.

[58] [A striking exception to Smith's generalization, in TMS III.2.20, that mathematicians and natural philosophers, 'who may have the most perfect assurance, both of the truth and of the importance of their discoveries, are frequently very indifferent about the reception they may meet with from the public'.]

[59] Rheticus circulated his *Narratio Prima* in 1540 to test the likely reception of a full account that he was trying to persuade Copernicus to publish. The Lutheran pastor, Andreas Osiander, who saw Copernicus' great work through the press, categorically stated (anonymously, as if by Copernicus himself) that the system was not to be taken as 'physically' true. Erasmus Reinhold, as Smith states, used the system as a basis for calculating the Prutenic tables, but it now appears doubtful whether he accepted the system except as a basis for this calculation.

[60] i.e. the *De Revolutionibus Orbium Coelestium* (1543).

[61] [Erasmus Reinhold (1511–53), author of *Prutenicae Tabulae Coelestium Motum* (1551), which were adopted as the basis for the Gregorian reform of the Julian calendar in 1583.]

to favour, and at last to embrace a system, which thus connected together so happily, the most disjointed of those objects that chiefly occupied their thoughts. Nor can any thing more evidently demonstrate, how easily the learned give up the evidence of their senses to preserve the coherence of the ideas of their imagination, than the readiness with which this, the most violent paradox in all philosophy, was adopted by many ingenious astronomers, notwithstanding its inconsistency with every sistem of physics then known in the world, and notwithstanding the great number of other more real objections, to which, as Copernicus left it, this account of things was most justly exposed.

36 It was adopted, however, nor can this be wondered at, by astronomers only.[62] The learned in all other sciences, continued to regard it with the same contempt as the vulgar. Even astronomers were divided about its merit; and many of them rejected a doctrine, which not only contradicted the established system of Natural Philosophy, but which, considered astronomically only, seemed to labour under several difficulties.

37 Some of the objections against the motion of the Earth, that were drawn from the prejudices of sense, the patrons of this system, indeed, easily enough, got over. They represented, that the Earth might really be in motion, though, to its inhabitants, it seemed to be at rest; and that the Sun, and Fixed Stars, might really be at rest, though from the Earth they seemed to be in motion; in the same manner as a ship,[63] which sails through a smooth sea, seems to those who are in it, to be at rest, though really in motion; while the objects which she passes along, seem to be in motion, though really at rest.

38 But there were some other objections, which, though grounded upon the same natural prejudices, they found it more difficult to get over. The Earth had always presented itself to the senses, not only as at rest, but as inert, ponderous, and even averse to motion. The imagination had always been accustomed to conceive it as such, and suffered the greatest violence, when obliged to pursue, and attend it, in that rapid motion which the system of Copernicus bestowed upon it.[64] To enforce their objection, the adversaries of this hypothesis

[62] This is a very interesting and perceptive assessment. The alleged acceptance by 'astronomers only' is indeed a serious historical mis-statement: Thomas Digges, Robert Recorde, Reinerus Gemma, and especially Giordano Bruno, were none of them 'astronomers' except in a loose sense; no 'professional' except Rheticus accepted it until the seventeenth century. Nevertheless, this rather gives force to Smith's *philosophical* approach.

[63] As Copernicus, *De Revolutionibus*, I.8 (following Virgil, *Aeneid*, iii.72), had noticed.

[64] [Cf. External Senses, 12: 'Great masses, perhaps, are, according to the ordinary habits of the imagination, supposed to be more fitted for rest than for motion.' Smith then goes on to say that the teaching of modern science makes it 'scarcely possible to refuse our [rational] assent' to the motion of the earth 'with a rapidity that almost passes all human comprehension'.]

were at pains to calculate the extreme rapidity of this motion. They represented, that the circumference of the Earth had been computed to be above twenty-three thousand miles: if the Earth, therefore, was supposed to revolve every day round its axis, every point of it near the equator would pass over above twenty-three thousand miles in a day; and consequently, near a thousand miles in an hour, and about sixteen miles in a minute; a motion more rapid than that of a cannon ball, or even than the swifter progress of sound. The rapidity of its periodical revolution was yet more violent than that of its diurnal rotation. How, therefore, could the imagination ever conceive so ponderous a body to be naturally endowed with so dreadful a movement? The Peripatetic Philosophy, the only philosophy then known in the world,[65] still further confirmed this prejudice. That philosophy, by a very natural, though, perhaps, groundless distinction, divided all motion into Natural and Violent. Natural motion was that which flowed from an innate tendency in the body, as when a stone fell downwards: Violent motion, that which arose from external force, and which was, in some measure, contrary to the natural tendency of the body, as when a stone was thrown upwards, or horizontally. No violent motion could be lasting; for, being constantly weakened by the natural tendency of the body, it would soon be destroyed. The natural motion of the Earth, as was evident in all its parts, was downwards, in a strait line to the center; as that of fire and air was upwards, in a strait line from the center. It was the heavens only that revolved naturally in a circle. Neither, therefore, the supposed revolution of the Earth round its own center, nor that round the Sun, could be natural motions; they must therefore be violent, and consequently could be of no long continuance. It was in vain that Copernicus replied,[66] that gravity was, probably, nothing else besides a tendency in the different parts of the same Planet, to unite themselves to one another; that this tendency took place, probably, in the parts of the other Planets, as well as in those of the Earth; that it could very well be united with a circular motion; that it might be equally natural to the whole body of the Planet, and to every part of it; that his adversaries themselves allowed, that a circular motion was natural to the heavens, whose diurnal revolution was infinitely more rapid than even that motion which he had bestowed upon the Earth; that though a like motion was natural to the Earth,

[65] It is largely true that the 'schools' (i.e. the universities) confined themselves to the Peripatetic (i.e. the Aristotelian) philosophy; but the powerful strain of Neoplatonism (largely mediated through the Hermetic philosophy) should not be overlooked. The consequential 'wind' had been considered by Ptolemy; see §40 below.

[66] [*De Revolutionibus*, I.9.]

it would still appear to be at rest to its inhabitants, and all the parts of it to tend in a strait line to the center, in the same manner as at present. But this answer, how satisfactory soever it may appear to be now, neither did nor could appear to be satisfactory then. By admitting the distinction betwixt natural and violent motions, it was founded upon the same ignorance of mechanical principles with the objection. The systems of Aristotle and Hipparchus supposed, indeed, the diurnal motion of the heavenly bodies to be infinitely more rapid than even that dreadful movement which Copernicus bestowed upon the Earth. But they supposed, at the same time, that those bodies were objects of a quite different species, from any we are acquainted with, near the surface of the Earth, and to which, therefore, it was less difficult to conceive that any sort of motion might be natural. Those objects, besides, had never presented themselves to the senses, as moving otherwise, or with less rapidity, than these systems represented them. The imagination, therefore, could feel no difficulty in following a representation which the senses had rendered quite familiar to it. But when the Planets came to be regarded as so many Earths, the case was quite altered. The imagination had been accustomed to conceive such objects as tending rather to rest than motion; and this idea of their natural inertness, encumbered, if one may say so, and clogged its flight, whenever it endeavoured to pursue them in their periodical courses, and to conceive them as continually rushing through the celestial spaces, with such violent and unremitting rapidity.

39 Nor were the first followers of Copernicus more fortunate in their answers to some other objections, which were founded indeed in the same ignorance of the laws of motion, but which, at the same time, were necessarily connected with that way of conceiving things, which then prevailed universally in the learned world.

40 If the Earth, it was said, revolved so rapidly from west to east, a perpetual wind would set in from east to west, more violent than what blows in the greatest hurricanes; a stone, thrown westwards, would fly to a much greater distance than one thrown with the same force eastwards; as what moved in a direction, contrary to the motion of the Earth, would necessarily pass over a greater portion of its surface, than what, with the same velocity, moved along with it. A ball, it was said, dropt from the mast of a ship under sail, does not fall precisely at the foot of the mast, but behind it; and in the same manner, a stone dropt from a high tower would not, upon the supposition of the Earth's motion, fall precisely at the bottom of the tower, but west of it, the Earth being, in the mean time, carried away eastward from below it. It is amusing to observe, by what subtile and

metaphysical evasions the followers of Copernicus endeavoured to elude this objection, which, before the doctrine of the Composition of Motion had been explained by Galileo,[67] was altogether unanswerable. They allowed, that a ball dropt from the mast of a ship under sail would not fall at the foot of the mast, but behind it; because the ball, they said, was no part of the ship, and because the motion of the ship was natural neither to itself nor to the ball. But the stone was a part of the earth, and the diurnal and annual revolutions of the Earth were natural to the whole, and to every part of it, and therefore to the stone. The stone, therefore, having naturally the same motion with the Earth, fell precisely at the bottom of the tower. But this answer could not satisfy the imagination, which still found it difficult to conceive how these motions could be natural to the Earth; or how a body, which had always presented itself to the senses as inert, ponderous, and averse to motion, should naturally be continually wheeling about both its own axis and the Sun, with such violent rapidity. It was, besides, argued by Tycho Brache, upon the principles of the same philosophy, which had afforded both the objection and the answer, that even upon the supposition, that any such motion was natural to the whole body of the Earth, yet the stone, which was separated from it, could no longer be actuated by that motion. The limb, which is cut off from an animal, loses those animal motions which were natural to the whole. The branch, which is cut off from the trunk, loses that vegetative motion which is natural to the whole tree. Even the metals, minerals, and stones, which are dug out from the bosom of the Earth, lose those motions which occasioned their production and encrease, and which were natural to them in their original state. Though the diurnal and annual motion of the Earth, therefore, had been natural to them while they were contained in its bosom; it could no longer be so when they were separated from it.

41 Tycho Brache, the great restorer of the science of the heavens, who had spent his life, and wasted his fortune upon the advancement of Astronomy,[68] whose observations were both more numerous and more accurate than those of all the astronomers who had gone before him, was himself so much affected by the force of this objection, that, though he never mentioned the system of Copernicus without some note of the high admiration he had conceived for its author, he could never himself be induced to embrace it: yet all his astronomical observations tended to confirm it. They demonstrated, that Venus

[67] [*Discourses on Two New Sciences*, IV; in *Opere* (National Edition, Florence, 1890–1910), viii. 268 ff.]

[68] Tycho Brahe is to be regarded less as the 'restorer' of astronomy than, at least as an observer, the first of the 'moderns'. Also, in the pursuit of his passion he 'wasted' not only his own 'fortunes' but those of his defenceless tenants.

and Mercury were sometimes above, and sometimes below the Sun; and that, consequently, the Sun, and not the Earth, was the center of their periodical revolutions. They showed, that Mars, when in his meridian at midnight, was nearer to the Earth than the Earth is to the Sun; though, when in conjunction with the Sun, he was much more remote from the Earth than that luminary; a discovery which was absolutely inconsistent with the system of Ptolemy, which proved, that the Sun, and not the Earth, was the center of the periodical revolutions of Mars, as well as of Venus and Mercury; and which demonstrated, that the Earth was placed betwixt the orbits of Mars and Venus. They made the same thing probable with regard to Jupiter and Saturn; that they, too, revolved round the Sun; and that, therefore, the Sun, if not the center of the universe, was at least, that of the planetary system. They proved, that Comets were superior to the Moon, and moved through the heavens in all possible directions; an observation incompatible with the Solid Spheres of Aristotle and Purbach, and which, therefore, overturned the physical part, at least, of the established Astronomy.

42 All these observations, joined to his aversion to the system, and perhaps, notwithstanding the generosity of his character, some little jealousy of the fame of Copernicus, suggested to Tycho the idea of a new hypothesis,[69] in which the Earth continued to be, as in the old account, the immoveable center of the universe, round which the firmament revolved every day from east to west, and, by some secret virtue, carried the Sun, the Moon, and the Five Planets along with it, notwithstanding their immense distance, and notwithstanding that there was nothing betwixt it and them but the most fluid ether. But, although all these seven bodies thus obeyed the diurnal revolution of the Firmament, they had each of them, as in the old system, too, a contrary periodical eastward revolution of their own, which made them appear to be every day, more or less, left behind by the Firmament. The Sun was the center of the periodical revolutions of the Five Planets; the Earth, that of the Sun and Moon. The Five Planets followed the Sun in his periodical revolution round the Earth, as they did the Firmament in its diurnal rotation. The three superior Planets comprehended the Earth within the orbit in which they revolved round the Sun, and had each of them an Epicycle to connect together, in the same manner as in the system of Ptolemy, their direct, retrograde, and stationary appearances. As, notwithstanding their immense distance, they followed the Sun in his periodical revolution round the Earth, keeping always at an equal distance from

[69] Tycho's hypothesis was not altogether 'new'. See the editor's Introduction, 18–19.

him, they were necessarily brought much nearer to the Earth when in opposition to the Sun, than when in conjunction with him. Mars, the nearest of them, when in his meridian at midnight, came within the orbit which the Sun described round the Earth, and consequently was then nearer to the Earth than the Earth was to the Sun. The appearances of the two inferior Planets were explained, in the same manner, as in the system of Copernicus, and consequently required no Epicycle to connect them. The circles in which the Five Planets performed their periodical revolutions round the Sun, as well as those in which the Sun and Moon performed theirs round the Earth, were, as both in the old and new hypothesis, Eccentric Circles, to connect together their differently accelerated and retarded motions.

43 Such was the system of Tycho Brache, compounded, as is evident, out of these of Ptolemy and Copernicus; happier than that of Ptolemy, in the account which it gives of the motions of the two inferior Planets; more complex, by supposing the different revolutions of all the Five to be performed round two different centers; the diurnal round the Earth, the periodical round the Sun; but, in every respect, more complex and more incoherent than that of Copernicus. Such, however, was the difficulty that mankind felt in conceiving the motion of the Earth, that it long balanced the reputation of that otherwise more beautiful system. It may be said, that those who considered the heavens only, favoured the system of Copernicus, which connected so happily all the appearances which presented themselves there. But that those who looked upon the Earth, adopted the account of Tycho Brache, which, leaving it at rest in the center of the universe, did less violence to the usual habits of the imagination. The learned were, indeed, sensible of the intricacy, and of the many incoherences of that system; that it gave no account why the Sun, Moon, and Five Planets, should follow the revolution of the Firmament; or why the Five Planets, notwithstanding the immense distance of the three superior ones, should obey the periodical motion of the Sun; or why the earth, though placed between the orbits of Mars and Venus, should remain immoveable in the center of the Firmament, and constantly resist the influence of whatever it was, which carried bodies that were so much larger than itself, and that were placed on all sides of it, periodically round the Sun. Tycho Brahe died before he had fully explained his system. His great and merited renown disposed many of the learned to believe, that, had his life been longer, he would have connected together many of these incoherences, and knew methods of adapting his system to some other appearances, with which none of his followers could connect it.

44 The objection to the system of Copernicus, which was drawn from

the nature of motion, and that was most insisted on by Tycho Brahe, was at last fully answered by Galileo; not, however, till about thirty years after the death of Tycho, and about a hundred after that of Copernicus. It was then that Galileo, by explaining the nature of the composition of motion, by showing, both from reason and experience, that a ball dropt from the mast of a ship under sail would fall precisely at the foot of the mast, and by rendering this doctrine, from a great number of other instances, quite familiar to the imagination, took off, perhaps, the principal objection which had been made to this hypothesis.

45 Several other astronomical difficulties, which encumbered this account of things, were removed by the same philosopher. Copernicus, after altering the center of the world, and making the Earth, and all the Planets revolve round the Sun, was obliged to leave the Moon to revolve round the Earth as before. But no example of any such secondary Planet having then been discovered in the heavens, there seemed still to be this irregularity remaining in the system. Galileo, who first applied telescopes to Astronomy,[70] discovered, by their assistance, the Satellites of Jupiter, which, revolving round that Planet, at the same time that they were carried along with it in its revolution, round either the Earth, or the Sun, made it seem less contrary to the analogy of nature, that the Moon should both revolve round the Earth, and accompany her in her revolution round the Sun.

46 It had been objected to Copernicus, that, if Venus and Mercury revolved round the Sun, in an orbit comprehended within the orbit of the Earth, they would show all the same phases with the Moon, present, sometimes their darkened, and sometimes their enlightened sides to the Earth, and sometimes part of the one, and part of the other. He answered, that they undoubtedly did all this; but that their smallness and distance hindered us from perceiving it. This very bold assertion of Copernicus was confirmed by Galileo.[71] His telescopes rendered the phases of Venus quite sensible, and thus demonstrated, more evidently than had been done, even by the

[70] The absolute priority of Galileo in turning the newly invented telescope on the heavens is now questioned. The Englishman, Thomas Harriot (1560–1621), was observing the Moon independently about the same time.

[71] [Galileo's discovery of the phases of Venus was first announced in his letter of 1 January 1610/11 to Giuliano de' Medici, Ambassador of the Duke of Tuscany at the Court of the Emperor Rudolph II in Prague. It is published in Galileo's *Opere* (National Edition), xi.11–12. His description of the mountains and seas on the Moon had, however, already been published in his *Sidereus Nuncius*, 1610 (*Opere*, iii.59 ff.). Smith's reference to these discoveries in non-chronological order might imply that he followed the description in Colin Maclaurin's *Account of Sir Isaac Newton's Discoveries*, 54. See § 58 and note 94 below.]

observations of Tycho Brahe, the revolutions of these two Planets round the Sun, as well as so far destroyed the system of Ptolemy.

47 The mountains and seas, which, by the help of the same instrument, he discovered, or imagined he had discovered in the Moon, rendering that Planet, in every respect, similar to the Earth, made it seem less contrary to the analogy of nature, that, as the Moon revolved round the Earth, the Earth should revolve round the Sun.

48 The spots which, in the same manner, he discovered in the Sun, demonstrating, by their motion, the revolution of the Sun round his axis, made it seem less improbable that the Earth, a body so much smaller than the Sun, should revolve round her axis in the same manner.

49 Succeeding telescopical observations, discovered, in each of the Five Planets, spots not unlike those which Galileo had observed in the Moon, and thereby seemed to demonstrate what Copernicus had only conjectured, that the Planets were naturally opaque, enlightened only by the rays of the Sun, habitable, diversified by seas and mountains, and, in every respect, bodies of the same kind with the Earth; and thus added one other probability to this system. By discovering, too, that each of the Planets revolved round its own axis, at the same time that it was carried round either the Earth or the Sun, they made it seem quite agreeable to the analogy of nature, that the Earth, which, in every other respect, resembled the Planets, should, like them too, revolve round its own axis, and at the same time perform its periodical motion round the Sun.

50 While, in Italy, the unfortunate Galileo was adding so many probabilities to the system of Copernicus, there was another philosopher employing himself in Germany, to ascertain, correct, and improve it: Kepler, with great genius, but without the taste, or the order and method of Galileo, possessed, like all his other countrymen, the most laborious industry, joined to that passion for discovering proportions and resemblances betwixt the different parts of nature, which, though common to all philosophers, seems, in him, to have been excessive. He had been instructed, by Maestlinus,[72] in the system of Copernicus; and his first curiosity was, as he tells us, to find out, why the Planets, the Earth being counted for one, were Six in number; why they were placed at such irregular distances from the Sun; and whether there was any uniform proportion betwixt their several distances, and the times employed in their periodical revolutions. Till some reason, or proportion of this kind, could be

[72] [Michael Maestlin (1550–1631), Professor of Mathematics at Tübingen, where he taught and became friendly with Kepler.]

discovered, the system did not appear to him to be completely coherent.[73] He endeavoured, first, to find it in the proportions of numbers, and plain figures; afterwards, in those of the regular solids; and, last of all, in those of the musical divisions of the Octave. Whatever was the science which Kepler was studying, he seems constantly to have pleased himself with finding some analogy betwixt it and the system of the universe;[74] and thus, arithmetic and music, plain and solid geometry, came all of them by turns to illustrate the doctrine of the Sphere, in the explaining of which he was, by his profession, principally employed. Tycho Brahe, to whom he had presented one of his books, though he could not but disapprove of his system, was pleased, however, with his genius, and with his indefatigable diligence in making the most laborious calculations. That generous and magnificent Dane invited the obscure and indigent Kepler to come and live with him,[75] and communicated to him, as soon as he arrived, his observations upon Mars, in the arranging and methodizing of which his disciples were at that time employed. Kepler, upon comparing them with one another, found, that the orbit of Mars was not a perfect circle; that one of its diameters was somewhat longer than the other; and that it approached to an oval, or an ellipse, which had the Sun placed in one of its foci. He found, too, that the motion of the Planet was not equable; that it was swiftest when nearest the Sun, and slowest when furthest from him; and that its velocity gradually encreased, or diminished, according as it approached or receded from him. The observations of the same astronomer discovered to him, though not so evidently, that the same things were true of all the other Planets; that their orbits were elliptical, and that their motions were swiftest when nearest the Sun, and slowest when furthest from him. They showed the same things, too, of the Sun, if supposed to revolve round the Earth; and consequently of the Earth, if supposed to revolve round the Sun.[76]

51 That the motions of all the heavenly bodies were perfectly circular, had been the fundamental idea, upon which every astronomical hypothesis, except the irregular one of the Stoics, had been built. A

[73] Smith omits to mention the most intractable objection to the Copernican system, the absence of any observed stellar parallax, i.e. the inference that if the Earth moves round the Sun, every star should be seen to make a roughly circular revolution once a year in the opposite sense. The absence of any such observed motion implied a then inconceivable distance of the stars from the Earth. Such stellar parallax was not measured until 1838.

[74] [Cf. II.4 above.]

[75] Kepler was indeed usually 'indigent', since his employers were commonly reluctant or unable to pay up; but when invited by Tycho to join him as an assistant, Kepler was already far from 'obscure'.

[76] Smith's account of Kepler's work, though highly condensed and chronologically 're-arranged', is substantially correct.

circle, as the degree of its curvature is every where the same, is of all curve lines the simplest and the most easily conceived.[77] Since it was evident, therefore, that the heavenly bodies did not move in strait lines, the indolent imagination found, that it could most easily attend to their motions if they were supposed to revolve in perfect circles. It had, upon this account, determined that a circular motion was the most perfect of all motions, and that none but the most perfect motion could be worthy of such beautiful and divine objects; and it had upon this account, so often, in vain, endeavoured to adjust to the appearances, so many different systems, which all supposed them to revolve in this manner.[78]

52 The equality of their motions was another fundamental idea, which, in the same manner, and for the same reason, was supposed by all the founders of astronomical systems. For an equal motion can be more easily attended to, than one that is continually either accelerated or retarded. All inconstancy, therefore, was declared to be unworthy those bodies which revolved in the celestial regions, and to be fit only for inferior and sublunary things. The calculations of Kepler overturned, with regard to the Planets, both these natural prejudices of the imagination; destroyed their circular orbits; and introduced into their real motions, such an inequality as no equalizing circle would remedy. It was, however, to render their motions perfectly equable, without even the assistance of an equalizing circle, that Copernicus, as he himself assures us, had originally invented his system. Since the calculations of Kepler, therefore, overturned what Copernicus had principally in view in establishing his system, we cannot wonder that they should at first seem rather to embarrass than improve it.

53 It is true, by these elliptical orbits and unequal motions, Kepler disengaged the system from the embarrassment of those small Epicycles, which Copernicus, in order to connect the seemingly accelerated and retarded movements of the Planets with their supposed real equality,[79] had been obliged to leave in it. For it is remarkable, that though Copernicus had delivered the orbits of the Planets from the enormous Epicycles of Hipparchus, that though in this consisted the great superiority of his system above that of the ancient astronomers, he was yet obliged, himself, to abandon, in some

[77] [Cf. LJ(A) vi.14: 'the constantly varying direction of the circle, which at the same time is allways similar and easily conceived, is preferred to the more varied figures of the elipse, parabola, and hyperbola, and the Archimedean spirrall, . . . as it is more easily conceved than these, whose nature can not at first sight be understood.']

[78] There is a good deal of special pleading, if not of actual inconsistency, in the argument as set out here.

[79] For 'equality' read 'uniformity'.

measure, this advantage, and to make use of some small Epicycles, to join together those seeming irregularities. His Epicycles indeed, like the irregularities for whose sake they were introduced, were but small ones, and the imaginations of his first followers seem, accordingly, either to have slurred them over altogether, or scarcely to have observed them. Neither Galileo, nor Gassendi, the two most eloquent of his defenders, take any notice of them. Nor does it seem to have been generally attended to, that there was any such thing as Epicycles in the system of Copernicus, till Kepler, in order to vindicate his own elliptical orbits, insisted, that even, according to Copernicus, the body of the Planet was to be found but at two different places in the circumference of that circle which the center of its Epicycle described.

54 It is true, too, that an ellipse is, of all curves lines after a circle, the simplest and most easily conceived; and it is true, besides all this, that, while Kepler took from the motion of the Planets the easiest of all proportions, that of equality, he did not leave them absolutely without one, but ascertained the rule by which their velocities continually varied; for a genius so fond of analogies, when he had taken away one, would be sure to substitute another in its room. Notwithstanding all this, notwithstanding that his system was better supported by observations than any system had ever been before, yet, such was the attachment to the equal motions and circular orbits of the Planets, that it seems, for some time, to have been in general but little attended to by the learned, to have been altogether neglected by philosophers, and not much regarded even by astronomers.[80]

55 Gassendi,[81] who began to figure in the world about the latter days of Kepler, and who was himself no mean astronomer, seems indeed to have conceived a good deal of esteem for his diligence and accuracy in accommodating the observations of Tycho Brahe to the system of Copernicus. But Gassendi appears to have had no comprehension of the importance of those alterations which Kepler had made in that system, as is evident from his scarcely ever mentioning them in the whole course of his voluminous writings upon Astronomy. Des Cartes, the cotemporary and rival of Gassendi, seems to have paid no attention to them at all, but to have built his Theory of the Heavens,[82] without any regard to them. Even those astronomers, whom a serious

[80] For a recent reassessment of the response to Kepler's 'new astronomy' see J. Russell, S. J., 'Kepler's Laws of Planetary Motion, 1609–1666', *British Journal of the History of Science*, ii (1964), 1–24.

[81] [Pierre Gassendi (1592–1655), best known as a philosopher, but also, as Smith implies, a scientist of some repute.]

[82] [In *Le Monde*, completed in 1633 but not published (presumably because of its acceptance of the Copernican system of astronomy which Galileo had just been forced to recant) until 1664, (*continued*)

attention had convinced of the justness of his corrections, were still so enamoured with the circular orbits and equal motions, that they endeavoured to compound his system with those ancient, but natural prejudices. Thus, Ward[83] endeavoured to show that, though the Planets moved in elliptical orbits, which had the Sun in one of their foci, and though their velocities in the elliptical line were continually varying, yet, if a ray was supposed to be extended from the center of any one of them to the other focus, and to be carried along by the periodical motion of the Planet, it would make equal angles in equal times, and consequently cut off equal portions of the circle of which that other focus was the center. To one, therefore, placed in that focus, the motion of the Planet would appear to be perfectly circular and perfectly equable, in the same manner as in the Equalizing Circles of Ptolemy and Hipparchus. Thus Bouillaud,[84] who censured this hypothesis of Ward, invented another of the same kind, infinitely more whimsical and capricious. The Planets, according to that astronomer, always revolve in circles; for that being the most perfect figure, it is impossible they should revolve in any other. No one of them, however, continues to move in any one circle, but is perpetually passing from one to another, through an infinite number of circles, in the course of each revolution; for an ellipse, said he, is an oblique section of a cone, and in a cone, betwixt the two vertices[85] of the ellipse there is an infinite number of circles, out of the infinitely small portions of which the elliptical line is compounded. The Planet, therefore, which moves in this line, is, in every point of it, moving in an infinitely small portion of a certain circle. The motion of each Planet, too, according to him, was necessarily, for the same reason, perfectly equable. An equable motion being the most perfect of all motions. It was not, however, in the elliptical line, that it was equable, but in any one of the circles that were parallel to the base of that cone, by whose section this elliptical line had been formed: for, if a ray was extended from the Planet to any one of those circles, and carried along by its periodical motion, it would cut off equal portions of that circle in equal times; another most fantastical equalizing circle, supported by no other foundation besides the frivolous connection

long after the death of its author. The basic doctrines of the work were nevertheless embodied in *Principia Philosophiae* (1664).]

[83] Seth Ward (1617–89) Savilian Professor of Astronomy at Oxford, Founder Fellow of the Royal Society, and Bishop of Exeter.

[84] Ismael Boulliau (various spellings, also known as Bullialdus—1605–94), author of *Astronomia Philolaica* (1645), was the first to apply the inverse square to planetary motion. [Ward criticized it in a work entitled *In Ismaelis Bullialdi Astronomiae Philolaicae Fundamenta Inquisitio Brevis* (1653) and Boulliau replied in *Astronomiae Philolaicae Fundamenta clarius explicata ... Adversa ... Sethi Wardi impugnationem* (1657).]

[85] [The text of the original edition has 'vortices', presumably a printer's error.]

betwixt a cone and an ellipse, and recommended by nothing but the natural passion for circular orbits and equable motions. It may be regarded as the last effort of this passion, and may[86] serve to show the force of that principle which could thus oblige this accurate observer, and great improver of the Theory of the Heavens, to adopt so strange an hypothesis. Such was the difficulty and hesitation with which the followers of Copernicus adopted the corrections of Kepler.

56 The rule, indeed, which Kepler ascertained[87] for determining the gradual acceleration or retardation in the movement of the Planets, was intricate, and difficult to be comprehended; it could therefore but little facilitate the progress of the imagination in tracing those revolutions which were supposed to be conducted by it. According to that astronomer, if a strait line was drawn from the center of each Planet to the Sun, and carried along by the periodical motion of the Planet, it would describe equal areas in equal times, though the Planet did not pass over equal spaces; and the same rule, he found, took place nearly with regard to the Moon. The imagination, when acquainted with the law by which any motion is accelerated or retarded, can follow and attend to it more easily, than when at a loss, and, as it were, wandering in uncertainty with regard to the proportion which regulates its varieties; the discovery of this analogy[88] therefore, no doubt, rendered the system of Kepler more agreeable to the natural taste of mankind: it was, however, an analogy too difficult to be followed, or comprehended, to render it completely so.

57 Kepler, besides this, introduced another new analogy into the system,[89] and first discovered, that there was one uniform relation observed betwixt the distances of the Planets from the Sun, and the times employed in their periodical motions. He found, that their periodical times were greater than in proportion to their distances, and less than in proportion to the squares of those distances; but, that they were nearly as the mean proportionals betwixt their distances and the squares of their distances; or, in other words, that the squares of their periodical times were nearly as the cubes of their distances;[90] an analogy, which, though, like all others, it no doubt rendered the system somewhat more distinct and comprehensible, was, however, as well as the former, of too intricate a nature to facilitate very much the effort of the imagination in conceiving it.

[86] [The text of the original edition has 'many', again simply a printer's error.]
[87] [*Astronomia Nova* (1609).]
[88] i.e. proportion.
[89] [*De Harmonice Mundi* (1619).]
[90] 'Cubes of their distances' should be 'cubes of their mean distances'.

58 The truth of both these analogies, intricate as they were, was at last fully established by the observations of Cassini.[91] That astronomer first discovered, that the secondary Planets of Jupiter and Saturn revolved round their primary ones, according to the same laws which Kepler had observed in the revolutions of the primary ones round the Sun, and that of the Moon round the earth; that each of them described equal areas in equal times, and that the squares of their periodic times were as the cubes of their distances. When these two last abstruse analogies, which, when Kepler at first observed them, were but little regarded, had been thus found to take place in the revolutions of the Four Satellites of Jupiter, and in those of the Five of Saturn, they were now thought not only to confirm the doctrine of Kepler, but to add a new probability to the Copernican hypothesis. The observations of Cassini seem to establish it as a law of the system, that, when one body revolved round another, it described equal areas in equal times; and that, when several revolved round the same body, the squares of their periodic times were as the cubes of their distances. If the Earth and the Five Planets were supposed to revolve round the Sun, these laws, it was said, would take place universally. But if, according to the system of Ptolemy, the Sun, Moon, and Five Planets were supposed to revolve round the Earth, the periodical motions of the Sun and Moon would, indeed, observe the first of these laws, would each of them describe equal areas in equal times; but they would not observe the second, the squares of their periodic times would not be as the cubes of their distances: and the revolutions of the Five Planets would observe neither the one law nor the other. Or if, according to the system of Tycho Brahe, the Five Planets were supposed to revolve round the Sun, while the Sun and Moon revolved round the Earth, the revolutions of the Five Planets round the Sun, would, indeed, observe both these laws; but those of the Sun and Moon round the Earth would observe only the first of them. The analogy of nature, therefore, could be preserved completely, according to no other system but that of Copernicus, which, upon that account, must be the true one. This argument is regarded by Voltaire,[92] and the Cardinal of Polignac,[93] as an irrefragable demonstration; even M^c^Laurin,[94] who was more capable of judging; nay, Newton himself,

[91] Giovanni Domenico Cassini (1625–1712), the first of a family of distinguished astronomers and virtual Director of the Observatory set up by the Académie Royale des Sciences, of which he was an early *pensionnaire*.

[92] [*Éléments de la philosophie de Newton* (1738).]

[93] Cardinal Melchior de Polignac (1661–1742).

[94] [Colin Maclaurin (1698–1746), educated at the University of Glasgow, appointed Professor of Mathematics at Marischal College and the University of Aberdeen in 1717, and then at the University of Edinburgh in 1725 with the recommendation of Newton. His *Account of Sir Isaac Newton's Discoveries* was published posthumously in 1748.]

seems to mention it[95] as one of the principal evidences for the truth of that hypothesis. Yet, an analogy of this kind, it would seem, far from a demonstration, could afford, at most, but the shadow of a probability.

59 It is true, that though Cassini supposed the Planets to revolve in an oblong curve, it was in a curve somewhat different from that of Kepler. In the ellipse the sum of the two lines, which are drawn from any one point in the circumference to the two foci, is always equal to that of those which are drawn from any other point in the circumference to the same foci. In the curve of Cassini, it is not the sum of the lines, but the rectangles which are contained under the lines, that are always equal. As this, however, was a proportion more difficult to be comprehended than the other, the curve of Cassini has never had the vogue.

60 Nothing now embarrassed the system of Copernicus, but the difficulty which the imagination felt in conceiving bodies so immensely ponderous as the Earth, and the other Planets, revolving round the Sun with such incredible rapidity. It was in vain that Copernicus pretended, that, notwithstanding the prejudices of sense, this circular motion might be as natural to the Planets, as it is to a stone to fall to the ground. The imagination had been accustomed to conceive such objects as tending rather to rest than motion. This habitual idea of their natural inertness was incompatible with that of their natural motion. It was in vain that Kepler,[96] in order to assist the fancy in connecting together this natural inertness with their astonishing velocities, talked of some vital and immaterial virtue, which was shed by the Sun into the surrounding spaces, which was whirled about with his revolution round his own axis, and which, taking hold of the Planets, forced them, in spite of their ponderousness and strong propensity to rest, thus to whirl about the center of the system. The imagination had no hold of this immaterial virtue, and could form no determinate idea of what it consisted in. The imagination, indeed, felt a gap, or interval, betwixt the constant motion and the supposed inertness of the Planets, and had in this, as in all other cases, some general idea or apprehension that there must be a connecting chain of intermediate objects to link together these discordant qualities. Wherein this connecting chain consisted, it was, indeed, at a loss to conceive; nor did the doctrine of Kepler lend it any assistance in this respect. That doctrine, like almost all those of the philosophy in fashion during his time, bestowed a name upon this

[95] [Newton's discussion, at the beginning of Book III of the *Principia*, contains no definite statement to this effect, but Smith's cautious form of expression does not imply otherwise.]
[96] [*Mysterium Cosmographicum* (1596), chap. 20; *Astronomia Nova* (1609), chaps. 33–4.]

invisible chain, called it an immaterial virtue, but afforded no determinate idea of what was its nature.

61 Des Cartes[97] was the first who attempted to ascertain, precisely, wherein this invisible chain consisted, and to afford the imagination a train of intermediate events, which, succeeding each other in an order that was of all others the most familiar to it, should unite those incoherent qualities, the rapid motion, and the natural inertness of the Planets. Des Cartes was the first who explained wherein consisted the real inertness of matter; that it was not in an aversion to motion, or in a propensity to rest, but in a power of continuing indifferently either at rest or in motion, and of resisting, with a certain force, whatever endeavoured to change its state from the one to the other. According to that ingenious and fanciful philosopher, the whole of infinite space was full of matter, for with him matter and extension were the same, and consequently there could be no void. This immensity of matter, he supposed, to be divided into an infinite number of very small cubes; all of which, being whirled about upon their own centers, necessarily gave occasion to the production of two different elements. The first consisted of those angular parts, which, having been necessarily rubbed off, and grinded yet smaller by their mutual friction, constituted the most subtile and moveable part of matter. The second consisted of those little globules that were formed by the rubbing off of the first. The interstices betwixt these globules of the second element was filled up by the particles of the first. But in the infinite collisions, which must occur in an infinite space filled with matter, and all in motion, it must necessarily happen, that many of the globules of the second element should be broken and grinded down into the first. The quantity of the first element having thus been encreased beyond what was sufficient to fill up the interstices of the second, it must, in many places, have been heaped up together, without any mixture of the second along with it. Such, according to Des Cartes, was the original division of matter. Upon this infinitude of matter thus divided, a certain quantity of motion was originally impressed by the Creator of all things, and the laws of motion were so adjusted as always to preserve the same quantity in it, without increase, and without diminution.[98] Whatever motion was lost by

[97] [See note 82 above.]

[98] *Principles of Philosophy*, II.36. When combined with Descartes's further statement of the law of inertia (§63 below—'Newton's' First Law of Motion, only partially envisaged by Galileo), this corresponds to the principle of the conservation of linear momentum (Newton's Third Law). Recognizing that this does not apply to certain cases of impact, Leibniz claimed that it is not momentum (product of mass and velocity) but *vis viva* (product of mass and square of velocity) that is conserved. This *cause célèbre* among the savants of the eighteenth century was resolved partly by d'Alembert (see the editor's Introduction, 22) in Smith's lifetime, and finally by Hermann von Helmholtz in 1847.

one part of matter, was communicated to some other; and whatever was acquired by one part of matter, was derived from some other: and thus, through an eternal revolution, from rest to motion, and from motion to rest, in every part of the universe, the quantity of motion in the whole was always the same.

62 But, as there was no void, no one part of matter could be moved without thrusting some other out of its place, nor that without thrusting some other, and so on. To avoid, therefore, an infinite progress, he supposed, that the matter which any body pushed before it, rolled immediately backwards, to supply the place of that matter which flowed in behind it; as we may observe in the swimming of a fish, that the water, which it pushes before it, immediately rolls backwards, to supply the place of what flows in behind it, and thus forms a small circle or vortex round the body of the fish.[99] It was, in the same manner, that the motion originally impressed by the Creator upon the infinitude of matter, necessarily produced in it an infinity of greater and smaller vortices, or circular streams: and the law of motion being so adjusted as always to preserve the same quantity of motion in the universe, those vortices either continued for ever, or by their dissolution give birth to others of the same kind. There was, thus, at all times, an infinite number of greater and smaller vortices, or circular streams, revolving in the universe.

63 But, whatever moves in a circle, is constantly endeavouring to fly off from the center of its revolution. For the natural motion of all bodies is in a straight line.[1] All the particles of matter, therefore, in each of those greater vortices, were continually pressing from the center to the circumference, with more or less force, according to the different degrees of their bulk and solidity. The larger and more solid globules of the second element forced themselves upwards to the circumference, while the smaller, more yielding, and more active particles of the first, which could flow, even through the interstices of the second, were forced downwards to the center. They were forced downwards to the center, notwithstanding their natural tendency was upwards to the circumference; for the same reason that a piece of wood, when plunged in water, is forced upwards to the surface, notwithstanding its natural tendency is downwards to the bottom;

[99] [Smith has said nothing here about the earlier history of this explanation of motion in a plenum. Descartes took it from ancient Greek philosophers who, having denied the existence of void, had to deal with the same problem. The process described is used in Plato's *Timaeus*, 79 A–E, to explain the mechanism of breathing. It is there termed *periosis*. Lucretius, i.370–83, illustrates it by the swimming of a fish, but only in order to oppose it and to insist upon the necessity for a void. The explanation was maintained by Hobbes in his *De Corpore*, chap. 22.12, chap. 25.3, as well as by Descartes. See A. E. Taylor, *Commentary on Plato's Timaeus* (1928), 558.]

[1] But see the editor's Introduction, 16.

because its tendency downwards is less strong than that of the particles of water, which, therefore, if one may say so, press in before it, and thus force it upwards. But there being a greater quantity of the first element than what was necessary to fill up the interstices of the second, it was necessarily accumulated in the center of each of these great circular streams, and formed there the firey and active substance of the Sun. For, according to that philosopher, the Solar Systems were infinite in number, each Fixed Star being the center of one: and he is among the first of the moderns, who thus took away the boundaries of the Universe; even Copernicus and Kepler, themselves, having confined it within, what they supposed, the vault of the Firmament.

64 The center of each vortex being thus occupied by the most active and moveable parts of matter, there was necessarily among them, a more violent agitation than in any other part of the vortex, and this violent agitation of the center cherished and supported the movement of the whole. But, among the particles of the first element, which fill up the interstices of the second, there are many, which, from the pressure of the globules on all sides of them, necessarily receive an angular form, and thus constitute a third element of particles less fit for motion than those of the other two. As the particles, however, of this third element were formed in the interstices of the second, they are necessarily smaller than those of the second, and are, therefore, along with those of the first, urged down towards the center, where, when a number of them happen to take hold of one another, they form such spots upon the surface of the accumulated particles of the first element, as are often discovered by telescopes upon the face of that Sun, which enlightens and animates our particular system. Those spots are often broken and dispelled, by the violent agitation of the particles of the first element, as has hitherto happily been the case with those which have successively been formed upon the face of our Sun. Sometimes, however, they encrust the whole surface of that fire which is accumulated in the center; and the communication betwixt the most active and the most inert parts of the vortex being thus interrupted, the rapidity of its motion immediately begins to languish, and can no longer defend it from being swallowed up and carried away by the superior violence of some other like circular stream; and in this manner, what was once a Sun, becomes a Planet. Thus, the time was, according to this system, when the Moon was a body of the same kind with the Sun, the firey center of a circular stream of ether, which flowed continually round her; but her face having been crusted over by a congeries of angular particles, the motion of this circular stream began to languish, and could no longer

defend itself from being absorbed by the more violent vortex of the Earth, which was then, too, a Sun, and which chanced to be placed in its neighbourhood. The Moon, therefore, became a Planet, and revolved round the Earth. In process of time, the same fortune, which had thus befallen the Moon, befell also the Earth; its face was encrusted by a gross and inactive substance; the motion of its vortex began to languish, and it was absorbed by the greater vortex of the Sun: but though the vortex of the Earth had thus become languid, it still had force enough to occasion both the diurnal revolution of the Earth, and the monthly motion of the Moon. For a small circular stream may easily be conceived as flowing round the body of the Earth, at the same time that it is carried along by that great ocean of ether which is continually revolving round the Sun; in the same manner, as in a great whirlpool of water, one may often see several small whirlpools, which revolve round centers of their own, and at the same time are carried round the center of the great one. Such was the cause of the original formation and consequent motions of the Planetary System. When a solid body is turned round its center, those parts of it, which are nearest, and those which are remotest from the center, complete their revolutions in one and the same time. But it is otherwise with the revolutions of a fluid: the parts of it which are nearest the center complete their revolutions in a shorter time, than those which are remoter. The Planets, therefore, all floating in that immense tide of ether which is continually setting in from west to east round the body of the Sun, complete their revolutions in a longer or a shorter time, according to their nearness or distance from him. There was, however, according to Des Cartes, no very exact proportion observed betwixt the times of their revolutions and their distances from the center. For that nice analogy, which Kepler had discovered betwixt them, having not yet been confirmed by the observations of Cassini, was, as I before took notice,[2] entirely disregarded by Des Cartes. According to him, too, their orbits might not be perfectly circular, but be longer the one way than the other, and thus approach to an Ellipse. Nor yet was it necessary to suppose, that they described this figure with geometrical accuracy, or even that they described always precisely the same figure. It rarely happens, that nature can be mathematically exact with regard to the figure of the objects she produces, upon account of the infinite combinations of impulses, which must conspire to the production of each of her effects. No two Planets, no two animals of the same kind, have exactly the same figure, nor is that of any one of them perfectly

[2] [§ 55 above.]

regular. It was in vain, therefore, that astronomers laboured to find that perfect constancy and regularity in the motions of the heavenly bodies, which is to be found in no other parts of nature.[3] These motions, like all others, must either languish or be accelerated, according as the cause which produces them, the revolution of the vortex of the Sun, either languishes, or is accelerated; and there are innumerable events which may occasion either the one or the other of those changes.

65 It was thus, that Des Cartes endeavoured to render familiar to the imagination, the greatest difficulty in the Copernican system, the rapid motion of the enormous bodies of the Planets. When the fancy had thus been taught to conceive them as floating in an immense ocean of ether, it was quite agreeable to its usual habits to conceive, that they should follow the stream of this ocean, how rapid soever. This was an order of succession to which it had been long accustomed, and with which it was, therefore, quite familiar. This account, too, of the motions of the Heavens, was connected with a vast, an immense system, which joined together a greater number of the most discordant phaenomena of nature, than had been united by any other hypothesis; a system in which the principles of connection, though perhaps equally imaginary, were, however, more distinct and determinate, than any that had been known before; and which attempted to trace to the imagination, not only the order of succession by which the heavenly bodies were moved, but that by which they, and almost all other natural objects, had originally been produced.— The Cartesian philosophy begins now to be almost universally rejected, while the Copernican system continues to be universally received. Yet, it is not easy to imagine, how much probability and coherence this admired system was long supposed to derive from that exploded hypothesis.[4] Till Des Cartes had published his principles, the disjointed and incoherent system of Tycho Brahe, though it was embraced heartily and completely by scarce any body, was yet constantly talked of by all the learned,[5] as, in point of probability,

[3] A perceptive recognition of the approximative character of all 'laws' of nature. This implies the removal of the distinction between 'natural' and 'celestial' realms and the necessity for the later theory of perturbations, involving a good deal of heart-searching among theologians regarding the 'perfection' of the Creator.

[4] [Cf. Letter to the Authors of the *Edinburgh Review*, 5, where Smith again writes of Descartes's natural philosophy as 'almost universally exploded' and of the advantages that it initially appeared to have. He also refers in TMS VII.ii.4.14 to the high regard in which Descartes's theory of vortices was long held. In the *Discours préliminaire* to the *Encyclopédie* (1751), d'Alembert writes: 'Si on juge sans partialité ces tourbillons devenus aujourd'hui presque ridicules, on conviendra, j'ose le dire, qu'on ne pouvoit alors imaginer mieux.']

[5] Galileo ignored it in his famous polemical work, *On the Two Chief Systems of the World, Ptolemaic and Copernican*: its consistency with the observed phases of Venus would have weakened his insistence on the movement of the Earth.

upon a level with that of Copernicus. They took notice, indeed, of its inferiority with regard to coherence and connection, expressing hopes, however, that these defects might be remedied by some future improvements. But when the world beheld that complete, and almost perfect coherence, which the philosophy of Des Cartes bestowed upon the system of Copernicus, the imaginations of mankind could no longer refuse themselves the pleasure of going along with so harmonious an account of things. The system of Tycho Brahe was every day less and less talked of, till at last it was forgotten altogether.

66 The system of Des Cartes, however, though it connected together the real motions of the heavenly bodies according to the system of Copernicus, more happily than had been done before, did so only when they were considered in the gross; but did not apply to them, when they were regarded in the detail. Des Cartes, as was said before,[6] had never himself observed the Heavens with any particular application. Though he was not ignorant, therefore, of any of the observations which had been made before his time, he seems to have paid them no great degree of attention; which, probably, proceeded from his own inexperience in the study of Astronomy. So far, therefore, from accommodating his system to all the minute irregularities, which Kepler had ascertained in the movements of the Planets; or from shewing, particularly, how these irregularities, and no other, should arise from it, he contented himself with observing, that perfect uniformity could not be expected in their motions, from the nature of the causes which produced them; that certain irregularities might take place in them, for a great number of successive revolutions, and afterwards give way to others of a different kind: a remark which, happily, relieved him from the necessity of applying his system to the observations of Kepler, and the other Astronomers.

67 [7]But when the observations of Cassini had established the authority of those laws, which Kepler had first discovered in the system, the philosophy of Des Cartes, which could afford no reason, why such particular laws should be observed, might continue to amuse the learned in other sciences, but could no longer satisfy those that were skilled in Astronomy. Sir Isaac Newton first attempted to give a physical account of the motions of the Planets, which should accommodate itself to all the constant irregularities which

[6] [Smith did not in fact say this before, but did say, in §55 (cf. the next sentence here in §66), that Descartes seems to have paid no attention to Kepler's work on observations made by Tycho Brahe.]

[7] This presumably marks the beginning of the material on Newton mentioned by Smith's editors in the concluding note to this section.

astronomers had ever observed in their motions. The physical connection, by which Des Cartes had endeavoured to bind together the movements of the Planets, was the laws of impulse; of all the orders of succession, those which are most familiar to the imagination; as they all flow from the inertness of matter. After this quality, there is no other, with which we are so well acquainted, as that of gravity. We never act upon matter, but we have occasion to observe it. The superior genius and sagacity of Sir Isaac Newton, therefore, made the most happy, and, we may now say, the greatest and most admirable improvement that was ever made in philosophy, when he discovered, that he could join together the movements of the Planets by so familiar a principle of connection, which completely removed all the difficulties the imagination had hitherto felt in attending to them.[8] He demonstrated, that, if the Planets were supposed to gravitate towards the Sun, and to one another, and at the same time to have had a projecting force originally impressed upon them, the primary ones might all described ellipses in one of the foci of which that great luminary was placed; and the secondary ones might describe figures of the same kind round their respective primaries, without being disturbed by the continual motion of the centers of their revolutions. That if the force, which retained each of them in their orbits, was like that of gravity, and directed towards the Sun, they would, each of them, describe equal areas in equal times. That if this attractive power of the Sun, like all other qualities which are diffused in rays from a center, diminished in the same proportion as the squares of the distances increased, their motions would be swiftest when nearest the Sun, and slowest when farthest off from him, in the same proportion in which, by observation, they are discovered to be; and that, upon the same supposition, of this gradual diminution of their respective gravities, their periodic times would bear the same proportion to their distances, which Kepler and Cassini had established betwixt them. Having thus shown, that gravity might be the connecting principle which joined together the movements of the Planets, he endeavoured next to prove that it really was so. Experience shews us, what is the power of gravity near the surface of the Earth. That it is such as to make a body fall, in the first second of its descent, through about fifteen Parisian feet. The Moon is about sixty semidiameters of the Earth distant from its surface. If gravity, therefore, was supposed to diminish, as the squares of the distance increase, a body, at the Moon, would fall towards the Earth in a minute; that is, in sixty seconds, through the same space, which it

[8] An optimistic assessment. See the editor's Introduction, 21–2.

falls near its surface in one second. But the arch[9] which the Moon describes in a minute, falls, by observation, about fifteen Parisian feet below the tangent drawn at the beginning of it. So far, therefore, the Moon may be conceived as constantly falling towards the Earth.[10]

68 The system of Sir Isaac Newton corresponded to many other irregularities which Astronomers had observed in the Heavens. It assigned a reason, why the centers of the revolutions of the Planets were not precisely in the center of the Sun, but in the common center of gravity of the Sun and the Planets. From the mutual attraction of the Planets, it gave a reason for some other irregularities in their motions; irregularities, which are quite sensible in those of Jupiter and Saturn, when those Planets are nearly in conjunction with one another. But of all the irregularities in the Heavens, those of the Moon had hitherto given the greatest perplexity to Astronomers; and the system of Sir Isaac Newton corresponded, if possible, yet more accurately with them than with any of the other Planets. The Moon, when either in conjunction, or in opposition to the Sun, appears furthest from the Earth, and nearest to it when in her quarters. According to the system of that philosopher, when she is in conjunction with the Sun, she is nearer the Sun than the Earth is; consequently, more attracted to him, and, therefore, more separated from the Earth. On the contrary, when in opposition to the Sun, she is further from the Sun than the Earth. The Earth, therefore, is more attracted to the Sun; and, consequently, in this case, too, further separated from the Moon. But, on the other hand, when the Moon is in her quarters, the Earth and the Moon, being both at equal distance from the Sun, are equally attracted to him. They would not, upon this account alone, therefore, be brought nearer to one another. As it is not in parallel lines, however, that they are attracted towards the Sun, but in lines which meet in his center, they are, thereby, still further approached to one another. Sir Isaac Newton computed the difference of the forces, with which the Moon and the Earth ought, in all those different situations, according to his theory, to be impelled towards one another; and found, that the different degrees of their approaches, as they had been observed by Astronomers, corresponded exactly to his computations. As the attraction of the Sun, in the conjunctions and oppositions, diminishes the gravity of the Moon towards the Earth, and, consequently, makes her necessarily extend her orbit, and, therefore, require a longer periodical time to finish it. But, when the Moon and the Earth are in that part of the orbit which is nearest the Sun, this attraction of the Sun will be the greatest;

[9] i.e. arc; a common spelling at that time.
[10] [*Principia*, Book III, prop. 4, theorem 4.]

consequently, the gravity of the Moon towards the Earth, will there be most diminished; her orbit be most extended; and her periodic time be, therefore, the longest. This is, also, agreeable to experience, and in the very same proportion, in which, by computation, from these principles, it might be expected.

69 The orbit of the Moon is not precisely in the same Plane with that of the Earth; but makes a very small angle with it. The points of intersection of those two Planes, are called, the Nodes of the Moon. These Nodes of the Moon are in continual motion, and in eighteen or nineteen years, revolve backwards, from east to west, through all the different points of the Ecliptic. For the Moon, after having finished her periodical revolution, generally intersects the orbit of the Earth somewhat behind the point where she had intersected it before. But, though the motion of the Nodes is thus generally retrograde, it is not always so, but is sometimes direct, and sometimes they appear even stationary; the Moon generally intersects the Plane of the Earth's orbit, behind the point where she had intersected it in her former revolution; but she sometimes intersects it before that point, and sometimes in the very same point. It is the situation of those Nodes which determines the times of Eclipses, and their motions had, upon this account, at all times, been particularly attended to by Astronomers. Nothing, however, had perplexed them more, than to account for these so inconsistent motions, and, at the same time, preserve their so much sought-for regularity in the revolutions of the Moon. For they had no other means of connecting the appearances together, than by supposing the motions which produced them, to be, in reality, perfectly regular and equable. The history of Astronomy, therefore, gives an account of a greater number of theories invented for connecting together the motions of the Moon, than for connecting together those of all the other heavenly bodies taken together. The theory of gravity, connected together, in the most accurate manner, by the different actions of the Sun and the Earth, all those irregular motions; and it appears, by calculation, that the time, the quantity, and the duration of those direct and retrograde motions of the Nodes, as well as of their stationary appearances, might be expected to be exactly such, as the observations of Astronomers have determined them.

70 The same principle, the attraction of the Sun, which thus accounts for the motions of the Nodes, connects, too, another very perplexing irregularity in the appearances of the Moon; the perpetual variation in the inclination of her orbit to that of the Earth.

71 As the Moon revolves in an ellipse, which has the centre of the Earth in one of its foci, the longer axis of its orbit is called the Line of

its Apsides. This line is found, by observation, not to be always directed towards the same points of the Firmament, but to revolve forwards, from west to east, so as to pass through all the points of the Ecliptic, and to complete its period in about nine years; another irregularity, which had very much perplexed Astronomers, but which the theory of gravity sufficiently accounted for.

72 The Earth had hitherto been regarded as perfectly globular, probably for the same reason which had made men imagine, that the orbits of the Planets must necessarily be perfectly circular. But Sir Isaac Newton,[11] from mechanical principles, concluded, that, as the parts of the Earth must be more agitated by her diurnal revolution at the Equator, than at the Poles, they must necessarily be somewhat elevated at the first, and flattened at the second. The observation, that the oscillations of pendulums were slower at the Equator than at the Poles, seeming to demonstrate, that gravity was stronger at the Poles, and weaker at the Equator, proved, he thought, that the Equator was further from the centre than the Poles. All the measures, however, which had hitherto been made of the Earth, seemed to show the contrary, that it was drawn out towards the Poles, and flattened towards the Equator. Newton, however, preferred his mechanical computations to the former measures of Geographers and Astronomers; and in this he was confirmed by the observations of Astronomers on the figure of Jupiter, whose diameter at the Pole seems to be to his diameter at the Equator, as twelve to thirteen; a much greater inequality than could be supposed to take place betwixt the correspondent diameters of the Earth, but which was exactly proportioned to the superior bulk of Jupiter, and the superior rapidity with which he performs his diurnal revolutions. The observations of Astronomers at Lapland and Peru have fully confirmed Sir Isaac's system,[12] and have not only demonstrated, that the figure of the Earth is, in general, such as he supposed it; but that the proportion of its axis to the diameter of its Equator is almost precisely such as he had computed it. And of all the proofs that have ever been adduced of the diurnal revolution of the Earth, this perhaps is the most solid and satisfactory.

73 Hipparchus,[13] by comparing his own observations with those of

[11] [Ibid., prop. 19, problem 3.]

[12] See the editor's Introduction, 7. [Smith had in his personal library a copy of the English translation of the book describing the results of the Lapland expedition: P.-L. M. de Maupertuis, *The Figure of the Earth, determined from observations made by order of the French King at the polar circle* (1738). See H. Mizuta, *Adam Smith's Library* (1967), 40. The results of the Peruvian expedition were given in Pierre Bouguer, *La Figure de la terre* (1749).]

[13] [For Hipparchus' discovery of the precession, and his estimate of its period, see Heath, *Aristarchus of Samos*, 172–3.]

some former Astronomers, had found that the equinoxial points were not always opposite to the same part of the Heavens, but that they advanced gradually eastward by so slow a motion, as to be scarce sensible in one hundred years, and which would require thirty-six thousand to make a complete revolution of the Equinoxes, and to carry them successively through all the different points of the Ecliptic. More accurate observations discovered that this precession[14] of the Equinoxes was not so slow as Hipparchus had imagined it, and that it required somewhat less than twenty-six thousand years to give them a complete revolution. While the ancient system of Astronomy, which represented the Earth as the immoveable centre of the universe, took place, this appearance was necessarily accounted for, by supposing that the Firmament, besides its rapid diurnal revolution round the poles of the Equator, had likewise a slow periodical one round those of the Ecliptic. And when the system of Hipparchus was by the schoolmen united with the solid Spheres of Aristotle, they placed a new christaline Sphere above the Firmament, in order to join this motion to the rest. In the Copernican system, this appearance had hitherto been connected with the other parts of that hypothesis, by supposing a small revolution in the Earth's axis from east to west. Sir Isaac Newton connected this motion by the same principle of gravity, by which he had united all the others, and shewed, how the elevation of the parts of the Earth at the Equator must, by the attraction of the Sun, produce the same retrograde motion of the Nodes of the Ecliptic, which it produced of the Nodes of the Moon. He computed the quantity of motion which could arise from this action of the Sun, and his calculations here too entirely corresponded with the observations of Astronomers.

74 Comets had hitherto, of all the appearances in the Heavens, been the least attended to by Astronomers. The rarity and inconstancy of their appearance, seemed to separate them entirely from the constant, regular, and uniform objects in the Heavens, and to make them resemble more the inconstant, transitory, and accidental phaenomena of those regions that are in the neighbourhood of the Earth. Aristotle,[15] Eudoxus, Hipparchus, Ptolemy, and Purbach, therefore, had all degraded them below the Moon, and ranked them among the meteors of the upper regions of the air. The observations of Tycho Brahe demonstrated, that they ascended into the celestial regions, and were often higher than Venus or the Sun. Des Cartes, at random, supposed them to be always higher than even the orbit of Saturn; and seems, by the superior elevation he thus bestowed upon them, to have

14 [The text of the original edition has 'procession', no doubt a printer's error.]
15 [*Meteorologica*, I.6–7; $342^b$–$345^a$.]

been willing to compensate that unjust degradation which they had suffered for so many ages before. The observations of some later Astronomers[16] demonstrated, that they too revolved about the Sun, and might therefore be parts of the Solar System. Newton accordingly applied his mechanical principle of gravity to explain the motions of these bodies. That they described equal areas in equal times, had been discovered by the observations of some later Astronomers; and Newton endeavoured to show how from this principle, and those observations, the nature and position of their several orbits might be ascertained, and their periodic times determined. His followers have, from his principles, ventured even to predict the returns of several of them, particularly of one which is to make its appearance in 1758*.[17] We must wait for that time before we can determine, whether his philosophy corresponds as happily to this part of the system as to all the others. In the mean time, however, the ductility of this principle, which applied itself so happily to these, the most irregular of all the celestial appearances, and which has introduced such complete coherence into the motions of all the Heavenly Bodies, has served not a little to recommend it to the imaginations of mankind.

75 But of all the attempts of the Newtonian Philosophy, that which would appear to be the most above the reach of human reason and experience, is the attempt to compute the weights and densities of the Sun, and of the Several Planets. An attempt, however, which was indispensibly necessary to complete the coherence of the Newtonian system. The power of attraction which, according to the theory of gravity, each body possesses, is in proportion to the quantity of matter contained in that body. But the periodic time in which one body, at a given distance, revolves round another that attracts it, is shorter in proportion as this power is greater, and consequently as the quantity of matter in the attracting body. If the densities of Jupiter and Saturn were the same with that of the Earth, the periodic times of their several Satellites would be shorter than by observation they are found to be. Because the quantity of matter, and consequently the attracting power of each of them, would be as the cubes of their diameters. By comparing the bulks of those Planets, and the periodic times of their Satellites, it is found that, upon the hypothesis of gravity, the density of Jupiter must be greater than that of Saturn, and the density of the

* It must be observed, that the whole of this Essay was written previous to the date here mentioned; and that the return of the comet happened agreeably to the prediction.

[16] [Smith may be alluding here to the observations of Johann Hevelius published in *Prodromus Cometicus* (1665), those of John Flamsteed in *Historia Coelestis Britannica* (1725), and those of Edmund Halley in *Astronomiae Cometicae Synopsis* (1705).]

[17] The omission of the name of Edmund Halley (1656–1742) is unaccountable. For a discussion of the original footnote see the editor's Introduction, 7–8.

Earth greater than that of Jupiter. This seems to establish it as a law in the system, that the nearer the several Planets approach to the Sun, the density of their matter is the greater: a constitution of things which would seem to be the most advantageous of any that could have been established; as water of the same density with that of our Earth, would freeze under the Equator of Saturn, and boil under that of Mercury.

76 Such is the system of Sir Isaac Newton, a system whose parts are all more strictly connected together, than those of any other philosophical hypothesis. Allow his principle, the universality of gravity, and that it decreases as the squares of the distance increase, and all the appearances, which he joins together by it, necessarily follow. Neither is their connection merely a general and loose connection, as that of most other systems, in which either these appearances, or some such like appearances, might indifferently have been expected. It is every where the most precise and particular that can be imagined, and ascertains the time, the place, the quantity, the duration of each individual phaenomenon, to be exactly such as, by observation, they have been determined to be. Neither are the principles of union, which it employs, such as the imagination can find any difficulty in going along with. The gravity of matter is, of all its qualities, after its inertness, that which is most familiar to us.[18] We never act upon it without having occasion to observe this property. The law too, by which it is supposed to diminish as it recedes from its centre, is the same which takes place in all other qualities which are propagated in rays from a centre, in light, and in every thing else of the same kind. It is such, that we not only find that it does take place in all such qualities, but we are necessarily determined to conceive that, from the nature of the thing, it must take place. The opposition which was made in France, and in some other foreign nations, to the prevalence of this system, did not arise from any difficulty which mankind naturally felt in conceiving gravity as an original and primary mover in the constitution of the universe. The Cartesian system, which had prevailed so generally before it, had accustomed mankind to conceive motion as never beginning, but in consequence of impulse, and had connected the descent of heavy bodies, near the surface of the Earth, and the other Planets, by this more general bond of union; and it was the attachment the world had conceived for this account of things, which indisposed them to that of Sir Isaac Newton. His system, however, now prevails over all opposition, and has advanced to the acquisition of the most universal empire that was ever established in philosophy. His principles, it must be acknow-

[18] But see the editor's Introduction, 21–2.

ledged, have a degree of firmness and solidity that we should in vain look for in any other system. The most sceptical cannot avoid feeling this. They not only connect together most perfectly all the phaenomena of the Heavens, which had been observed before his time, but those also which the persevering industry and more perfect instruments of later Astronomers have made known to us; have been either easily and immediately explained by the application of his principles, or have been explained in consequence of more laborious and accurate calculations from these principles, than had been instituted before. And even we, while we have been endeavouring to represent all philosophical systems as mere inventions of the imagination,[19] to connect together the otherwise disjointed and discordant phaenomena of nature, have insensibly been drawn in, to make use of language expressing the connecting principles of this one, as if they were the real chains which Nature makes use of to bind together her several operations. Can we wonder then, that it should have gained the general and complete approbation of mankind, and that it should now be considered, not as an attempt to connect in the imagination the phaenomena of the Heavens, but as the greatest discovery that ever was made by man, the discovery of an immense chain of the most important and sublime truths, all closely connected together, by one capital fact, of the reality of which we have daily experience.

## NOTE by the EDITORS

The Author, at the end of this Essay, left some Notes and Memorandums, from which it appears, that he considered this last part of his History of Astronomy as imperfect, and needing several additions. The Editors, however, chose rather to publish than to suppress it. It must be viewed, not as a History or Account of Sir Isaac Newton's Astronomy, but chiefly as an additional illustration of those Principles in the Human Mind which Mr. Smith has pointed out to be the universal motives of Philosophical Researches.

[19] [Cf. II.12 above.]

THE

# PRINCIPLES

## WHICH LEAD AND DIRECT

# PHILOSOPHICAL ENQUIRIES;

## ILLUSTRATED BY THE

# HISTORY of the ANCIENT PHYSICS

1 From arranging and methodizing the System of the Heavens, Philosophy descended to the consideration of the inferior parts of Nature, of the Earth, and of the bodies which immediately surround it.[1] If the objects, which were here presented to its view, were inferior in greatness or beauty, and therefore less apt to attract the attention of the mind, they were more apt, when they came to be attended to, to embarrass and perplex it, by the variety of their species, and by the intricacy and seeming irregularity of the laws or orders of their succession. The species of objects in the Heavens are few in number; the Sun, the Moon, the Planets, and the Fixed Stars, are all which those philosophers could distinguish. All the changes too, which are ever observed in these bodies, evidently arise from some difference in the velocity and direction of their several motions; but the variety of meteors in the air, of clouds, rainbows, thunder, lightning, winds, rain, hail, snow, is vastly greater;[2] and the order of their succession seems to be still more irregular and unconstant. The species of fossils, minerals, plants, animals, which are found in the Waters, and near the surface of the Earth, are still more intricately diversified; and if we regard the different manners of their production, their mutual influence in altering, destroying, supporting one another, the orders of their succession seem to admit of an almost infinite variety. If the imagination, therefore, when it considered the appearances in the Heavens, was often perplexed, and driven out of its natural career, it would be much more exposed to the same embarrassment, when it directed its attention to the objects which the Earth presented to it, and when it endeavoured to trace their progress and successive revolutions.

[1] [Cf. WN V.i.f.24.]

[2] [See Astronomy, III.1.]

2 To introduce order and coherence into the mind's conception of this seeming chaos of dissimilar and disjointed appearances, it was necessary to deduce all their qualities, operations, and laws of succession, from those of some particular things, with which it was perfectly acquainted and familiar, and along which its imagination could glide smoothly and easily, and without interruption.[3] But as we would in vain attempt to deduce the heat of a stove from that of an open chimney, unless we could show that the same fire which was exposed in the one, lay concealed in the other; so it was impossible to deduce the qualities and laws of succession, observed in the more uncommon appearances of Nature, from those of such as were more familiar, if those customary objects were not supposed, however disguised in their appearance, to enter into the composition of those rarer and more singular phaenomena. To render, therefore, this lower part of the great theatre of nature a coherent spectacle to the imagination, it became necessary to suppose, first, That all the strange objects of which it consisted were made up out of a few, with which the mind was extremely familiar: and secondly, That all their qualities, operations, and rules of succession, were no more than different diversifications of those to which it had long been accustomed, in these primary and elementary objects.

3 Of all the bodies of which these inferior parts of the universe seem to be composed, those with which we are most familiar, are the Earth, which we tread upon; the Water, which we every day use; the Air, which we constantly breath; and the Fire, whose benign influence is not only required for preparing the common necessaries of life, but for the continual support of that vital principle which actuates both plants and animals. These, therefore, were by Empedocles, and the other philosophers of the Italian school, supposed to be the elements, out of which, at least, all the inferior parts of nature were composed. The familiarity of those bodies to the mind, naturally disposed it to look for some resemblance to them in whatever else was presented to its consideration. The discovery of some such resemblance united the new object to an assortment of things, with which the imagination was perfectly acquainted. And if any analogy could be observed betwixt the operations and laws of succession of the compound, and those of the simple objects, the movement of the fancy, in tracing their progress, became quite smooth, and natural, and easy. This natural anticipation, too, was still more confirmed by such a slight and inaccurate analysis of things, as could be expected in the infancy of science, when the curiosity of mankind, grasping at an account of

[3] [Cf. Astronomy, II.7.]

all things before it had got full satisfaction with regard to any one, hurried on to build, in imagination, the immense fabric of the universe. The heat, observed in both plants and animals, seemed to demonstrate, that Fire made a part of their composition. Air was not less necessary for the subsistance of both, and seemed, too, to enter into the fabric of animals by respiration, and into that of plants by some other means. The juices which circulated through them showed how much of their texture was owing to Water. And their resolution into Earth by putrefaction, discovered that this element had not been left out in their original formation. A similar analysis seemed to shew the same principles in most other compound bodies.

4 The vast extent of those bodies seemed to render them, upon another account, proper to be the great stores out of which nature compounded all the other species of things. Earth and Water divide almost the whole of the terrestrial globe between them. The thin transparent covering of the Air surrounds it to an immense height upon all sides. Fire, with its attendant, light, seems to descend from the celestial regions, and might, therefore, either be supposed to be diffused through the whole of those aetherial spaces, as well as to be condensed and conglobated in those luminous bodies, which sparkle across them, as by the Stoics; or, to be placed immediately under the sphere of the Moon, in the region next below them, as by the Peripatetics, who could not reconcile the devouring nature of Fire with the supposed unchangeable essence of their solid and crystalline spheres.

5 The qualities, too, by which we are chiefly accustomed to characterize and distinguish natural bodies, are all of them found, in the highest degree in those Four Elements. The great divisions of the objects, near the surface of the Earth, are those into hot and cold, moist and dry, light and heavy. These are the most remarkable properties of bodies; and it is upon them that many of their other most sensible qualities and powers seem to depend. Of these, heat and cold were naturally enough regarded by those first enquirers into nature, as the active, moisture and dryness, as the passive qualities of matter. It was the temperature of heat and cold which seemed to occasion the growth and dissolution of plants and animals; as appeared evident from the effects of the change of the seasons upon both. A proper degree of moisture and dryness was not less necessary for these purposes; as was evident from the different effects and productions of wet and dry seasons and soils. It was the heat and cold, however, which actuated and determined those two otherwise inert qualities of things, to a state either of rest or motion. Gravity and levity were regarded as the two principles of motion, which directed

all sublunary things to their proper place: and all those six qualities, taken together, were, upon such an inattentive view of nature, as must be expected in the beginnings of philosophy, readily enough apprehended to be capable of connecting together the most remarkable revolutions, which occur in these inferior parts of the universe. Heat and dryness were the qualities which characterized the element of Fire; heat and moisture that of Air; moisture and cold that of Water; cold and dryness that of Earth. The natural motion of two of these elements, Earth and Water, was downwards, upon account of their gravity. This tendency, however, was stronger in the one than in the other, upon account of the superior gravity of Earth. The natural motion of the two other elements, Fire and Air, was upwards, upon account of their levity; and this tendency, too, was stronger in the one than in the other, upon account of the superior levity of Fire. Let us not despise those ancient philosophers, for thus supposing, that these two elements had a positive levity, or a real tendency upwards. Let us remember, that this notion has an appearance of being confirmed by the most obvious observations; that those facts and experiments, which demonstrate the weight of the Air, and which no superior sagacity, but chance alone,[4] presented to the moderns, were altogether unknown to them;[5] and that, what might, in some measure, have supplied the place of those experiments, the reasonings concerning the causes of the ascent of bodies, in fluids specifically heavier than themselves, seem to have been unknown in the ancient world, till Archimedes discovered them,[6] long after their system of physics was completed, and had acquired an established reputation: that those reasonings are far from being obvious, and that by their inventor, they seem to have been thought applicable only to the ascent of Solids in Water, and not even to that of Solids in air, much less to that of one fluid in another. But it is this last only which could explain the ascent of flame, vapours, and fiery exhalations, without the supposition of a specific levity.

6 Thus, each of those Four Elements had, in the system of the universe, a place which was peculiarly allotted to it, and to which it naturally tended. Earth and Water rolled down to the centre; the Air spread itself above them; while the Fire soared aloft, either to the

[4] Smith gives no indication of what he means by 'chance' in this context. The experiments on the weight of the air were amongst the first and best documented of the 'new experimental philosophy'.

[5] [Anaxagoras showed experimentally that air was corporeal (Aristotle, *Physics*, VI.6,213$^{a}$22, and *De Caelo*, II.13,294$^{b}$21), but it seems to be true that no ancient thinker proved that it had weight.]

[6] [Archimedes 'discovered them' in his treatise *On Floating Bodies*: T. L. Heath, *Manual of Greek Mathematics*, 332–6.]

celestial region, or to that which was immediately below it. When each of those simple bodies had thus obtained its proper sphere, there was nothing in the nature of any one of them to make it pass into the place of the other, to make the Fire descend into the Air, the Air into the Water, or the Water into the Earth; or, on the contrary, to bring up the Earth into the place of the Water, the Water into that of the Air, or the Air into that of the Fire. All sublunary things, therefore, if left to themselves, would have remained in an eternal repose. The revolution of the heavens, those of the Sun, Moon, and Five Planets, by producing the vicissitudes of Day and Night, and of the Seasons, prevented this torpor and inactivity from reigning through the inferior parts of nature; inflamed by the rapidity of their circumvolutions, the element of Fire, and forced it violently downwards into the Air, into the Water, and into the Earth, and thereby produced those mixtures of the different elements which kept up the motion and circulation of the lower parts of nature; occasioned, sometimes, the entire transmutation of one element into another, and sometimes the production of forms and species different from them all, and in which, though the qualities of them all might be found, they were so altered and attempered by the mixture, as scarce to be distinguishable.

7 Thus, if a small quantity of Fire was mixed with a great quantity of Air, the moisture and moderate warmth of the one entirely surmounted and changed into their own essence the intense heat and dryness of the other; and the whole aggregate became Air. The contrary of which happened, if a small quantity of Air was mixed with a great quantity of Fire: the whole, in this case, became Fire. In the same manner, if a small quantity of Fire was mixed with a great quantity of Water, then, either the moisture and cold of the Water might surmount the heat and dryness of the Fire, so as that the whole should become Water; or, the moisture of the Water might surmount the dryness of the Fire, while in its turn, the heat of the Fire surmounted the coldness of the Water, so as that the whole aggregate, its qualities being heat and moisture, should become Air, which was regarded as the more natural and easy metamorphosis of the two. In the same manner they explained how like changes were produced by the different mixtures of Fire and Earth, Earth and Water, Water and Air, Air and Earth; and thus they connected together the successive transmutations of the elements into one another.

8 Every mixture of the Elements, however, did not produce an entire transmutation. They were sometimes so blended together, that the qualities of the one, not being able to destroy, served only to attemper those of the other. Thus Fire, when mixed with water, produced

sometimes a watery vapour, whose qualities were heat and moisture; which partook at once of the levity of the Fire, and of the gravity of the Water, and which was elevated by the first into the Air, but retained by the last from ascending into the region of Fire. The relative cold, which they supposed prevailed in the middle region of the Air, upon account of its equal distance, both from the region of Fire, and from the rays that are reflected by the surface of the Earth, condensed this vapour into Water; the Fire escaped it, and flew upwards, and the Water fell down in rain, or, according to the different degrees of cold that prevailed in the different seasons, was sometimes congealed into snow, and sometimes into hail. In the same manner, Fire, when mixed with Earth, produced sometimes a fiery exhalation, whose qualities were heat and dryness, which being elevated by the levity of the first into the Air condensed by the cold, so as to take fire, and being at the same time surrounded by watery vapours, burst forth into thunder and lightning, and other fiery meteors. Thus they connected together the different appearances in the Air, by the qualities of their Four Elements; and from them, too, in the same manner, they endeavoured to deduce all the other qualities in the other homogeneous bodies, that are near the surface of the Earth. Thus, to give an example, with regard to the hardness and softness of bodies; heat and moisture, they observed, were the great softners of matter. Whatever was hard, therefore, owed that quality either to the absence of heat, or to the absence of moisture. Ice, crystal, lead, gold, and almost all metals, owed their hardness to the absence of heat, and were, therefore, dissolveable by Fire. Rock-salt, nitre, alum, and hard clay, owed that quality to the absence of moisture, and were, therefore, dissolveable in water. And, in the same manner, they endeavoured to connect together most of the other tangible qualities of matter. Their principles of union, indeed, were often such as had no real existence, and were always vague and undetermined in the highest degree; they were such, however, as might be expected in the beginnings of science, and such as, with all their imperfections, could enable mankind both to think and to talk, with more coherence, concerning those general subjects, than without them they would have been capable of doing. Neither was their system entirely devoid either of beauty or magnificence. Each of the Four Elements having a particular region allotted to it, had a place of rest, to which it naturally tended, by its motion, either up or down, in a straight line, and where, when it had arrived, it naturally ceased to move. Earth descended, till it arrived at the place of Earth; Water, till it arrived at that of Water; and Air, till it arrived at that of Air; and there each of them tended to a state of eternal repose and inaction.

The Spheres consisted of a Fifth Element,[7] which was neither light nor heavy, and whose natural motion made it tend, neither to the center, nor from the center, but revolve round it in a circle. As, by this motion, they could never change their situation with regard to the center, they had no place of repose, no place to which they naturally tended more than to any other, but revolved round and round for ever. This Fifth Element was subject neither to generation nor corruption, nor alteration of any kind; for whatever changes may happen in the Heavens, the senses can scarce perceive them, and their appearance is the same in one age as in another. The beauty, too, of their supposed crystalline spheres seemed still more to entitle them to this distinction of unchangeable immortality. It was the motion of those Spheres, which occasioned the mixtures of the Elements, and from thence, the production of all the forms and species, that diversify the world. It was the approach of the Sun and of the other Planets, to the different parts of the Earth, which, by forcing down the element of Fire, occasioned the generation of those forms.[8] It was the recess of those bodies, which, by allowing each Element to escape to its proper sphere, brought about, in an equal time, their corruption. It was the periods of those great lights of Heaven, which measured out to all sublunary things, the term of their duration, of their growth, and of their decay, either in one, or in a number of seasons, according as the Elements of which they were composed, were either imperfectly or accurately blended and mixed with one another. Immortality, they could bestow upon no individual form, because the principles out of which it was formed, all tending to disengage themselves, and to return to their proper spheres, necessarily, at last, brought about its dissolution. But, though all individuals were thus perishable, and constantly decaying, every species was immortal, because the subject matter out of which they were made, and the revolution of the Heavens, the cause of their successive generations, were always the same.

9 In the first ages of the world, the seeming incoherence of the appearances of nature, so confounded mankind, that they despaired of discovering in her operations any regular system. Their ignorance, and confusion of thought, necessarily gave birth to that pusillanimous superstition, which ascribes almost every unexpected event, to the arbitrary will of some designing, though invisible beings, who

[7] [Aristotle's view of the Aether was never as widely accepted as the following account implies, being criticized not only by the Epicureans but by many of his own successors. It should not be assumed that all who accepted the concentric spheres as an astronomical hypothesis subscribed to it. See P. Moraux, article 'Quinta Essentia', in Pauly's *Real-Encyclopädie der classischen Alterthumswissenschaft*, Halbband 47 (1963), col. 1231a ff.]

[8] [Aristotle, *De Generatione et Corruptione*, II.10, 336$^{a}$14 ff.; *Metaphysics*, Λ, 1071$^{a}$15.]

produced it for some private and particular purpose.[9] The idea of an universal mind, of a God of all, who originally formed the whole, and who governs the whole by general laws, directed to the conservation and prosperity of the whole, without regard to that of any private individual, was a notion to which they were utterly strangers. Their gods, though they were apprehended to interpose, upon some particular occasions, were so far from being regarded, as the creators of the world, that their origin was apprehended to be posterior to that of the world. The Earth, according to Hesiod,[10] was the first production of the chaos. The Heavens arose out of the Earth, and from both together, all the gods, who afterwards inhabited them. Nor was this notion confined to the vulgar, and to those poets who seem to have recorded the vulgar theology. Of all the philosophers of the Ionian school, Anaxagoras, it is well known, was the first who supposed, that mind and understanding were requisite to account for the first origin of the world, and who, therefore, compared with the other philosophers of his time, talked, as Aristotle observes, like a sober man among drunkards;[11] but whose opinion was, at that time, so remarkable, that he seems to have got a sirname from it.[12] The same notion, of the spontaneous origin of the world, was embraced, too, as the same author tells us,[13] by the early Pythagoreans, a sect, which, in the antient world, was never regarded as irreligious. Mind, and understanding, and consequently Deity, being the most perfect, were necessarily, according to them, the last productions of Nature. For in all other things, what was most perfect, they observed, always came last. As in plants and animals, it is not the seed that is most perfect, but the complete animal, with all its members, in the one; and the complete plant, with all its branches, leaves, flowers, and fruits, in the other. This notion, which could take place only while Nature was still considered as, in some measure, disorderly and inconstant in her operations, was necessarily renounced by those philosophers, when, upon a more attentive survey, they discovered, or imagined they had discovered, more distinctly, the chain which bound all her different parts to one another. As soon as the Universe was regarded as a complete machine, as a coherent system, governed by general laws, and directed to general ends, viz. its own preservation and prosperity, and that of all the species that are in it; the resemblance which it evidently bore to those machines which are

9 [Cf. Astronomy, III.2.]
10 [*Theogony*, 116 ff., noted by Aristotle in *Metaphysics*, A, $984^b27$–9 and $989^a10$–11.]
11 [*Metaphysics*, A, $984^b15$–19.]
12 [Diogenes Laertius, II.6, reports that Anaxagoras was nicknamed *Nous*, and confirms this by some lines from the satirical poet Timon of Phlius.]
13 [*Metaphysics*, Λ, $1072^b30$–$1073^a3$.]

produced by human art, necessarily impressed those sages with a belief, that in the original formation of the world there must have been employed an art resembling the human art, but as much superior to it, as the world is superior to the machines which that art produces. The unity of the system, which, according to this ancient philosophy, is most perfect, suggested the idea of the unity of that principle, by whose art it was formed; and thus, as ignorance begot superstition, science gave birth to the first theism that arose among those nations, who were not enlightened by divine Revelation. According to Timaeus, who was followed by Plato,[14] that intelligent Being, who formed the world, endowed it with a principle of life and understanding, which extends from its centre to its remotest circumference, which is conscious of all its changes, and which governs and directs all its motions to the great end of its formation. This Soul of the world was itself a God, the greatest of all the inferior, and created deities; of an essence that was indissoluble, by any power but by that of him who made it, and which was united to the body of the world, so as to be inseparable by every force, but his who joined them, from the exertion of which his goodness secured them. The beauty of the celestial spheres attracting the admiration of mankind, the constancy and regularity of their motions seeming to manifest peculiar wisdom and understanding, they were each of them supposed to be animated by an Intelligence of a nature that was, in the same manner, indissoluble and immortal, and inseparably united to that sphere which it inhabited. All the mortal and changeable beings which people the surface of the earth were formed by those inferior deities; for the revolutions of the heavenly bodies seemed plainly to influence the generation and growth of both plants and animals, whose frail and fading forms bore the too evident marks of the weakness of those inferior causes, which joined their different parts to one another. According to Plato and Timaeus,[15] neither the Universe, nor even those inferior deities, who govern the Universe, were eternal, but were formed in time, by the great Author of all things, out of that matter which had existed from all eternity. This at least their words seem to import, and thus they are understood by Cicero,[16] and by all the other writers of earlier antiquity, though some of the later Platonists have interpreted them differently.[17]

[14] [Timaeus Locrus, 94 D, but see note 12 to Astronomy, III, above; Plato, *Timaeus*, 30 B, 34 B.]

[15] [Plato, *Timaeus*, 28 B, 37 D, 41 A; Timaeus Locrus, 93 A–95 A.]

[16] [Perhaps *De Natura Deorum*, I.8.19. But the work is a dialogue, and Cicero himself is not speaking.]

[17] [The Neoplatonists followed the interpretation of Xenocrates—that Plato used temporal language in describing the formation of the world only as a device of exposition. See A. E. Taylor, *Commentary on Plato's Timaeus*, 66, 68.]

10 According to Aristotle, who seems to have followed the doctrine of Ocellus,[18] the world was eternal; the eternal effect of an eternal cause. He found it difficult, it would seem, to conceive what could hinder the First Cause from exerting his divine energy from all eternity. At whatever time he began to exert it, he must have been at rest during all the infinite ages of that eternity which had passed before it. To what obstruction, from within or from without, could this be owing? or how could this obstruction, if it ever had subsisted, have ever been removed?[19] His idea of the nature and manner of existence of this First Cause, as it is expressed in the last book of his Physics, and the five last chapters of his Metaphysics,[20] is indeed obscure and unintelligible in the highest degree, and has perplexed his commentators more than any other parts of his writings. Thus far, however, he seems to express himself plainly enough: that the First Heaven,[21] that of the Fixed Stars, from which are derived the motions of all the rest, is revolved by an eternal, immoveable, unchangeable, unextended being, whose essence consists in intelligence, as that of a body consists in solidity and extension; and which is therefore necessarily and always intelligent, as a body is necessarily and always extended: that this Being was the first and supreme mover of the Universe: that the inferior Planetary Spheres derived each of them its peculiar revolution from an inferior being of the same kind; eternal, immoveable, unextended, and necessarily intelligent: that the sole object of the intelligence of those beings was their own essence, and the revolution of their own spheres; all other inferior things being unworthy of their consideration; and that therefore whatever was below the Moon was abandoned by the gods to the direction of Nature, and Chance, and Necessity.[22] For though those celestial beings were, by the revolutions of their several Spheres, the original causes of the generation and corruption of all sublunary forms, they were causes who neither knew nor intended the effects which they

[18] See note 12 to Astronomy, III, above.

[19] [This hardly represents Aristotle's reasoning. In the text presumably referred to (*Physics*, VIII.5), Aristotle does not ask 'what could hinder the First Cause from exerting his divine energy from all eternity'; his argument is that the eternal motion, which is an evident fact, positively requires a First Cause, of which activity or actuality is the essence.]

[20] [*Physics*, VIII; *Metaphysics*, Λ, 6–10, 1071$^{b}$3 ff. Smith seems to forget that this is not the last book of the *Metaphysics*. Or he may intend to dispute the traditional order of books.]

[21] [The text of the original edition has 'Heavens,' presumably a printer's error since the verb, 'is revolved', is singular.]

[22] [This is verbally correct, but one must consider what Nature means for Aristotle. He holds that 'all things have by nature some part in the divine' (*Nicomachean Ethics*, VII.13,1153$^{b}$32), and develops this thought in *De Partibus Animalium*, I.5,644$^{b}$22 ff. See translation of the chapter by D. M. Balme, *Aristotle's De Partibus Animalium I and De Generatione Animalium I*, Clarendon Aristotle (1972), 17–18. Further, Nature aims without conscious prevision at ends or purposes, and in this respect the human arts are said to imitate her while falling short of the accuracy of her operations (*Physics*, Book II).]

produced. This renowned philosopher seems, in his theological notions, to have been directed by prejudices which, though extremely natural, are not very philosophical. The revolutions of the Heavens, by their grandeur and constancy, excited his admiration, and seemed, upon that account, to be effects not unworthy a Divine Intelligence. Whereas the meanness of many things, the disorder and confusion of all things below,[23] exciting no such agreeable emotion, seemed to have no marks of being directed by that Supreme Understanding. Yet, though this opinion saps the foundations of human worship, and must have the same effects upon society as Atheism itself, one may easily trace, in the Metaphysics upon which it is grounded, the origin of many of the notions, or rather of many of the expressions, in the scholastic theology, to which no notions can be annexed.

11 The Stoics, the most religious of all the ancient sects of philosophers,[24] seem in this, as in most other things, to have altered and refined upon the doctrine of Plato.[25] The order, harmony, and coherence which this philosophy bestowed upon the Universal System, struck them with awe and veneration. As, in the rude ages of the world, whatever particular part of Nature excited the admiration of mankind, was apprehended to be animated by some particular divinity; so the whole of Nature having, by their reasonings, become equally the object of admiration, was equally apprehended to be animated by a Universal Deity, to be itself a Divinity, an Animal; a term which to our ears seems by no means synonimous with the foregoing; whose body was the solid and sensible parts of Nature, and whose soul was that aetherial Fire, which penetrated and actuated the whole. For of all the four elements, out of which all things were composed, Fire or Aether seemed to be that which bore the greatest resemblance to the Vital Principle which informs both plants and animals, and therefore most likely to be the Vital Principle which animated the Universe. This infinite and unbounded Aether, which extended itself from the centre beyond the remotest circumference of Nature, and was endowed with the most consummate reason and intelligence, or rather was itself the very essence of reason

[23] 'Disorder and confusion' is a travesty of Aristotle's views on 'all things below'. See *De Partibus Animalium*, 645a, and also the editor's Introduction, 23–4.

[24] [Smith writes again, in TMS I.ii.3.4, of the religious character of the Stoic doctrine of cosmic harmony. His long account of Stoic ethics, in TMS VII.ii.1.15–47, also contains frequent references to religion.]

[25] [A similar judgment recurs in Ancient Logics, 9, below. It is perhaps derived from Cicero's statements (*De Finibus*, III.3,10; IV.2,3) that Zeno was not justified in founding a new school since he had little to contribute but a novel vocabulary. The originality of Stoic formal logic was not appreciated until the twentieth century. Expositions which emphasize the originality of many Stoic doctrines have been given by M. Pohlenz, *Die Stoa* (1948), and S. Sambursky, *The Physics of the Stoics* (1959).]

and intelligence, had originally formed the world, and had communicated a portion, or ray, of its own essence to whatever was endowed with life and sensation, which, upon the dissolution of those forms, either immediately or sometime after, was again absorbed into that ocean of Deity from whence it had originally been detached. In this system, the Sun, the Moon, the Planets, and the Fixed Stars, were each of them also inferior divinities, animated by a detached portion of that aetherial essence which was the soul of the world. In the system of Plato, the Intelligence which animated the world was different from that which originally formed it. Neither were these which animated the celestial spheres, nor those which informed inferior terrestrial animals, regarded as portions of this plastic soul of the world. Upon the dissolution of animals, therefore, their souls were not absorbed in the soul of the world, but had a separate and eternal existence, which gave birth to the notion of the transmigration of souls. Neither did it seem unnatural, that, as the same matter which had composed one animal body might be employed to compose another, that the same intelligence which had animated one such being should again animate another. But in the system of the Stoics, the intelligence which originally formed, and that which animated the world, were one and the same, all inferior intelligences were detached portions of the great one; and therefore, in a longer, or in a shorter time, were all of them, even the gods themselves, who animated the celestial bodies, to be at last resolved into the infinite essence of this almighty Jupiter, who, at a destined period, should, by an universal conflagration, wrap up all things, in that aetherial and fiery nature, out of which they had originally been deduced, again to bring forth a new Heaven and a new Earth, new animals, new men, new deities; all of which would again, at a fated time, be swallowed up in a like conflagration, again to be re-produced, and again to be re-destroyed, and so on without end.

THE

# PRINCIPLES

WHICH LEAD AND DIRECT

# PHILOSOPHICAL ENQUIRIES;

ILLUSTRATED BY THE HISTORY OF THE

# ANCIENT LOGICS and METAPHYSICS

1 In every transmutation, either of one element into another, or of one compound body, either into the elements out of which it was composed, or into another compound body, it seemed evident, that, both in the old and in the new species, there was something that was the same, and something that was different. When Fire was changed into Air, or Water into Earth, the Stuff, or Subject-matter of this Air and this Earth, was evidently the same with that of the former Fire or Water; but the Nature or Species of those new bodies was entirely different. When, in the same manner, a number of fresh, green, and odoriferous flowers were thrown together in a heap, they, in a short time, entirely changed their nature, became putrid and loathsome, and dissolved into a confused mass of ordure, which bore no resemblance, either in its sensible qualities or in its effects, to their former beautiful appearance. But how different soever the species, the subject-matter of the flowers, and of the ordure, was, in this case too, evidently the same. In every body, therefore, whether simple or mixed, there were evidently two principles, whose combination constituted the whole nature of that particular body. The first was the Stuff, or Subject-matter, out of which it was made; the second was the Species, the Specific Essence, the Essential, or, as the schoolmen have called it, the Substantial Form of the Body. The first seemed to be the same in all bodies, and to have neither qualities nor powers of any kind, but to be altogether inert and imperceptible by any of the senses, till it was qualified and rendered sensible by its union with some species or essential form. All the qualities and powers of bodies seemed to depend upon their species or essential forms. It was not the stuff or matter of Fire, or Air, or Earth, or Water, which enabled

those elements to produce their several effects, but that essential form which was peculiar to each of them. For it seemed evident, that Fire must produce the effects of Fire, by that which rendered it Fire; Air, by that which rendered it Air; and that in the same manner all other simple and mixed bodies must produce their several effects, by that which constituted them such or such bodies; that is, by their specific Essence or essential forms. But it is from the effects of bodies upon one another, that all the changes and revolutions in the material world arise. Since these, therefore, depend upon the specific essences of those bodies, it must be the business of philosophy,[1] that science which endeavours to connect together all the different changes that occur in the world, to determine wherein the specific Essence of each object consists, in order to foresee what changes or revolutions may be expected from it. But the specific Essence of each individual object is not that which is peculiar to it as an individual, but that which is common to it, with all other objects of the same kind. Thus the specific Essence of the Water, which now stands before me, does not consist in its being heated by the Fire, or cooled by the Air, in such a particular degree; in its being contained in a vessel of such a form, or of such dimensions. These are all accidental circumstances, which are altogether extraneous to its general nature, and upon which none of its effects as Water depend. Philosophy, therefore, in considering the general nature of Water, takes no notice of those particularities which are peculiar to this Water, but confines itself to those things which are common to all water. If, in the progress of its enquiries, it should descend to consider the nature of Water that is modified by such particular accidents, it still would not confine its consideration to this water contained in this vessel, and thus heated at this fire, but would extend its views to Water in general contained in such kind of vessels, and heated to such a degree at such a fire. In every case, therefore, Species, or Universals, and not Individuals, are the objects of Philosophy. Because whatever effects are produced by individuals, whatever changes can flow from them, must all proceed from some universal nature that is contained in them. As it was the business of Physics, or Natural Philosophy, to determine wherein consisted the Nature and Essence of every particular Species of things, in order to connect together all the different events that occur in the material world; so there were two other sciences, which, though they had originally arisen out of that system of Natural Philosophy I have just been describing, were, however, apprehended to go before it, in the order in which the knowledge of Nature ought to be communicated.

[1] i.e. natural philosophy. [For the words that follow, cf. Astronomy, II.12, where (natural) philosophy is described as 'the science of the connecting principles of nature'.]

The first of these, Metaphysics, considered the general nature of Universals, and the different sorts or species into which they might be divided. The second of these, Logics,[2] was built upon this doctrine of Metaphysics; and from the general nature of Universals, and of the sorts into which they were divided, endeavoured to ascertain the general rules by which we might distribute all particular objects into general classes, and determine to what class each individual object belonged; for in this, they justly enough apprehended, consisted the whole art of philosophical reasoning. As the first of these two sciences, Metaphysics, is altogether subordinate to the second, Logic, they seem, before the time of Aristotle, to have been regarded as one, and to have made up between them that ancient Dialectic of which we hear so much, and of which we understand so little: neither does this separation seem to have been much attended to, either by his own followers, the ancient Peripatetics, or by any other of the old sects of philosophers. The later schoolmen, indeed, have distinguished between Ontology and Logic; but their Ontology contains but a small part of what is the subject of the metaphysical books of Aristotle, the greater part of which, the doctrines of Universals, and every thing that is preparatory to the arts of defining and dividing, has, since the days of Porphery,[3] been inserted into their Logic.[4]

2 According to Plato and Timaeus,[5] the principles out of which the Deity formed the World, and which were themselves eternal, were three in number. The Subject-matter of things, the Species or specific Essences of things, and what was made out of these, the sensible objects themselves. These last had no proper or durable existence, but were in perpetual flux and succession. For as Heraclitus had said, that no man ever passed the same river twice,[6] because the water which he had passed over once was gone before he could pass over it a second time; so, in the same manner, no man ever saw, or heard, or touched the same sensible object twice. When I look at the window, for example, the visible species, which strikes my eyes this moment, though resembling, is different from that which struck my eyes the immediately preceding moment. When I ring the bell, the sound, or audible species which I hear this moment, though resembling in the same manner, is different, however, from that which I heard the

[2] The use of the word 'logics' is unusual, but consistent with the strictly plural form of 'physics' and 'metaphysics', the Latin form of each of which was originally a neuter plural corresponding to the Greek sense of 'physical things'. See also the editor's Introduction, 24–5.

[3] [i.e. Porphyry.]

[4] [In WN V.i.f.29 Smith describes rather differently the confusing character of Ontology. He says that it was supposed to deal with qualities and attributes common to Metaphysics and Physics but was sometimes itself called Metaphysics.]

[5] [Plato, *Timaeus*, 48 E ff.; Timaeus Locrus, 94 A–B. See note 12 to Astronomy, III.]

[6] [Aristotle, *Metaphysics*, Γ, $1010^a13$–14.]

moment before. When I lay my hand on the table, the tangible species which I feel this moment, though resembling, in the same manner, is numerically different too from that which I felt the moment before. Our sensations, therefore, never properly exist or endure one moment; but, in the very instant of their generation, perish and are annihilated for ever. Nor are the causes of those sensations more permanent. No corporeal substance is ever exactly the same, either in whole or in any assignable part, during two successive moments, but by the perpetual addition of new parts, as well as loss of old ones, is in continual flux and succession. Things of so fleeting a nature can never be the objects of science, or of any steady or permanent judgment. While we look at them, in order to consider them, they are changed and gone, and annihilated for ever. The objects of science, and of all the steady judgments of the understanding, must be permanent, unchangeable, always existent, and liable neither to generation nor corruption, nor alteration of any kind.[7] Such are the species or specific essences of things. Man is perpetually changing every particle of his body; and every thought of his mind is in continual flux and succession. But humanity, or human nature, is always existent, is always the same, is never generated, and is never corrupted. This, therefore, is the object of science, reason, and understanding, as man is the object of sense, and of those inconstant opinions which are founded upon sense. As the objects of sense were apprehended to have an external existence, independent of the act of sensation, so these objects of the understanding were much more supposed to have an external existence independent of the act of understanding. Those external essences were, according to Plato,[8] the exemplars, according to which the Deity formed the world, and all the sensible objects that are in it. The Deity comprehended within his infinite essence, all these species, or eternal exemplars, in the same manner as he comprehended all sensible objects.

3 Plato, however, seems to have regarded the first of those as equally distinct with the second from what we would now call the Ideas or Thoughts of the Divine Mind *, and even to have supposed, that they

* He calls them, indeed, Ideas, a word which, in him, in Aristotle, and all the other writers of earlier antiquity, signifies a Species, and is perfectly synonimous with that other word *Ειδος*, more frequently made use of by Aristotle. As, by some of the later sects of philosophers, particularly by the Stoics, all species, or specific essences, were regarded as mere creatures of the mind, formed by abstraction, which had no real existence external to the thoughts that conceived them, the word Idea came, by degrees, to its present signification, to mean, first, an abstract thought or conception; and afterwards, a thought or conception of any kind; and thus became synonymous with that other Greek word *Εννοια*, from which it had originally a very (*continued*)

[7] [Plato, *Timaeus*, 52 A–B.]   [8] [*Timaeus*, 29 A.]

had a particular place of existence, beyond the sphere of the visible corporeal world; though this has been much controverted, both by

different meaning. When the later Platonists, who lived at a time when the notion of the separate existence of specific essences were universally exploded, began to comment upon the writings of Plato, and upon that strange fancy that, in his writings, there was a double doctrine; and that they were intended to seem to mean one thing, while at bottom they meant a very different, which the writings of no man in his senses ever were, or ever could be intended to do;[9] they represented his doctrine as meaning no more, than that the Deity formed the world after what we would now call an Idea, or plan conceived in his own mind, in the same manner as any other artist.[10] But, if Plato had meant to express no more than this most natural and simple of all notions, he might surely have expressed it more plainly, and would hardly, one would think, have talked of it with so much emphasis, as of something which it required the utmost reach of thought to comprehend. According to this representation, Plato's notion of Species, or Universals, was the same with that of Aristotle. Aristotle, however, does not seem to understand it as such; he bestows a great part of his Metaphysics upon confuting it, and opposes it in all his other works; nor does he, in any one of them, give the least hint, or insinuation, as if it could be suspected that, by the Ideas of Plato, was meant the thoughts or conceptions of the Divine Mind. Is it possible that he, who was twenty years in his school, should, during all that time, have misunderstood him, especially when his meaning was so very plain and obvious? Neither is this notion of the separate existence of Species, distinct both from the mind which conceives them, and from the sensible objects which are made to resemble them, one of those doctrines which Plato would but seldom have occasion to talk of. However it may be interpreted, it is the very basis of his philosophy; neither is there a single dialogue in all his works which does not refer to it. Shall we suppose, that that great philosopher, who appears to have been so much superior to his master in every thing but eloquence, wilfully, and upon all occasions, misrepresented, not one of the deep and mysterious doctrines of the philosophy of Plato, but the first and most fundamental principle of all his reasonings; when the writings of Plato were in the hands of every body; when his followers and disciples were spread all over Greece; when almost every Athenian of distinction, that was nearly of the same age with Aristotle, must have been bred in his school; when Speusippus, the nephew and successor of Plato, as well as Xenocrates, who continued the school in the Academy, at the same time that Aristotle held his in the Lyceum, must have been ready, at all times, to expose and affront him for such gross disingenuity. Does not Cicero, does not Seneca understand this doctrine in the same manner as Aristotle has represented it? Is there any author in all antiquity who seems to understand it otherwise, earlier than Plutarch, an author, who seems to have been as bad a critic in philosophy as in history, and to have taken every thing at second-hand in both, and who lived after the origin of that eclectic philosophy, from whence the later Platonists[11] arose, and who seems himself to have been one of that sect? Is there any one passage in any Greek author, near the time of Aristotle and Plato, in which the word Idea is used in its present meaning, to signify a thought or conception? Are not the words, which in all languages express reality or existence, directly opposed to those which express thought, or conception only? Or, is there any other difference betwixt a thing that exists, and a thing that does not exist, except this, that the one is a mere conception, and that the other is something more than a conception? With what propriety, therefore, could Plato talk of those eternal species, as of the only things which had any real existence, if they were no more than the conceptions of the Divine Mind? Had not the Deity, according to Plato, as well as according to the Stoics, from all eternity, the idea of every individual, as well as of every species, and of the state in which every individual was to be, in each different instance of its existence? Were not all the divine ideas, therefore, of each individual, or of all the different states, which each individual was to be in during the course of its existence, equally eternal and unalterable with those of the species? With what sense, therefore, could Plato say, that the first were eternal, because the Deity had conceived

[9] The coexistence of esoteric and exoteric writings is pretty well attested among men far from being 'out of their senses'. There are plausible grounds for believing that Plato may in his later years have been among them, though probably not in respect of the Ideas, where he was doing no more than change his mind. Cf. *Theaetetus*, 152 C, for a suggestion by 'Socrates'.

[10] [The question 'Are Plato's Ideas thoughts of the Divine Mind?' is answered in the negative by E. Zeller, *Plato and the Older Academy* (English translation, 1888, made from the 3rd edition of Zeller's *Philosophie der Griechen*), 243–8. His general line of argument is in fact very similar to Smith's.]

[11] [In TMS VII.ii.3.1 Smith identifies the 'Eclectics' with the 'later Platonists'.]

the later Platonists, and by some very judicious modern critics,[12] who have followed the interpretation of the later Platonists, as what did most honour to the judgment of that renowned philosopher. All the objects in this world, continued he, are particular and individual. Here, therefore, the human mind has no opportunity of seeing any Species, or Universal Nature. Whatever ideas it has, therefore, of such beings, for it plainly has them, it must derive from the memory of what it has seen, in some former period of its existence, when it had an opportunity of visiting the place or Sphere of Universals.[15] For some time after it is immersed in the body, during its infancy, its childhood, and a great part of its youth, the violence of those passions which it derives from the body, and which are all directed to the particular and individual objects of this world, hinder it from turning its attention to those Universal Natures, with which it had been conversant in the world from whence it came. The Ideas, of these, therefore, seem, in this first period of its existence here, to be overwhelmed in the confusion of those turbulent emotions, and to be almost entirely wiped out of its remembrance. During the continuance of this state, it is incapable of Reasoning, Science and Philosophy, which are conversant about Universals. Its whole attention is turned

them from all eternity, since he had conceived the others from all eternity too, and since his ideas of the Species could, in this respect, have no advantage of those of the individual? Does not Plato, in many different places, talk of the Ideas of Species or Universals as innate, and having been impressed upon the mind in its state of pre-existence, when it had an opportunity of viewing these Species as they are in themselves, and not as they are expressed in their copies, or representative upon earth? But if the only place of the existence of those Species was the Divine Mind, will not this suppose, that Plato either imagined, like Father Malbranche, that in its state of pre-existence, the mind saw all things in God;[13] or that it was itself an emanation of the Divinity? That he maintained the first opinion, will not be pretended by any body who is at all versed in the history of science. That enthusiastic notion, though it may seem to be favoured by some passages in the Fathers, was never, it is well known, coolly and literally maintained by any body before that Cartesian philosopher. That the human mind was itself an emanation of the Divine, though it was the doctrine of the Stoics, was by no means that of Plato; though, upon the notion of a pretended double doctrine, the contrary has lately been asserted. According to Plato, the Deity formed the soul of the world out of that substance which is always the same, that is, out of Species or Universals; out of that which is always different, that is, out of corporeal substances; and out of a substance that was of a middle nature between these, which it is not easy to understand what he meant by. Out of a part of the same composition, he made those inferior intelligences who animated the celestial spheres, to whom he delivered the remaining part of it, to form from thence the souls of men and animals. The souls of those inferior deities, though made out of a similar substance or composition, were not regarded as parts, or emanations of that of the world; nor were those of animals, in the same manner, regarded as parts or emanations of those inferior deities; much less were any of them regarded as parts, or emanations of the great Author of all things.[14]

---

[12] Presumably the so-called 'Cambridge Platonists', of whom Henry More (1614–87) and Ralph Cudworth (1617–88) were the most significant in this connection. Smith mentions Cudworth in §6 below. [In TMS VII.ii.3.3 Smith names Cudworth, More, and John Smith (1618–52) as leading members of the group.]

[13] [Malebranche, *Recherche de la vérité*, III.ii.6.]

[14] On this long and searching footnote, see the editor's Introduction, 25.

[15] [This view is defended by Plato in the *Meno* and in the *Phaedo*, 73 A–76 E.]

towards particular objects, concerning which, being directed by no general notions, it forms many vain and false opinions, and is filled with error, perplexity, and confusion. But, when age has abated the violence of its passions, and composed the confusion of its thoughts, it then becomes more capable of reflection, and of turning its attention to those almost forgotten ideas of things with which it had been conversant in the former state of its existence. All the particular objects in this sensible world, being formed after the eternal exemplars in that intellectual world, awaken, upon account of their resemblance, insensibly, and by slow degrees, the almost obliterated ideas of these last. The beauty, which is shared in different degrees among terrestrial objects, revives the same idea of that Universal Nature of beauty which exists in the intellectual world: particular acts of justice, of the universal nature of justice; particular reasonings, and particular sciences, of the universal nature of science, and reasoning; particular roundnesses, of the universal nature of roundness; particular squares, of the universal nature of squareness. Thus science, which is conversant about Universals, is derived from memory; and to instruct any person concerning the general nature of any subject, is no more than to awaken in him the remembrance of what he formerly knew about it. This both Plato and Socrates imagined they could still further confirm, by the fallacious experiment, which shewed, that a person might be led to discover himself, without any information, any general truth, of which he was before ignorant, merely by being asked a number of properly arranged and connected questions concerning it.[16]

4 The more the soul was accustomed to the consideration of those Universal Natures, the less it was attached to any particular and individual objects; it approached the nearer to the original perfection of its nature, from which, according to this philosophy, it had fallen. Philosophy, which accustoms it to consider the general Essence of things only, and to abstract from all their particular and sensible circumstances, was, upon this account, regarded as the great purifier of the soul. As death separated the soul from the body, and from the bodily senses and passions, it restored it to that intellectual world, from whence it had originally descended, where no sensible Species called off its attention from those general Essences of things. Philosophy, in this life, habituating it to the same considerations, brings it, in some degree, to that state of happiness and perfection, to which death restores the souls of just men in a life to come.

5 Such was the doctrine of Plato concerning the Species or Specific

[16] A reference to the well-known elicitation by Socrates of a geometrical proof from a slave (*Meno*, 82 B–85 C).

Essence of things. This, at least, is what his words seem to import, and thus he is understood by Aristotle, the most intelligent and the most renowned of all his disciples. It is a doctrine, which, like many of the other doctrines of abstract Philosophy, is more coherent in the expression than in the idea; and which seems to have arisen, more from the nature of language, than from the nature of things.[17] With all its imperfections it was excusable, in the beginnings of philosophy, and is not a great deal more remote from the truth, than many others which have since been substituted in its room by some of the greatest pretenders to accuracy and precision. Mankind have had, at all times, a strong propensity to realize their own abstractions, of which we shall immediately see an example,[18] in the notions of that very philosopher who first exposed the ill-grounded foundation of those Ideas, or Universals, of Plato and Timaeus. To explain the nature, and to account for the origin of general Ideas, is, even at this day, the greatest difficulty in abstract philosophy. How the human mind, when it reasons concerning the general nature of triangles, should either conceive, as Mr. Locke imagines it does,[19] the idea of a triangle, which is neither obtusangular, nor rectangular, nor acutangular; but which was at once both none and all of those together; or should, as Malbranche thinks necessary for this purpose,[20] comprehend at once, within its finite capacity, all possible triangles of all possible forms and dimensions, which are infinite in number, is a question, to which it is surely not easy to give a satisfactory answer. Malbranche, to solve it, had recourse to the enthusiastic and unintelligible notion of the intimate union of the human mind with the divine, in whose infinite essence the immensity of such species could alone be comprehended; and in which alone, therefore, all finite intelligences could have an opportunity of viewing them. If, after more than two thousand years reasoning about this subject, this ingenious and sublime philosopher was forced to have recourse to so strange a fancy, in order to explain it, can we wonder that Plato, in the very first dawnings of science, should, for the same purpose, adopt an hypothesis, which has been thought, without much reason, indeed, to have some affinity to that of Malbranche, and which is not more out of the way?

6 What seems to have misled those early philosophers, was, the notion, which appears, at first, natural enough, that those things, out of which any object is composed, must exist antecedent to that object. But the things out of which all particular objects seem to be composed, are the stuff or matter of those objects, and the form or specific

[17] Cf. §7 below.
[18] [Presumably the discussion, in §7 below, of Aristotle's doctrine of potential existence.]
[19] [*Essay concerning Human Understanding*, IV.vii.9.]
[20] [*Recherche de la vérité*, III.ii.6.]

Essence, which determines them to be of this or that class of things. These, therefore, it was thought, must have existed antecedent to the object which was made up between them. Plato, who held, that the sensible world, which, according to him, is the world of individuals, was made in time, necessarily conceived, that both the universal matter, the object of a spurious reason,[21] and the specific essence, the object of proper reason and philosophy out of which it was composed, must have had a separate existence from all eternity. This intellectual world, very different from the intellectual world of Cudworth,[22] though much of the language of the one has been borrowed from that of the other, was necessarily, and always existent; whereas the sensible world owed its origin to the free will and bounty of its author.

7 A notion of this kind, as long as it is expressed in very general language; as long as it is not much rested upon; nor attempted to be very particularly and distinctly explained, passes easily enough, through the indolent imagination, accustomed to substitute words in the room of ideas; and if the words seem to hang easily together, requiring no great precision in the ideas. It vanishes, indeed; is discovered to be altogether incomprehensible, and eludes the grasp of the imagination, upon an attentive consideration. It requires, however, an attentive consideration; and if it had been as fortunate as many other opinions of the same kind, and about the same subject, it might, without examination, have continued to be the current philosophy for a century or two. Aristotle, however, seems immediately to have discovered, that it was impossible to conceive, as actually existent, either that general matter, which was not determined by any particular species, or those species which were not embodied, if one may say so, in some particular portion of matter. Aristotle, too, held, as we have already observed,[23] the eternity of the sensible world. Though he held, therefore, that all sensible objects were made up of two principles, both of which, he calls, equally, substances, the matter and the specific essence, he was not obliged to hold, like Plato, that those principles existed prior in the order of time to the objects which they afterwards composed. They were prior, he said, in nature, but not in time, according to a distinction which was of use to him upon some other occasions.[24] He distinguished, too, betwixt actual and

[21] [Plato, *Timaeus*, 51 A, 52 B.]

[22] [A reference to the title, as well as the content, of Cudworth's metaphysical treatise, mainly inspired by his interpretation of Plato: *The True Intellectual System of the Universe* (1678).]

[23] [Ancient Physics, 10.]

[24] [While this remark leaves a correct general impression, Aristotle nowhere seems to say explicitly that his principles (matter and specific essence) are prior in nature but not in time.]

potential existence.[25] By the first, he seems to have understood, what is commonly meant, by existence or reality; by the second, the bare possibility of existence. His meaning, I say, seems to amount to this; though he does not explain it precisely in this manner. Neither the material Essence of body could, according to him, exist actually without being determined by some specific Essence, to some particular class of things, nor any specific Essence without being embodied in some particular portion of matter. Each of these two principles, however, could exist potentially in this separate state. That matter existed potentially, which, being endowed with a particular form, could be brought into actual existence; and that form, which, by being embodied in a particular portion of matter, could, in the same manner, be called forth into the class of complete realities. This potential existence of matter and form, he sometimes talks of, in expressions which very much resemble those of Plato, to whose notion of separate Essence it bears a very great affinity.

8 Aristotle, who seems in many things original, and who endeavoured to seem to be so in all things, added the principle of privation to those of matter and form, which he had derived from the ancient Pythagorean school. When Water is changed into Air, the transmutation is brought about by the material principle of those two elements being deprived of the form of Water, and then assuming the form of Air. Privation, therefore, was a third principle opposite to form, which entered into the generation of every Species, which was always from some other Species. It was a principle of generation, but not of composition, as is obvious.

9 The Stoics, whose opinions were, in all the different parts of philosophy, either the same with, or very nearly allied to those of Aristotle and Plato, though often disguised in very different language, held, that all things, even the elements themselves, were compounded of two principles,[26] upon one of which depended all the active; and upon the other, all the passive powers of these bodies.[27] The last of these, they called the Matter; the first, the Cause, by which they

[25] [Matter and specific essence as substances: *Metaphysics*, Z, and H (especially 1042$^{a}$24–$^{b}$6), also Λ, 1079$^{a}$9 ff. Actual and potential existence: *Metaphysics*, Θ. See in general Sir David Ross, *Aristotle's Metaphysics* (1924), vol. i, Introduction, xci–cxxx, and J. Owens, *The Doctrine of Being in Aristotelian Metaphysics*, ed. 2 (1963).]

[26] [Perhaps taken from Diogenes Laertius, VII.134.]

[27] [Perhaps derived from Seneca, *Epistulae Morales*, 65.2: 'Dicunt, ut scis, Stoici nostri duo esse in rerum natura ex quibus omnia fiant, causam et materiam. Materia iacet iners, res ad omnia parata, cessatura si nemo moveat. Causa autem, id est ratio, materiam format et quocumque vult versat, ex illa varia opera producit. Esse ergo debet, unde fiat aliquid, deinde a quo fiat.'

But whereas Smith is maintaining that this amounts to the same as the Platonic-Aristotelian account, the drift of Seneca's Epistle is that the Stoics by no means agreed with Plato and Aristotle, and were able to give a simpler account of the Cause. The essence of things, he says (§§ 11–13), cannot properly be regarded as a cause; it is at best an ingredient in one.]

meant the very same thing which Aristotle and Plato understood, by their specific Essences. Matter, according to the Stoics, could have no existence separate from the cause or efficient principle which determined it to some particular class of things. Neither could the efficient principle exist separately from the material, in which it was always necessarily embodied. Their opinion, therefore, so far coincided with that of the old Peripatetics. The efficient principle, they said, was the Deity. By which they meant, that it was a detached portion of the etherial and divine nature, which penetrated all things, that constituted what Plato would have called the specific Essence of each individual object; and so far their opinion coincides pretty nearly with that of the latter Platonists, who held, that the specific Essences of all things were detached portions of their created deity, the soul of the world; and with that of some of the Arabian and Scholastic Commentators of Aristotle, who held, that the substantial forms of all things descended from those Divine Essences which animated the Celestial Spheres. Such was the doctrine of the four principal Sects of the ancient Philosophers, concerning the specific Essences of things, of the old Pythagoreans, of the Academical, Peripatetic, and Stoical Sects.[28]

10 As this doctrine of specific Essences seems naturally enough to have arisen from that ancient system of Physics, which I have above described, and which is, by no means, devoid of probability, so many of the doctrines of that system, which seem to us, who have been long accustomed to another, the most incomprehensible, necessarily flow from this metaphysical notion. Such are those of generation, corruption, and alteration; of mixture, condensation, and rarefaction. A body was generated or corrupted, when it changed its specific Essence, and passed from one denomination to another. It was altered when it changed only some of its qualities, but still retained the same specific Essence, and the same denomination. Thus, when a flower was withered, it was not corrupted; though some of its qualities were changed, it still retained the specific Essence, and therefore justly passed under the denomination of a flower. But, when, in the further progress of its decay, it crumbled into earth, it was corrupted; it lost the specific Essence, or substantial form of the flower, and assumed that of the earth, and therefore justly changed its denomination.

11 The specific Essence, or universal nature that was lodged in each particular class of bodies, was not itself the object of any of our senses,

[28] Since Smith wrote in an age when 'physical' (not yet 'chemical') atomism was a dominant mode of thought, it is surprising that the essay should break off without any reference to the Greek atomists—Leucippus and Democritus, mainly 'physical', and the later Epicurus (also strongly 'moral'), as set forth in the poem *De Rerum Natura* by Lucretius.

but could be perceived only by the understanding. It was by the sensible qualities, however, that we judged of the specific Essence of each object. Some of these sensible qualities, therefore, we regarded as essential, or such as showed, by their presence or absence, the presence or absence of that essential form from which they necessarily flowed: Others were accidental, or such whose presence or absence had no such necessary consequences. The first of these two sorts of qualities was called Properties; the second, Accidents.

12 In the Specific Essence of each object itself, they distinguished two parts; one of which was peculiar and characteristical of the class of things of which that particular object was an individual, the other was common to it with some other higher classes of things. These two parts were, to the Specific Essence, pretty much what the Matter and the Specific Essence were to each individual body. The one, which was called the Genus, was modified and determined by the other, which was called the Specific Difference, pretty much in the same manner as the universal matter contained in each body was modified and determined by the Specific Essence of that particular class of bodies. These four, with the Specific Essence or Species itself, made up the number of the Five Universals, so well known in the schools by the names of Genus, Species, Differentia, Proprium, and Accidens.