THE GENERAL SCHOLIUM: SOME NOTES ON NEWTON'S PUBLISHED AND UNPUBLISHED ENDEAVOURS[1]

Steffen Ducheyne[2]

Abstract: Newton's immensely famous, but tersely written, General Scholium is primarily known for its reference to the argument of design and Newton's famous *dictum* "hypotheses non fingo". In the essay at hand, I shall argue that this text served a variety of goals and try to add something new to our current knowledge of how Newton tried to accomplish them. The General Scholium highlights a cornucopia of features that were central to Newton's natural philosophy in general: matters of experimentation, methodological issues, theological matters, matters related to the instauration of *prisca sapientia*, epistemological claims central to Newton's empiricism, and, finally, metaphysical issues. For Newton these matters were closely interwoven. I shall address these matters based on a thorough study of the extant manuscript material.

1. Justifying the *Principia*: From the Classical Scholia to the General Scholium

The aim of this paper is twofold. Its primary aim is *descriptive* (and can be consulted in the appendices): it sets out to describe and give an overview of the bulk of Newton's manuscripts related to the General Scholium[3] (first published in the second edition of the *Principia*[4] in 1713) and, to a lesser extent, the material from the Portsmouth Collection pertaining to the so-called Classical Scholia[5] (composed between 1693-1694). Its secondary aim is *interpretative*: it attempts to re-assess and, ultimately, to provide some new interpretative perspectives on the General Scholium

[1] The author is thankful to Provosts and Syndics of Cambridge University Library. The author is indebted to Adam Perkins, Godfrey Waller and the other members of the Manuscript Department at the Cambridge University Library for their kind assistance during my study of the Portsmouth and Macclesfield collection, and to Stephen D. Snobelen, Scott Mandelbrote, Eric Schliesser, and three anonymous referees of *Isis* for their comments on an earlier draft version. I am much obliged to Volkmar Schüller for the cornucopia of material he sent me. The research stay, which allowed the author to study Newton's manuscripts, was financed by the Research Foundation (Flanders). For the manuscripts pertaining to the Keynes and Yahuda Collection, I have relied on the online transcriptions provided by the Newton Project (http://www.newtonproject.ic.ac.uk [accessed October 2006]).

[2] The author is Postdoctoral Research Fellow of the Research Foundation (Flanders) and is associated with the *Centre for Logic and Philosophy of Science* and the *Centre for History of Science*, both at Ghent University (Belgium). The author can be contacted by e-mail at Steffen.Ducheyne@UGent.be or by regular mail at *Centre for Logic and Philosophy of Science*, Ghent University, Blandijnberg 2, room 2.26, B-9000 Ghent, Belgium <URL: http://logica.ugent.be/steffen>.

[3] For the basics on the editing process of the second edition of the *Principia*, see I. Bernard Cohen, *Introduction to Newton's 'Principia'*, Harvard University Press: Cambridge, 1971, pp. 227-251. See Appendix B.

[4] The author will use the Koyré-Cohen-Whitman variorum edition of the *Principia*: Alexandre Koyré, I. Bernard Cohen and Anne Whitman (eds.), *Isaac Newton's 'Philosophiae Naturalis Principia Mathematica': The Third Edition (1726) with Variant Readings*, Cambridge University Press: Cambridge, 1972.

[5] Cohen, *Introduction to Newton's 'Principia'*, pp. 188-189; Richard S. Westfall, *Never at Rest, A Biography of Isaac Newton*, Cambridge University Press: Cambridge, [1980] 1998, pp. 510-511.

and its genesis. In trying to do so, not only only the five draft-versions of the General Scholium are studied, but also some earlier material (e.g. the suppressed *Preface* and *Conclusion* to the first edition of the *Principia*[6]) and some yet un-transcribed manuscript material that was written in roughly the same period as the drafts to the General Scholium.[7]

In Appendix B to this paper, the relevant differences between the various drafts of the General Scholium will be dealt with in full detail. The idea behind this is that such variations reflect, firstly, how Newton changed his mind during the time of composing them and, secondly, highlight the ways in which Newton tried to combine several often differing endeavours and intellectual goals (which will be addressed in the following section). It is the authors firm conviction that if we seek to understand Newton's General Scholium, we should not only consult the published result, but also consider the sections that, for a variety of reasons, did not appear in the final result. Not only Newton's final version of the General Scholium helps to unravel Newton's goals, but also the manuscripts that never made it to print. This material will occupy centre-stage in this essay. Although, a catalogue of manuscripts related to the Classical Scholia from the Portsmouth Collection[8] is discussed, our discussion will focus on the General Scholium.

The study of the Classical Scholia has, no doubt, dramatically changed our image of Newton. In their 1966 joint paper, which was to become the *locus classicus* in the study of Newton's Classical Scholia, "Newton and the 'Pipes of Pan'", James E. McGuire and Piyo M. Rattansi first pointed to the importance of several of Newton's unpublished draft *scholia* to Propositions IV to IX of Book III of the *Principia*. In a nutshell, their view is that:

> The central purpose of the 'classical' scholia was to support the doctrine of universal gravitation as developed in these Propositions, and to enquire into its nature as a cosmic force. This doctrine is shown by Newton to be identifiable in the writings of the ancients. As will become clear, he is not using this historical evidence in a random fashion, or merely for literary ornamentation. Rather the evidence is used in a serious and systematic fashion, as support for, and justification of, the components of Newton's theory of matter, space and gravitation. The evidence is used to establish four basic theses, which correspond to the matter of Proposition IV to IX. These are, that there was an ancient knowledge of the truth of the following four principles: that matter is atomic in structure and moves by gravity through void space; that gravitational force acts universally; that gravity diminishes in the ratio of the inverse square of the distances between bodies; and that the true cause of gravity is the direct[9] action of God.[10]

---

[6] See Appendix C.

[7] See Appendix A.

[8] See Appendix D.

[9] McGuire and Rattansi's claim is rendered doubtful in view of the following fragment in which Newton distinguished between the spirit causing gravity and God. On Royal Society Ms. 247: f. 14^{v}, Newton wrote: "Hactenus proprietates gravitatis explicui. Causas ejus minime expendo. Dicam tamen quid Veteres hac de re senserint. ~~XXXX nimirum spiritum quedam per caelos XXXX~~ nempe caelos esse corporis prope vacuos ~~XXXdemtis~~ sed spiritu tamen quodam infinito quem Deum nominabant ubique ~~XXXXX et plenis~~ impleri: ~~in quo astra infimaXXXXX~~ corpora autam ~~XXXX~~ in spiritu illo libereme moveri ~~XXXX~~ ejus vi et virtute ~~corpora~~ naturali ad invicem

After having written his highly technical and innovative *Principia*, Newton sought to justify his concept of attraction by showing that the ancients had already discovered the law of universal gravitation. Moreover,

> For him they represented a deeper penetration into the *prisca sapientia*, possible only when the preliminary work has been accomplished through experience.[11]

In a seminal paper written by Paolo Casini in 1984, McGuire and Rattansi's account was scrutinized and the Classical Scholia made available.[12] The final edition has been provided only recently by Volkmar Schüller.[13] According to Casini's interpretation,

---

~~impelli~~ perpetuo impelli, idque magis vel minus pro ratione harmonica distantiarum, & in hic im<pul>su gravitatem consistere. Hunc spiritum aliqui a Deo summo distinxerunt & animam mundi vocarunt." (Volkmar Schüller, "Newton's *Scholia* from David Gregory's Estate on the Propositions IV through IX Book II of his *Principia*", Appendix 1, in: Wolfgang Lefèvre (ed.), *Newton, And Kant, Philosophy and Science in the Eighteenth Century*, Kluwer: Dordrecht/Boston/London, 2001, pp. 213-265, p. 240). In the last sentence, Newton rapports that some ancients differentiated this spirit from God. This leaves open the option that this spirit operates as an intermediary. In Volkmar Schüller, *Newtons Scholia aus David Gregorys Nachlaß zu den Propositionen IV- IX Buch III seiner* Principia, Max-Planck-Institut für Wissenschaftsgeschichte, Preprint 144, 2000, pp. 71-87, Schüller also transcribed Gregory's introduction to his *Astronomiae physicae & geometricae elementa* (1720). The appendix (pp. 89-117) contains reproductions of the manuscript material (Royal Society Ms. 247: ff. 6-14).

[10] J. E. McGuire and P. M. Rattansi, Newton and the 'Pipes of Pan', *Notes and Records of the Royal Society of London*, 1966, 21(2), pp. 108-143, pp. 111-112. Only in 1984 did Newton's Classical Scholia become commonly accessible, see P. Casini, "Newton: The Classical Scholia", *History of Science*, 1984, 22(1), pp. 1-55. Casini's paper contains several pertinent criticisms to McGuire and Rattansi's account. He convincingly tempered their view that the Cambridge Platonists, Ralph Cudworth and Henry More, were a direct source of inspiration for Newton (*ibid.*, pp. 4-5), and, on a more general level, their Hermetic-alchemist interpretation of Newton (*ibid.*, pp. 10-15). Indeed, McGuire and Rattansi's analysis of the "striking similarities" remains fairly sketchy (e.g., McGuire and Rattansi, "Newton and the 'Pipes of Pan'", p. 130, *cf.* p. 135) and on some occasions almost inconsistent (*cf.* On the same page where McGuire and Rattansi claim that there is a direct influence from the Cambridge Platonists to Newton, they also claim that: "Newton's Platonism was not directly the Platonism of More and Cudworth, with their stress on such intermediaries as the Hylarchical Principle; but it was also a Platonism in the spirit of the early Church Fathers."; *ibid.*, p. 114). Also note that there is considerable tension between the view they ascribe to Newton according to which God is the direct cause of gravity, and the view they attribute to the Cambridge Platonists, according to which gravity is caused by the divine by means of an intermediary. In a later paper, McGuire wrote that "Hermeticism is too simple an answer to a complex problem of this sort: it gives only a single-valued account of how Newton liberalized the ontology of the mechanical philosophy to include various types of agents" (James E. McGuire, "Neoplatonism and Active Principles: Newton and the Corpus Hermeticum", in: Robert S. Westman and James E. McGuire, *Hermeticism and the Scientific Revolution, Papers read at a Clark Seminar March 9, 1974*, Los Angeles: William Andrew Clark Memorial Library, 1977, pp. 93-142, p. 126). He reiterated his stress on the importance of the Cambridge Platonism from which "Newton's general ontology of force was generated from" (*ibid.*, p. 95, *cf.* p. 119) and which "provided an essential framework for his critical response to Cartesianism" (*ibid.*, p. 103).

[11] *Ibid.*, p. 137.

> [...] the Classical Scholia belong to a particular tradition: rather than consorting with the tradition of the *prisca* in the broad sense, they belong to a variant properly called 'Copernican' which was used to vindicate the validity – on both the technical and philosophical level – of ancient cosmological models which were alternatives to the geostatic system. Copernicus, Galileo, Kepler and their followers had often understood the progress of astronomy as being also a reversion towards propositions comprehended intuitively by the Ancients.[14]

The study of the Classical Scholia has contributed to the study of Newton's "extra-scientific" activities (and, to a certain extent, made possible similar studies of the General Scholium).

Now let us turn to some recent contributions to our knowledge of the General Scholium. Recently, Rudolf De Smet and Karin Verhelst have claimed that the General Scholium[15] highlights not only Newton's religious concerns but also his philosophical concerns (a claim that, as far as the author knows, has not been denied by any notable Newton scholars[16]) and, correspondingly, have attempted to explore, following Betty Jo Teeter Dobbs[17], Newton's indebtedness to neo-Platonism and Stoicism by focussing on Philo Judaeus and Justus Lipsius.[18] Stephen D. Snobelen has

---

[12] It should be noted that although Casini has taken the CUL manuscripts into account (Casini, "Newton: The Classical Scholia", p. 18), his transcription is mainly based upon David Gregory's annotations of Newton's Classical Scholia (Royal Society of London, Ms. 247: ff. 6-14). Gregory visited Newton on 4th-7th May 1694 at Cambridge and Newton later entrusted the manuscript of the Classical Scholia to him (see *ibid*., pp. 16-17 and Schüller, "Newton's *Scholia*", pp. 214-215 for the details). Schüller dates Gregory's memorandum back to July 1694 (*ibid*., p. 214). The precise reasons why Newton decided not to include these *scholia* in the second edition of the *Principia* remain unclear. The actual transcriptions are on Casini, "Newton: The Classical Scholia", pp. 25-38. For some corrections, see Rudolf De Smet and Karin Verhelst, Newton's Scholium Generale: The Platonic and Stoic Legacy – Philo, Justus Lipsius and the Cambridge Platonists, *History of Science*, 2001, 39(1), pp. 1-30, p. 21 and Schüller, "Newton's *Scholia*", pp. 218-245.

[13] Schüller, "Newton's *Scholia*", pp. 213-265.

[14] Casini, "Newton: The Classical Scholia", p. 10.

[15] On the *General Scholium* see I. B. Cohen in: Newton, *The Principia*, pp. 274-292; Betty Jo Teeter Dobbs, *The Janus Faces of Genius, The role of alchemy in Newton's thought*, Cambridge University Press: Cambridge, 1991, esp. pp. 169-212; see also pp. 35-37, p. 83, p. 224, pp. 226-229, pp. 243-244; Derek Gjertsen, *The Newton Handbook*, Routledge & Kegan Paul: London/New York, 1986, pp. 463-464; Westfall, *Never at Rest*, pp. 748-751.

[16] Especially not after the pioneering work of James E. McGuire on Newton's metaphysics (see James E. McGuire, *Tradition and Innovation, Newton's Metaphysics of Nature*, The University of Western Ontario Series in Philosophy of Science (vol. 56), Kluwer: Dordrecht/Boston/London, 1995, in which seven articles from 1967-1978 are collected). In the original 1966 paper McGuire and Rattansi clearly wrote: "Thus the ontological problem of causation, conceived in the classical neoplatonic framework, was central to Newton's thought." (McGuire and Rattansi, Newton and the 'Pipes of Pan', p. 125).

[17] Dobbs, *The Janus Faces of Genius*, pp. 202-206.

[18] Although they provide convincing evidence for their claims on Philo (especially on p. 8), similar evidence seems to be lacking for their claims on the Cambridge Platonists and Justus Lipsius. They merely succeed in demonstrating vague parallelisms. Characteristic of this is their conclusion on Ralph Cudworth: "It is clear that despite the absence of explicit proof, there are sufficient similarities and parallels to suggest that Newton's debt to Cudworth was greater than

further intriguingly scrutinized the General Scholium, which he characterizes as a "theologically-charged appendix"[19], like a Russian doll and rendered explicit the underlying unitarian, anti-Trinitarian and, more specifically, Socinian layers.[20] We will return to Snobelen's study in a moment.

In the essay at hand, the author will point to the differing endeavours (including endeavours related to theology, natural philosophy, scientific explanation, epistemology, metaphysics, and experimentation) Newton attempted to reconcile in the General Scholium. An attempt is made to offer some *new* perspectives that help to explain the content of the published version or some of the intentions it served. The General Scholium is at the cross-roads of a variety of intellectual goals that were central to Newton's thinking. The study at hand studies the material related to the General Scholium into four groups to which we now turn.

2. The General Scholium: Published and Unpublished Endeavours

In this section, we shall centre my study of the General Scholium around four themes: (1) Newton's experiments concerning non-gravitational forces (in this section we shall render explicit the reasons of Newton's suppression of the experimental material related to the non-gravitational forces in nature), (2) his articulation of causal explanation (here it is shown that Newton interpreted the force of gravitation as a proximate cause), (3) his hidden theological agenda (here some traces of Newton's anti-Trinitarian agenda in the draft versions of the General Scholium are highlighted), (4) and, finally, his concerns with Cartesianism and especially with Gottfried W. Leibniz's natural philosophy (here it is indicated how Newton conceived of Cartesianism as an anti-Mosaic, heretical movement). Each theme intends to add something new on our current knowledge of the General Scholium which has escaped detailed, scholarly scrutiny so far.

Newton on Non-gravitational Forces

It is abundantly clear from both published work as well as from manuscript material that Newton sought to (but, as we will see, also failed to) experimentally demonstrate, i.e. to rigidly deduce from phenomena according to his own, highly developed, methodological standards, the forces of magnetism and electricity[21], short-range

---

one might be led to believe from his manuscript *Out of Cudworth*." (Rudolf De Smet and Karin Verhelst, Newton's Scholium Generale, p. 13).

[19] Stephen D. Snobelen, ""God of Gods, and Lord of Lords:" the Theology of Isaac Newton's General Scholium to the *Principia*", *Osiris*, 2001, 16, pp. 169-208, p. 170. He interestingly points to the fact that ca. 58 percent of the General Scholium is related to theology (*ibid.*, p. 172, footnote 7).

[20] *Ibid.*, pp. 191-196.

[21] See R.W. Howe, "Newton on Electricity and The Aether", in: Zev Bechler (ed.), *Contemporary Newton Research*, Studies in the History of Modern Science 9, Dordrecht/Boston/London: D.

attractive and repulsive forces, and the causes producing fermentation, nutrition, corruption and generation of organisms[22], putrescence, muscular movement and perception[23], refraction, reflection and, finally, diffraction.[24] These rather "speculative" experiments were never included in the *Principia*, the work "which Newton was the most anxious to make immune from attack"[25] and are merely hinted at in the General Scholium.[26] However, a systematic survey of the subtle changes in the observations or experimental set-ups which Newton, at some point in between 1687-1713, intended to be included in the *Principia*, and by means of which he sought to establish and study the other non-gravitational forces in nature, has, to the best of my knowledge, not been undertaken. This is precisely the goal of this section.

In order to understand Newton's various attempts in this area it is necessary to consult (1) the observations and experiments he referred to in the suppressed *Preface* and *Conclusion* to the first edition of the *Principia*, (2) the draft versions of the General Scholium (especially the A-version and, to lesser extent, the C-version), (3) and the text as it appeared in the second and third edition of the *Principia*.[27] Newton's choice to suppress this material can be traced from these manuscripts.

We shall start chronologically with the *Preface* written in 1687. Newton began by expressing his hope that the other (non-gravitational) phenomena would be derived from mechanical principles by the same mode of reasoning (as the force of gravitation) [ex Principijs Mechanicis eodem argumentandi genere derivare liceret[28]]. He distinguished between three classes of fundamental forces: gravity, magnetism and the force producing attractive and repellent forces between particles at small distances.[29] In order to render the force of the latter type more plausible, Newton gave a cornucopia of phenomena that served the purpose of illustrating this force. Newton stated that attractive and repellent forces at small distances accounted for various chemical reactions and for the cohesion of bodies, and that they also explained why

---

Reidel Publishing Company, 1982, pp. 197-213. It should be noted that Home's study is based on material from or related to *The Opticks*.

[22] See especially Newton's manuscript *De vita et morte vegetabili* (Maurizio Mamiani and Emanuela Trucco, 'Newton E I Fenomeni della Vita,' *Nuncius* 6, 1991, pp. 69-96, pp. 78-79). According to Mamiani and Trucco, this piece was composed in the same period as the General Scholium.

[23] See especially Newton's unpublished manuscript, *De motu et sensatione animalium* which was also related to the composition of the General Scholium (1713) (CUL Add. Ms. 3970: f. 236^{r}, transcribed in Mamiani and Trucco, "Newton E I Fenomeni della Vita", pp. 78-79). See also the interesting study of Wess Wallace, "The vibrating nerve impulse in Newton, Willis and Gassendi: First steps in a mechanical theory of communication", *Brain and Cognition* 51, 2003, pp. 66-94, pp. 68-74.

[24] Hall and Hall, *Unpublished Scientific Papers*, p. 333, pp. 350-351, pp. 355-359; Mamiani and Trucco, "Newton E I Fenomeni della Vita", pp. 69-96, pp. 78-87 [for transcriptions of CUL Add. Ms. 3970: f. 236^{r}, f. 237^{v-r}, f. 238^{v-r}, f. 240^{v-r}]; *cf*. Newton, *The Principia*, pp. 287-292, pp. 943-944; *cf*. Newton, *The Opticks*, p. 376, pp. 396-403.

[25] Hall and Hall, *Unpublished Scientific Papers*, p. 187.

[26] Newton, *The Principia*, pp. 943-944.

[27] See Appendix B and C for a detailed description of the contents of the holographs.

[28] Hall and Hall, *Unpublished Scientific Papers*, p. 303.

[29] *Ibid.*, p. 304.

bodies are “hard, soft, fluid, elastic, malleable, dense, rare, volatile, fixt; [capable of] emitting, refracting, reflecting or stopping light”[30]. In trying to justify his claim, he fiercely relied on Nature’s causal parsimony[31] and *speculated* that the motions of smaller bodies could be explained by forces “just as the motions of larger bodies are ruled by the greater force of gravity”:

> For if Nature be simple and pretty comfortable to herself, causes will operate in the same kind of way in all phenomena, so that the motions of smaller bodies depend upon certain smaller forces just as the motions of larger bodies are ruled by the greater force of gravity. It remains therefore that we inquire by means of fitting experiments whether there are forces of this kind in nature, then what are their properties, quantities and effects.[32] For if all natural motions of great or small bodies can be explained through such forces, nothing more will remain to inquire the causes of gravity, magnetic attraction and the other forces.[33]

Essentially Newton was arguing for the usage of transduction (see *infra*) in natural philosophy. Here we also find Newton setting the agenda for the future study of natural philosophy. Newton distinguished between four experimental issues that need to be addressed in order to complete the study of the fundamental forces in nature: (a) the investigation of whether there are forces of a certain type, (b) the investigation of their effects, (c) their properties, and (d) their quantities.

However, to explain these short-range forces is more problematic than to explain universal gravitation. This is more apparent from Newton’s suppressed *Conclusion*. Here Newton’s tone changed and he now hinted at some of the difficulties an experimental treatment of such short-range forces poses. Newton began the *Conclusion* by observing that there are plenty of other motions than those caused by the force of gravity:

> Hitherto I have explained the System of this *visible world* [Mundi aspectabilis], as far as concerns the *greater motions which can be easily detected* [facile sentiri possunt]. There are however innumerable other local motions which *on account of the minuteness of the moving particles cannot be detected* [ob parvitatem corpusculorum moventium, sentiri nequeunt], such as the motions of the moving particles in hot bodies, in fermenting bodies, in putrescent bodies, in growing bodies, in the organs of sensation and so forth. If any one shall have the good fortune to discover all these, I might almost say that he will have laid bare the whole nature of bodies so far as the mechanical causes of things are concerned. I have least of all undertaken the improvement of this part of philosophy. I may say briefly, however, that nature is exceedingly simple and conformable to herself [natura valde simplex est et sibi consona]. Whatever reasoning [Quam rationem] holds for the greater motions [in majoribus motibus], should hold for lesser ones as well [in minoribus]. The former depend upon the greater attractive forces of larger bodies, and I suspect that the

[30] *Ibid.*, p. 306.

[31] See also Newton’s *regulae philosophandi* (Newton, *The Principia*, pp. 794-795); *cf*. Newton, *The Opticks*, p. 397; *cf*. McGuire and Rattansi, “Newton and the ‘Pipes of Pan’”, p. 125.

[32] *Cf*. Newton, *The Principia*, p. 411, pp. 588-589.

[33] Hall and Hall, *Unpublished Scientific Papers*, p. 307.

> latter depend upon the lesser forces, as yet unobserved, of *insensible particles* [particularum insensibilium].[34]

Newton began by reiterating his belief in transduction. One obvious stumbling-block for applying such mode of argumentation is that, in this case, *not only the forces which produce these "lesser motions" cannot be observed, but also that the lesser motions themselves cannot be detected on account of the minuteness of their particles*. So basically, Newton's *sole* justification was his appeal to Nature's consonance: "whatever reasoning holds for greater motions, should hold for lesser ones as well". As we shall shortly see, Newton began to see the difficulty with such "transductive" arguments. Next, Newton gave several illustrations of such short-range attractive forces. He listed several chemical reactions during the course of which we can observe that the particles involved attract each other, i.e. approach one another, and pointed to the activity of cohesive forces.[35] Subsequently, he gave several illustrations of short-range repellent forces (for instance, the force by which the particles of oil repel the particles of water when mixed together).[36] Newton merely provided these examples in order to render the existence of short-range attractive and repellent forces more *plausible* and to, at least, justify further research on these matters. They certainly did not have a demonstrative nature. Newton freely admitted that he had not demonstrated that such non-gravitational forces are *verae causae*:

> I have briefly set these matters out, not in order to make a rash assertion that there are attractive and repulsive forces in bodies, but so that I can give opportunity to imagine further experiments by which it can be ascertained more certainly whether or not they exist. For if it shall be settled that they are true [forces] [This refers to (a) of the aforementioned issues of investigation.] it will remain for us to investigate their causes and properties diligently, as being the true principles from which, according to geometrical reasoning, all *the more secret motions of the least particles* are no less brought into being than are the motions of the greater bodies which we saw in the foregoing [books] derived from the laws of gravity [tanquam vera principia a quibus omnes particularum minimarum secretiores motus secundum rationes Geometricas non minus oriantur quam motus majorum corporum ex legibus Gravitatis in praecedentibus derivari vidimus].[37]

As it stood, Newton had not quite succeeded in deriving from mechanical principles by geometrical reasoning the lesser motions. In an additional paragraph, he wrote:

> I am far from affirming that my views are correct, and I acknowledge their great imperfection, nevertheless they are simple and easy to conceive, and of the same kind as the natural philosophy of the cosmic system which depends on the attractive forces of greater bodies.[38]

---

[34] *Ibid.*, p. 333 (emphasis added), *cf.* p. 321.
[35] *Ibid.*, pp. 333-336, *cf.* pp. 321-323.
[36] *Ibid.*, pp. 336-340, *cf.* pp. 324-327.
[37] *Ibid.*, pp. 340-341 (emphasis added).
[38] *Ibid.*, p. 345.

Now we will make a jump in time and turn to three experiments Newton intended to include in the General Scholium (see especially the A-version[39]) concerning the electrical force (vis electrica) by which the particles of bodes are variously moved.[40] From 1707 onwards Newton was enormously fascinated by electricity as a direct consequence of a series of electrostatic experiments which were performed by Francis Hauksbee (1670-1713) at *The Royal Society*.[41] Initially Newton planned to add "about a quarter of a Sheet" on the attraction of the small particles of bodies to the General Scholium, but replaced it by the paragraph on "a certain subtle, electric spirit".[42] Ultimately these experiments turned out unsatisfactory to Newton, since in the General Scholium he did not mention them and he only declared that:

> But these things cannot be explained in a few words; furthermore, there is not a sufficient number of experiments to determine and demonstrate accurately the laws governing the actions of this spirit.[43]

In the first experiment Newton observed that when two contiguously placed pieces of glass were immersed in still water "the water [by the attraction of the glass] ascends between the pieces of glass above the surface of the water, and the height of ascent will be inversely as the distances between the glasses"[44]. He also added that the experiment "succeeds in the Boylian vacuum and so does not depend on the weight of the incumbent atmosphere"[45]. A variant of this experiment consisted in placing a drop of orange oil[46] between two plates of glass (the first plate was placed horizontally and, at one end, met the second plate; the second plate was kept inclined and touched the drop of orange oil which lay at the other end of the first plate). As soon as the second plate touched the drop of orange oil, "the drop began to move towards the meeting-point of the glasses"[47]. This also succeeds *in vacuo*. Therefore: "the origin of this motion lies in the attraction of the glasses"[48]. Because of Newton's usage of screening-off procedures, these experimental set-ups were more sophisticated than those from the suppressed *Preface* and *Conclusion* to the first edition of the *Principia*, and, correspondingly, they added more substance to Newton's claims on these short-range attractive forces. The fact that these experiments also occurred *in vacuo*

[39] See Appendix [B.1] and [B.3].

[40] See Westfall, *Never at Rest*, pp. 744-748.

[41] Westfall, *Never at Rest*, pp. 684-686; Dobbs, *The Janus Faces of Genius*, p. 222; and Cohen in: Newton, *The Principia*, p. 281.

[42] Cohen, *Introduction to Newton's 'Principia'*, pp. 240-241; also see Westfall, *Never at Rest*, pp. 745 (footnote 149) for a list of possibly similar drafts.

[43] Newton, *The Principia*, p. 944. By "this spirit" Newton most certainly referred to "the elastic and electric spirit" (see Alexandre Koyré and I. Bernard Cohen, "Newton's "Electric and Elastic Spirit"", *Isis* 51(3), 1960, p. 337).

[44] Hall and Hall, *Unpublished Scientific Papers*, p. 354.

[45] *Ibid.*

[46] And not "orange juice" as Westfall notes (Westfall, *Never at Rest*, p. 746).

[47] Hall and Hall, *Unpublished Scientific Papers*, p. 345.

[48] *Ibid.*

guaranteed that other forces (e.g. the pressure of the atmosphere[49]) can no longer be adduced as the causes of the phenomena under observation. But the sophistication was by no means limited to Newton's reliance on screening-off procedures: Newton also tried to quantify such short-range attractive forces. In a third experiment he described how, when the meeting point of the plates was raised so that the lower glass is now inclined to the horizon, the drop rose more slowly than previously and finally came to rest. In such a state of equilibrium, the weight is equal to the attraction of the glass:

> Thus from the inclination of the lower glass the weight of the drop is given, and from the weight of the drop the attraction of the glass is given. The inclinations of the lower glass by which the drop was maintained in equilibrium, and the distances of the drop from the meeting-point of the glasses, are shown in the following table [not given].[50]

In an ingenious way Newton tried to measure the short-range accelerative force of the glass by studying the weight in equilibrium of the drop at various inclinations. The missing table can be found on another draft of the General Scholium (*De vi electrica* (CUL Add. Ms. 3970: ff. 602-604)).[51] Since the experiments are described in more detail[52], Newton's writing is relatively neat throughout the manuscript[53], and the implications of the experiments are now discussed in a more straightforward manner, this draft is most likely written after the composition of the A-version to the General Scholium. As we have seen, in the A-version Newton had succeeded in providing more sophisticated proof for the existence of the "electrical" force. Correspondingly, his 1687 agnosticism about the existence of such force disappeared and Newton's tone became more determined in *De vi electrica*: "It is *certain from phenomena* that electric and magnetic attractions also exist."[54]. By these experiments, Newton noted, "it is *fully enough clear* that glass at small distances always abounds in electric force"[55]. However, the data Newton obtained when comparing the varying inclinations of the plate and the distances, from the meeting point of the plates to the place where the drop of orange oil is in equilibrium, did not suffice to yield an accurate determination of the law governing such attraction.[56] Newton could therefore only provisionally conclude that this force is "very nearly inversely in the ratio of the square of the

[49] This was Newton's earlier explanation of the rising of water between glass plates (Westfall, *Never at Rest*, p. 746).

[50] *Ibid.*, p. 455.

[51] Newton, *The Principia*, pp. 287-292, p. 289. The folios at CUL Add. Ms. 3965: ff. 351-352 are but irrelevantly different from the folios Cohen has transcribed.

[52] *Ibid.*, pp. 288-290.

[53] *Ibid.*, p. 283.

[54] *Ibid.*, p. 287 (emphasis added).

[55] *Ibid.*, p. 289 (emphasis added).

[56] The reader can understand Newton's dissatisfaction by comparing the values obtained when multiplying the inclinations (which stood as a measure for the attractive force of the glass) with the square of the corresponding distance.

distance"[57]. However, the existence of such forces could no longer be disputed.[58] The second half of this draft is devoted to showing how this "electric spirit" might also account for optical phenomena (refraction, reflection and inflexion), the state of aggregation of bodies, and, finally, fermentation and digestion.[59]

How are we to understand Newton's dissatisfaction with these observations and experiments related to the non-gravitational forces in nature? One might simply respond to this question by stating that the empirical data Newton required was not at hand. While this is certainly the case, there is a more fundamental reason to it. I shall commence by making some points on Newton's optics where he ran into similar difficulties as with his electrical spirit.[60] In his monumental study of Newton's optics[61], Alan E. Shapiro concludes that Newton's method of transduction was not up to the task of treating the colours of natural bodies.[62] Shapiro points out that Newton's failure in optics was due to the failure of the method of transduction *within* the domain of optics. Transduction refers to the method of making of inferences about the unobservable, *microscopic components* of bodies from the observed laws and properties of *macroscopic bodies*.[63] In such an inference, we apply the observed macroscopic properties of bodies to their microscopic constituents. Without transduction, it would be impossible, according to Newton's own words, to derive "the qualities of imperceptible bodies from the qualities of perceptible ones".[64] For instance, when arguing that opacity is produced by the parts of bodies, Newton used macroscopic examples.[65] Similarly, in the early 1670s, Newton assumed that coloured bodies, consisting of absorbing primordial particles and pores, are produced by the highest order corpuscles in the same way as a fragment of a thin film.[66] Again, Newton illustrated his theory with a macroscopic example. This seems to suggest that in his early optical work Newton considered the transduction of macroscopic

---

[57] *Ibid. Cf.* in CUL Add. Ms 3968: f. 586 (draft material pertaining to Newton's review of the *Principia* in *Acta Eruditorum*), Newton noted that "He [Newton] has told his friends that there are sufficient Phaenomena to ground an inquiry upon but not yet sufficient to determin [sic] the laws of attraction." (Cohen's translation in: Newton, *The Principia*, p. 282).

[58] In CUL Add. Ms. 3970: f. 240^{r}, Newton wrote: "Et (attractiones elect) quemadmodum attractio gravitatis ad majores Planetarum (Cometarum) & maris nostri motus explicandos sufficit: sic vires electricae et magneticae (ad motus minores alios omnes particularum corporum motus exp[l]icando sufficere videntur) ad explicandas actiones et motus particularum (inter se) corporis cujuscumque inter se sufficere videntur" (Mamiani and Trucco, "Newton E I Fenomeni della Vita", p. 86).

[59] *Ibid.*, pp. 290-292. Again there is much correspondence with material from *Query 31*.

[60] For Newton's methodological and empirical problems in optics, see Steffen Ducheyne, "On Optical and Mechanical Models: Newton's Failure to Construct a Satisfactory Theory of the Phenomena of Light and Colour", *Logique et Analyse*, 194, 2006, pp. 199-223.

[61] Alan E. Shapiro, *Fits, Passions and Paroxysms, Physics Method, and Chemistry and Newton's Theory of Colored Bodies and Fits of Easy Reflection*, Cambridge University Press: Cambridge, 1993.

[62] *Ibid.*, p. 134.

[63] *Ibid.*, pp. 4-5.

[64] CUL Add. Ms. 3965: f. 266^{r} (a draft relating to the *Regulae Philosophandi* early 1690s) quoted from *ibid*., p. 45. See Cohen, *Introduction to Newton's Principia*, pp. 23-26.

[65] *Ibid.*, p. 114.

[66] *Ibid*., p. 113.

properties to their microscopic constituents as unproblematic. The vulnerability of transduction, however, lies in the following: justifying transduction for the properties of light and colour depends, as Shapiro puts it, on the composition or hierarchical arrangement of the corpuscles that compose bodies.[67] In fact, Newton began to see this weakness in the early 1690s (which converges with Newton's utterances from the manuscript material we have just considered).[68] This primordial methodological assumption was based on the simplicity or analogy of nature.[69]

We can further understand Newton's dissatisfaction with his optical work by contrasting it with Newton's contentment with his mechanical work. In the study of the celestial and terrestrial bodies, the make-up of the affected entities (= the effects) is known. We know that the effects which we want to explain are material bodies moving along certain trajectories. We know the make-up of what we want to explain (bodies *and* their constituents have the property of *mass*). In optics, by contrast, we do not know the make-up of optical phenomena such as prismatic dispersion, because this would already presuppose an optical theory. In optics transduction is problematic because it amounts to asserting the corporality of light. In this case, we would be introducing concocted hypotheses into our natural philosophy. The same holds *salva veritate* for the other forces causing "other local motions which on account of the minuteness of the moving particles cannot be detected, such as the motions of the moving particles in hot bodies, in fermenting bodies, in putrescent bodies, in growing bodies, in the organs of sensation and so forth."[70]. Newton disliked having to *postulate* a variety of unobservable motion and particles, without having rigidly deduced them from phenomena.

We shall further illustrate this by means of an example why the method of transduction was successful in mechanics. Let us see how Newton arrived at *universal* gravitation in Proposition 7, Book III. In the preceding propositions Newton had proved that all planets gravitate towards each other and that the gravity of each planet varies inversely as the square of the distance. It follows by proposition 69, Book I, that gravity towards all planets is proportional to their mass. Since all the parts of a planet A are heavy towards planet B, and since the gravity of each part is to the gravity of the whole as the matter of that part to the matter of the whole, and since to every action there is an equal reaction (by the third law of motion), it follows that planet B will gravitate in turn towards all the parts of A, and its gravity to any one part will be to its gravity toward the whole of the planet as the matter of that part to the matter of the whole.[71] Hence, the gravity towards the whole planet arises from and is compounded of the gravity of the individual parts (Corollary 1). From Corollary 3 to Proposition 74, Book I, it follows that the gravity toward each of the individual particles of a body is inversely as the squares of the distance of the places from those particles (Corollary 2). *In mechanics, transduction is unproblematic because the constituents of bodies share the same theoretically relevant property with the bodies they constitute: namely, mass (which is a*

[67] *Ibid.*, p. 45.
[68] *Ibid.*, p. 46. In this period Newton was in the process of composing Book II of *The Opticks*.
[69] *Ibid.*, p. 44.
[70] Hall and Hall, *Unpublished Scientific Papers*, p. 333.
[71] Newton, *The Principia*, p. 811.

measure of inertia). Newton's awareness of the problems with transduction did not stop him to excogitate further experiments (*cf*. the A-version). However, since they were not accurate enough and did not agree with Newton's high methodological standards, he chose to suppress them in the final version of the General Scholium.

One final point may be added to that. Let us look at Newton's explanation of the planetary motions. Newton derived that a centripetal force is a necessary (Proposition 1, Book I) and sufficient (Proposition, 2 Book I) cause for Kepler's area law[72]: Kepler's area law is valid *if and only if* there is an acting centripetal force.[73] In Proposition 1, Book III (which concerns the circumjovial and circumsaturnian planets), Newton infers a centripetal force (tending towards Jupiter/Saturn) from the observation that Kepler's second law holds *quam proxime* (by Proposition 2 (or 3), Book I); and from the observation that Kepler's third law holds *quam proxime* he infers that this force varies inversely as the square of the distance (by Corollary 6 to Proposition 4, Book I).[74] In Proposition 2, Book III (which concerns the primary planets), he similarly infers a centripetal force (tending towards the Sun) from the observation that the second law holds *quam proxime* (by Proposition 2, Book I) and that it varies inversely as the square of the distance from the observation that the third law holds *quam proxime* for the primary planets (by (Corollary 6 to) Proposition 4, Book I[75]). The conditional sentences in Book I function as "inference-tickets"[76] for discovering forces. Moreover, in the case of the primary planets the inverse square law is proved "with the greatest exactness from the fact that the aphelia are at rest" since the slightest departure from an inverse square law would entail motion in the aphelia (by Book I, Proposition 45[77]).[78] In other

[72] Given that the laws of motion are valid, Newton is able to deduce that the area law is caused by its necessary and sufficient causal condition: a centripetal force (Cohen, *The Newtonian Revolution*, p. 63). Cohen states that, in commenting on Propositions 1-3, Book I, Newton had demonstrated by mathematics that a mathematically descriptive law of motion was equivalent to a set of *causal* conditions of forces and motions (*ibid.*, p. 28, p. 37).

[73] Hence a centripetal force is a necessary and sufficient condition for the area law. As Newton wrote: "Since the uniform description of areas indicates the center towards which that force is directed by which a body is most affected and by which it is drawn away from rectilinear motion and kept in orbit, why should we not in what follows use uniform description of areas as a criterion for a center about which all orbital motion takes place in free spaces?" (Newton, *The Principia*, p. 449).

[74] For the secondary planets Newton's application of Corollary 6 is no surprise, since he assumed that the orbits of the circumjovial planets, e.g., do "not differ sensibly from circles concentric with Jupiter" (*ibid.*, p. 797).

[75] Newton presupposed a circular approximation here.

[76] The term is due to Arthur Prior. In general, "inference-tickets" link motions to forces, forces to motions, and macro-physical to microphysical forces composing them (George E. Smith, "The Methodology of the Principia", in: I.B. Cohen and G.E. Smith (eds.), *The Cambridge Companion to Newton*, Cambridge University Press: Cambridge, 2002, p. 143). For reasons of brevity, I simplify Newton's complex methodology. Smith's article provides an excellent account of Newton's methodology. On this matter, see also Steffen Ducheyne, "Mathematical Models in Newton's Principia: A New View of the Newtonian Style", *International Studies in the Philosophy of Science*, 19(1), 2005, pp. 1-19 and *idem.*, "The Argument(s) for Universal Gravitation", *Foundations of Science*, 11(4), 2006, pp. 419-447.

[77] This proposition concerns ellipses. It is therefore more suitable than Corollary 6 to Proposition 4, which supposes circular motion.

words, Newton was using the law of inertia as a criterion for whether forces were acting on a body (and thus as a criterion for accepting the existence of forces).[79] *By contrast, in disciplines of natural philosophy where microscopic phenomena were dealt with, no such inference-tickets were at hand, because we cannot introduce a theoretically relevant property without introducing hypotheses on the make-up of the microscopic phenomena we intend to explain.* However, it is clear that, as manuscript evidence testifies, demonstrating these (other) non-gravitational forces experimentally, according to the highly developed mathematical methodology he had spelled out in the *Principia*, was one of Newton's paramount endeavours as a natural philosopher.

Newton on Causal Explanation

Let us now turn to a different theme: Newton's articulation of causal explanation in the *Principia*. In a recent study, Ernan V. McMullin tends to downplay the importance of causal explanation and abduction in Newton's natural philosophy. According to Ernan McMullin, Newton's innovative approach in the *Principia* "appeared to allow him to dispense with the troubling hypothetical element that the search for causal explanation had led his predecessors to admit into physics".[80] McMullin's interpretation is untenable in view of the manuscript material to which we now turn.

After Gottfried W. Leibniz criticised Newton for introducing a *qualitas occulta*[81], i.e. gravity, into natural philosophy, Newton became increasingly pressed to clarify the kind

---

[78] Newton, *The Principia*, p. 802.

[79] William Whewell aptly put it as follows in his *Philosophy of the Inductive Sciences*: "*Force is any cause which has motion, or change of motion, for its effect*; and thus, all the exchange of velocity of a body which can be referred to extraneous bodies, - as the air which surrounds it, or the support on which it rests, - is considered as the effect of forces; and this consideration is looked upon as explaining the difference between the motion which really takes place in the experiment, and that motion which, as the law asserts, would take place if the body were not acted on by any forces." (William Whewell, *The Philosophy of the Inductive Sciences*, Frank Cass & Co: London, [first edition: 1847] 1967, vol. I, p. 217).

[80] Ernan V. McMullin, "The impact of Newton's *Principia* on the philosophy of science", *Philosophy of science*, 68, 2001(3), pp. 279-310, pp. 288-289.

[81] See Westfall, *Never at Rest*, pp. 772-773. In an unpublished letter written the editor of *The Memoirs of Literature* from ca. May 1712 Newton defended himself as follows to Leibniz's critique: "Because they do not explain gravity by a mechanical hypothesis, he charges them with making it a supernatural thing, a miracle and a fiction invented to support an ill-grounded opinion and compares their method of philosophy to that of Mr. de Roberval's Aristarchus, which is all one as to call it romantic [i.e. fictional]. They show that there is a universal gravity and that all phenomena of the heavens are the effect of it and with the cause of gravity they meddle not but leave it to be found out by them that can explain it, whether mechanical or otherwise. [...] And therefore if any man should say that bodies attract one another by a power whose cause is unknown to us, or by a power seated in the frame of nature by the will of God, or by a power seated in a substance in which bodies move and float without resistance and which has therefore no *vis inertiae* but acts by other laws than those that are mechanical: I know not why he should be said to introduce miracles and occult qualities and fictions into the world." (Newton, *Philosophical Writings*, ed. Janiak, pp. 115-116).

of explanation he had offered in the *Principia* and, more generally[82], to clarify his method of philosophizing from a methodological point of view.[83] The crux of Newton's solution for meeting this public criticism lay in carefully distinguishing between different "levels of causation": phenomena are caused by proximate causes, which are in their turn caused by further causes, i.e. their remote causes. In the *Principia*, Newton had only provided explanations involving the proximate causes of orbital motion (centripetal forces), while he deliberately neglected[84] from the remote causes as not to engage in the act of feigning hypotheses. According to Newton, causal processes were structured hierarchically: phenomena derive from causes which in their turn are caused by more general causes. At the end of this causal chain, God is the ultimate cause of everything. Hence, Newton declared that "the main Business of natural Philosophy is to argue from Phaenomena without feigning Hypotheses, and to deduce Causes from Effects, *till we come to the very first Cause, which is certainly not mechanical*".[85] In the published General Scholium, Newton famously wrote:

> Thus far I have explained the phenomena of the heavens and of our sea by the force of gravity, but I have not yet assigned a cause to gravity. Indeed, this force arises from some cause that penetrates as far as the centers of the sun and planets without diminution of its power to act, and that acts not in proportion to the quantity of the surfaces of the particles on which it acts (as mechanical causes are wont to do) but in proportion to the quantity of solid matter, and whose action is extended everywhere to immense distances, always decreasing as the squares of the distances. (...) And it is enough that gravity really exits and acts according to certain laws that we have set forth and is sufficient to explain all the motions of the heavenly bodies.[86]

Gerd Buchdahl has made it clear that we should always make the distinction between "the logical status of gravity itself, as a 'primary' cause, and the modus operandi, if any, of a secondary explanatory mechanism for gravity".[87] Newton took the above statement to mean that he had proved gravity as a primary or proximate cause for the heavenly and terrestrial motions, but that he did not succeed in discovering a further secondary or remote cause for gravity. Nevertheless, an explanation referring exclusively to the primary cause (and neglecting the secondary mechanism – if any – causing it) was fully legitimate to his mind. In CUL Add. Ms 9597.2, Newton thought the consequences of not accepting such "partial" explanations through: this would

---

[82] *Cf.* Gjertsen, *The Newton Handbook*, p. 463 and Cohen in Newton, *The Principia*, p. 274.

[83] *Cf.* Alan E. Shapiro, "Newton's "Experimental Philosophy"", *Early Science and Medicine* 9(3), 2004, pp. 168-217. See *infra*.

[84] Newton explicitly wrote: "Moreover, I use interchangeable and indiscriminately words signifying attraction, impulse, or any sort of propensity toward a center, considering these forces not from a physical but only from a mathematical point of view. Therefore let the reader beware of thinking that by words of this kind I am anywhere defining a species or mode of action of a physical cause or reason, or that I am attributing forces in a true and physical sense to centers (which are mathematical points) if I happen to say that centers attract or that centers have forces." (Newton, *The Principia*, p. 408; see also *ibid.*, p. 588).

[85] Newton, *The Opticks*, p. 369 (emphasis added).

[86] Newton, *The Principia*, p. 943.

[87] Gerd Buchdahl, Gravity and intelligibility: Newton to Kant, in: R. E. Butts and J. W. Davis (eds.), *The methodological heritage of Newton*, Bristol, 1970, pp. 74-102, p. 81.

imply – a view impossible for Newton to accept – that the only satisfactory explanations were "causally complete", i.e. that they fully explain all causal agents occurring in between the observed phenomena and the ultimate cause:

> Otherwise, altogether no phenomenon could rightly be explained by its cause, unless the cause of this cause and the cause of the prior cause were to be exposed and so successively [and] continuously until the primary cause is arrived at.[88]

Newton thought that such "partial" explanations were perfectly legitimate, for he wrote:

> And to understand this without knowing the cause of gravity, is as good a progress in philosophy as to understand the frame of a clock & the dependence of y^{e} wheels upon one another without knowing the cause of the gravity of the weight which moves the machine is in the philosophy of clockwork, or the understanding the frame of the bones & muscles by the contracting or dilating of the muscles without knowing how the muscles are contracted or dilated by the power of y^{e} mind is [in] the philosophy of animal motion.[89]

Similarly, in CUL Add. Ms. 9597.2.11, Newton wrote:

> And, although, for the moment not all [of] philosophy is clear [to us], it is nevertheless quite sufficient to apprehend something from day to day than to occupy human minds with the prejudices of hypotheses.[90]

In CUL Add. Ms 3965.9, Newton explicitly articulated his views on explanation by means of distinguishing between proximate and remote causes:

> He who investigates the laws and effects of electric forces with the same success and certainty will greatly promote philosophy [i.e., natural philosophy], even if perhaps he does not know the cause of these forces. First, the phenomena should be observed, then their proximate causes – and afterward the causes of the causes – should be investigated, and finally it will be possible to come down from the causes of the causes (established by phenomena) to their effects, by arguing a priori. Natural philosophy should be founded not on metaphysical opinions, but on its own principles and [end][91]

---

[88] Author's translation of: "Alias nullum om[n]ino phaenomenon <per causam suam> recte explicari posset nisi causa <hujus> causae, & causa ~~priori~~ causae prioris redderetur & sic deinceps usque donec ad causam primam deventum sit." (CUL Add. Ms. 9597.2.11: f. 3^{r}; see Appendix [A.3]).

[89] Newton, *Correspondence*, vol. V, p. 300. For a recent interpretation of Newton as a mind-body substance monist, see Liam Dempsey, "Written in the flesh: Newton on the mind-body relation", *Studies in History and Philosophy of Science*, Part A, 37 (3), 2006, pp. 420-441.

[90] Authors translation of : "Et quamvis tota philosophia non statim pateat, tamen satius est aliquid indies addiscere quam hypotheseωn praejudicijs mentes hominum preoccupare." (CUL Add. Ms. 9597.2.11: f. 2^{r}; see Appendix [A.2]).

[91] Cohen's translation of "Qui leges et effectus Virium electricarum pari successu et certitudine eruerit, philosophiam multum promovebit, etsi <forte> causam harum Virium ignoraverit. ~~Nam~~ Phaenomena <observanda> primo ~~<spectanda> consideranda~~ <sunt>, dein horum causae proximae, & postea causae causarum ~~eruenda~~ eruenda; ac tandem a causis <supremis causarum>

Natural philosophy should proceed from phenomena to proximate causes, then from proximate causes to remote causes, and then finally – *a priori* – from remote causes to proximate causes. It is especially in this manuscript material that Newton's hierarchical account of causal explanation is apparent. We can clearly see such articulation in the above manuscript material.[92]

The Theology of the General Scholium

Recent studies have aptly brought the importance of Newton's "God of Dominion" into perspective.[93] Stephen D. Snobelen has provided ample contextualisation of the theology in the General Scholium by shedding light on how Newton, in several theological manuscripts written around the same time as the General Scholium, frequently stressed that only the Father is truly "God of Gods" (*cf*. Deuteronomy 10: 17).[94] From the early-1670s until the end of his life, Newton consistently adopted a heretic anti-Trinitarian position that was composed of a complex mix of Arian and

---

per phaenomena stabilitis, ad <~~causas~~> ~~caus phaenomena~~ <eorum effectus>, <~~eorum causas proximas~~> argumentando a priori, descendere licebit. ~~Et inter Phaenomena numerandae sunt actiones mentis quae nobis innotescunt quarum conseij sumus~~ Philosophia naturalis non in opinionibus Metaphysicis, sed in Principiis propijs fundanda est; & haec [end]" (CUL Add. Ms. 3965.9: f. 109^{v}; see Appendix [A.1]). See Newton, *The Principia*, pp. 53-54.

[92] On the Aristotelian strands in Newton's thinking see Steffen Ducheyne, "Newton's Training in the Aristotelian Textbook Tradition: From Effects to Causes and Back", *History of Science*, 2005, 43(3), pp. 217-237.

[93] See especially James E. Force, "Newton's God of Dominion: The Unity of Newton's Theological, Scientific and Political Thought", in: James E. Force and Richard H. Popkin, *Essays on the Context, Nature, and Influence of Isaac Newton's Theology*, Kluwer: Dordrecht, 1990, pp. 75-102, esp. pp. 78-83; *idem.*, "The Nature of Newton's "Holy Alliance" between Science and Religion: From the Scientific Revolution to Newton (and Back Again)", in: Margaret J Osler (ed.), *Rethinking the Scientific Revolution*, Cambridge: Cambridge University Press, 2000, pp. 247-269; Larry Stewart, "Seeing Through the Scholium: Religion and Reading Newton in the Eighteenth Century", *History of Science* 34 (2), 1996, pp. 123-165, pp. 128-131; and especially Snobelen, "*God of Gods, and Lord of Lords*".

[94] *Cf*. Keynes Ms. 3 (*Irenicum*, post-1710), p. 29, p. 35, pp. 47-48; Keynes Ms. 7 (*A short Schem of the true Religion*, post-1710), f. 1^{v}; and, Yahuda Ms. 12 (*Treatise on Church History*, late 1670s): f. 1^{r}. In an entry "Deus pater" Newton wrote that "There is one Body, one spirit, even as ye are called in one hope of your calling One Lord, one Faith, one Baptisme, One God & Father of all, who is above all & through all & in you all. Eph 4.6." (Keynes Ms. 2 (*Theological Notebook*, composed ca. 1684-1690), part 1, p. XI). In this manuscript, Newton also sharply contrasted "the only true God" with "Iesus Christ whom thou hast sent" (*ibid*.). In a different manuscript, Newton called God's son "the *Man* Christ Jesus" (Keynes Ms. 8 (*Twelve articles on religion*, post-1710), f. 1^{r} (emphasis added)). Newton further urged that a proper *mon*archy needs the dominion of only *one* principle (*cf*. "Poterit autem et ad istum modum dici unum esse principium Deitatis, non duo, propria Monarchia unius dominatus haberi debet" (Keynes Ms. 2 (*Theological Notebook*, composed ca. 1684-1690), part 2, p. 14; see also the entry "De Deo uno", p. 85)). Newton's radical subordinationist view of Christ is especially clear in the manuscript *Of the Church* (Newton Ms., Foundation Martin Bodmer, Geneva; see Snobelen, "God of Gods, and Lord of Lords", esp. pp. 181-186).

Socinian elements.[95] Correspondingly, in Newton's Christology, the unity of the Father and the Son is merely moral, *not* metaphysical.[96] Traces of Newton's heretical views can, as Snobelen has cogently argued, be found in the General Scholium.

The General Scholium under its final published form consists of almost 60 percent of theological material. In the first two paragraphs of the General Scholium[97], Newton set the stage for his treatment of God: the motion of the celestial bodies acts according to the law of universal gravitation, but their regular position (the primary planets revolve in concentric circles around the sun, in the same direction and very nearly on the same plane) can only be explained by "the design and dominion of an intelligent and powerful being"[98]. Newton subtly added that the fixed stars are "constructed according to a similar design and subject to the dominion of *One* [*Unius* dominio]"[99]. Although Newton's usage of the predicate "unus" might *prima facie* appear as an aside, it hints at Newton's anti-Trinitarian intentions.[100] (This is, as we shall see, further confirmed in the C-E draft versions of the General Scholium.) Newton clarified in the following paragraph that "God" is a relative term (vox relativa) which refers to dominion, and that, while lesser "Gods" might have *some* dominion, there is *only one* "Lord of Lords", constituted by *supreme* domination. Implicitly this entailed that Christ could not be the "Lord of Lord". In the fourth paragraph Newton began expounding his theological view:

> He rules all things, not as the world soul [anima mundi] but as the lord of all. And because of his dominion he is called Lord God *Pantokrator*. For "god" is a relative word and has reference to servants, and godhood [deitas] is the lordship of God, not over his own body as is supposed by those for whom God is the world soul, but over his servants. The supreme God [Deus summus] is an eternal, infinite, and absolutely perfect being; but a being, however perfect, without dominion is not the Lord God. For we do say my God, your God, the God of Israel, the God of Gods [deus deorum], and Lord of Lords [dominus dominorum], but we do not say my eternal one, your eternal one, the eternal one of Israel, the eternal one of the gods; we do not say my infinite one, or my perfect one. These designations [appellationes] do not have reference to servants. The word "god" is used far and wide to mean "lord", but every lord is not a god. The lordship of a spiritual being constitutes a god, a true lordship constitutes a true god [vera [dominatio] verum [deum]], a supreme lordship a supreme god [summa [dominatio] summum [deum]], and imaginary lordship an

[95] For an excellent study on Newton's heretical position, the tradition on which drew, the selected few to whom he privately entrusted his theological views, and his strategies of concealment, see Stephen D. Snobelen, "Isaac Newton, heretic: the strategies of a Nicodemite", *British Journal of the History of Science*, 32, 1999, pp. 381-419. Newton concealed his heretical position for obvious legal and social reasons, but also because of Newton's conviction that theology (the "strong meats") "should only be handled by the experienced and mature members of the remnant, and, even then, only in private" (*ibid*., p. 407).

[96] Snobelen, "Isaac Newton, heretic", p. 386 (see note 41 for references to Newton's manuscripts).

[97] Again, for a paragraph-by-paragraph overview of the General Scholium and a comparison with the drafts, see Appendix B.

[98] Newton, *The Principia*, p. 940.

[99] *Ibid*.

[100] See Snobelen, "God of Gods, and Lord of Lords", pp. 177-178.

> imaginary god[101]. And from true lordship it follows that the true God is living, intelligent and powerful; from the other perfections that he is supreme, or supremely perfect. He is eternal and infinite, omnipotent and omniscient, that is, he endures from eternity to eternity [ab aeterno in aeternum], and he is present from infinity to infinity [ab infinito in ininitum]; he rules all things, and he knows all things that happen or can happen. He is not eternity and infinity, but eternal and infinite; he is not duration and space, but he endures and is present. He endures always and is present everywhere, and by existing always and everywhere he constitutes [constituit] duration and space.[102] Since each and every particle of space is *always*, and each and every indivisible moment of duration is *everywhere*, certainly the maker and lord of all things will not be *never* or *nowhere*.[103]

Newton continued by noting that, as "active power [virtus] cannot subsist without substance [substantia]", God is substantially omnipresent and that in him "all things are contained and move".[104] Because God is a spiritual, incorporeal being bodies do not act on him, nor conversely. Adopting such relative notion of "God" in terms of dominion, Newton rejected absolute characterisations of "God". We cannot, as Trinitarian orthodoxy would want it, define God's substance or essence[105] by using predicates such as "eternal", "infinite", "omnipotent" or "omniscient" to characterize His essence. We can only know God's attributes, not his substance. God acts "in a way utterly unknown to us". Correspondingly Newton stressed that, when we utilize human-like expressions to discourse about God, such language is purely allegorical and not literally true. Newton drew close analogy here with our knowledge of the primary, i.e. substantial, properties of bodies:

> We see only the shapes and colors of bodies, we hear only their sounds, we touch only their external surfaces, we smell only their odors, and we taste only their flavors. But there is no direct sense and there are no indirect reflected actions by which we know innermost substances, much less do we have an idea of the substance of God. We know him only by his properties and attributes and by the wisest and best construction of things and their final causes, and we admire him because of his perfections, but we venerate and worship him because of his dominion. For we worship him as servants, and a god without dominion, providence, and final causes is nothing other than fate and necessity.[106]

---

[101] This is almost certainly a sneer at the Cartesians and Leibniz's *intelligentia supra-mundana*.

[102] For Newton's ontology of space and time, see especially James E. McGuire, "The Fate of the Date; The Theology of Newton's Principia Revisited", in: Margaret J Osler (ed.), *Rethinking the Scientific Revolution*, Cambridge: Cambridge University Press, 2000, pp. 271-295; and the papers collected in McGuire, *Tradition and Innovation*.

[103] *Ibid.*, pp. 940-941. In the third edition, Newton added that "God is one and the same God always and everywhere". For several Biblical references that concur to Newton's theological stance, see Snobelen, "God of Gods, and Lord of Lords", p. 177.

[104] *Ibid.*

[105] Newton, *The Principia,* p. 942. Snobelen discusses several examples of compatible manuscript material (see Snobelen, "*God of Gods, and Lord of Lords*", pp. 180-186). For Descartes's idea of God, see Jean-Marie Beyssade, "The Idea of God and the Proofs of His Existence", in: John Cottingham (ed.), *The Cambridge Companion to Descartes*, Cambridge University Press: Cambridge, 1992, pp. 174-99.

[106] Newton, *The Principia,* p. 942.

By the study of natural philosophy we can get to know God's dominion, his providence and the final causes he installed. Correspondingly, Newton concluded that "to treat of God from phenomena is certainly a part of natural philosophy".[107]

Let us now probe into the five draft versions of the General Scholium. We shall use these snapshots as a tool to gain understanding into the process of composition of the theological material from the General Scholium. In the first edition of the *Principia* there is only one reference to God.[108] Snobelen notes that the drafts only "offer some insight in variant wording and additional material", that "the theological material largely conforms to the final published version and is every bit as terse", and that especially the lack of access to Newton's unpublished manuscript treatises on theology and Church history have obstructed the decipherment of the General Scholium.[109] Here we point to the fact that the draft versions, on minute inspection, already give away Newton's heretical agenda. In the various consecutive drafts (A-E)[110] of the General Scholium, Newton increasingly adds more and more theology. In the A-version of drafts of the General Scholium, Newton's only explicit reference to God is the following:

> If the fixed stars are the centres of similar systems, all these are under the same one dominion [unius dominio]: This being rules all things not as the soul of the world but as the Lord of the Universe. He is omnipresent and in him all things are contained and move, and without resistance since this Being is not corporeal and is not resisted by body.[111]

The B-version already contained the essentials of Newton's Hebraic credo of God as a universal ruler, a *Pantokrator*, albeit that the relevant paragraph is somewhat shorter near the end.[112] In this version, Newton is also more explicit on how the discourse of God from phenomena pertains to experimental philosophy properly:

> And thus much concerning God, to discourse of whom from the phenomena undoubtedly pertains to experimental philosophy. The intermediate causes of things appear from the phaenomena, and from these the more profound causes, until one arrives at the highest cause.[113]

---

[107] *Ibid.*, p. 943. In the second edition Newton wrote "experimental philosophy".

[108] *Scilicet*: "Collocavit igitur Deus Planetas in diversis distantiis a Sole, ut quilibet pro gradu densitatis calore Solis majore vel minore fruatur." (Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 582, footnote concerning lines 31-36 of page 405 of the third edition of the *Principia*).

[109] Snobelen, "God of Gods, and Lord of Lords", p. 180, footnote 47.

[110] For an inventory with all relevant differences between the drafts and the published version, see Appendix B.

[111] Hall and Hall, *Unpublished Scientific Papers*, p. 352, *cf.* p. 349; CUL Add. Ms. 3965.12: f. 357^{r}; Appendix B, [B.1].

[112] See [B.2]; *cf.* Keynes Ms. 3 (*Irenicum*, post-1710), p. 43.

[113] Hall and Hall, *Unpublished Scientific Papers*, p. 348, footnote 1; CUL Add. Ms. 3965.12: f. 359^{r}. Newton's view of science as a progressive ascension to causes of increasing generality which ultimately reveals the highest or most general cause is also given in *Query 31* of *The Opticks* (Newton, *The Opticks*, p. 404).

According to Newton, our scientific knowledge progresses from knowledge of "intermediate" causes, to knowledge of "more profound" causes, and, ultimately, to knowledge of the highest cause. In this version Newton began adding several scriptural references, which are also included in the published version: Acts 17: 27-28 ["That they should seek the Lord, if haply they might feel after him, and find him, though he be not far from every one of us: For in him we live, and move, and have our being; as certain also of your own poets have said, For we are also his offspring." [114]], Deuteronomy 4: 39 ["Know therefore this day, and consider *it* in thine heart, that the LORD he *is* God in heaven above, and upon the earth beneath: *there* is none else."] and 10: 14 ["Behold, the heaven and the heaven of heavens *is* the LORD's thy God, the earth *also*, with all that therein *is*."], I Kings 8: 27 ["But will God indeed dwell on the earth? behold, the heaven and heaven of heavens cannot contain thee; how much less this house that I have builded?"], Job 22: 12 ["*Is* not God in the height of heaven? and behold the height of the stars, how high they are!"], Psalms 139: 7 ["Whither shall I go from thy spirit? or whither shall I flee from thy presence?"], and Jeremiah 23: 23-24 ["*Am* I a God at hand, saith the LORD, and not a God afar off? Can any hide himself in secret places that I shall not see him? saith the LORD. Do not I fill heaven and earth? saith the LORD."]. These references relate to and give the necessary scriptural backing to Newton's views on God's omnipresence.

In the C-version Newton's list of scriptural references verses is more extended.[115] In addition to the references of the B-version, Newton now added: John 1: 18 ["No man hath seen God at any time[116]; the only begotten Son, which is in the bosom of the Father, he hath declared *him*."] and 5: 37 ["And the Father himself, which hath sent me, hath borne witness of me. Ye have neither heard his voice at any time, nor seen his shape."], I John 4: 12 ["No man hath seen God at any time. If we love one another, God dwelleth in us, and his love is perfected in us."], I Timothy 1: 17 ["Now unto the King eternal, immortal, invisible, the only wise God, *be* honour and glory for ever and ever. Amen."], and 6: 16 ["Who only hath immortality, dwelling in the light which no man can approach unto; whom no man hath seen, nor can see: to whom *be* honour and power everlasting. Amen."], Colossians 1: 15 ["Who is the image of the invisible God, the firstborn of every creature:"], Exodus 28: 4 ["And these *are* the garments which they shall make; a breastplate, and an ephod, and a robe, and a broidered coat, a mitre, and a girdle: and they shall make holy garments for Aaron thy brother, and his sons, that he may minister unto me in the priest's office."[117]], Deuteronomy 4: 12 ["And the LORD spake unto you out of the midst of the fire: ye heard the voice of the words, but saw no similitude; only *ye heard* a voice."] and 4: 15-16 ["Take ye therefore

---

[114] All scriptural references are quoted are from Robert Carroll and Stephen Prickett (eds.), *The Bible, Authorized King James Version with Apochrypha*, Oxford: Oxford University Press, 1997.

[115] See [B.3]. The references to the ancients (Cicero, Thales, Anaxogoras, Virgil, Philo, and Aratus) are not included here (Cohen, *The Principia*, pp. 941-942, footnote j).

[116] *Cf*. Keynes Ms. 8 (*Twelve articles on religion*, post-1710), f. 1[r].

[117] This *prima facie* curious reference probably relates to the fact that in the Bible mortal beings are sometimes called "gods". In the second edition Newton wrote in footnote b: "And in this sense princes are called gods, Psalms 82.6 and John 10.35. And Moses is called a god of his brother Aaron and a god of king Pharaoh (Exod. 4.16 and 7.1)" (*ibid.*, p. 941, footnote g).

good heed unto yourselves; for ye saw no manner of similitude on the day *that* the LORD spake unto you in Horeb out of the midst of the fire: Lest ye corrupt *yourselves*, and make you a graven image, the similitude of any figure, the likeness of male or female,"], and Isaiah 40: 18-19 ["To whom then will ye liken God? or what likeness will ye compare unto him? The workman melteth a graven image, and the goldsmith spreadeth it over with gold, and casteth silver chains."]. The references from the Old Testament support Newton's view that, whenever we apply human-like properties to God, our talk of God is purely allegorical. The content of the references from the New Testament is, however, striking: they imply that Christ is but a messenger of God and certainly not His worldly incarnation. In other words: in the C-version Newton revealed his anti-Trinitarian agenda through these scriptural references. That Newton himself distinguished between orthodox and heretical references is further confirmed in the D-version.

In the D-version Newton dropped reference to Exodus 28: 4, Deuteronomy 4: 12, 14-15 and Isaiah 40: 18-19 and regrouped the biblical references into two groups: on CUL Add. Ms. 3970.12: f. 363^{r}, (1) Acts 17: 27-28, Deuteronomy 4: 39 and 10: 14, I Kings 8: 27, Job 22: 12, Psalms 139: 7, Jeremiah 23: 23-24, and (2), on CUL Add. Ms. 3970.12: f. 363^{v}: John 1: 18[118] and 5: 37, Colossians 1: 15[119], I Timothy 1: 17 and 6: 16, and I John 4: 12. The former group relates to the omnipresence of God, the latter to Newton's subordinationist view of Christ.[120]

In the E-version group (2) has completely disappeared and, like in the B-version, Newton, by way of compromise, underscored and capitalized "unius" (initially Newton wrote "unius" in small capitals). Newton chose to withdraw these all but too revealing references and decided to hide his intention behind a more subtle typography. As stating group (2) would have made Newton's anti-Trinitarianism obvious, Newton preferred to suppress them and write a more complex anti-Trinitarian hermeneutics into the General Scholium.[121]

Newton on the Dangers of Leibniz's Cartesian Philosophy

Richard S. Westfall has noted that "the *General Scholium* contained a vigorous reassertion of those principles Newton had adopted in his rebellion against the perceived dangers of Cartesian mechanical philosophy".[122] Alan E. Shapiro has recently argued that Newton "had consciously avoided using "experimental philosophy" until the beginning of the eighteenth century, when he publicly introduced that venerable term in the second edition of the *Principia* in 1713 in order to defend his work, especially the theory of gravity, against the criticism of Cartesians

[118] Also referred to in Keynes Ms. 2 (*Theological Notebook*, 1684-1690), part 1, p. 12^{v}.

[119] Also referred to in *ibid.*, p. XII.

[120] In the second edition of the *Principia* Newton referred to Acts 17: 27-28, John 14: 2, Deuteronomy 4: 39 and 10: 14, Psalms 139: 7-9, I Kings 8: 27, Job 22: 12-14 and Jeremiah 23:23-24. In the third edition, he omitted John 14: 2 (*ibid.*, p. 942, footnote j). The latter group is identical to the references given in the E-version (see [B.5]).

[121] *Cf.* Snobelen, "God of Gods, and Lord of Lords", p. 170, *cf.* p. 180, footnote 43.

[122] Westfall, *Never at Rest*, p. 749.

and Leibnizians but, above all, Leibniz himself".[123] Newton used "experimental philosophy" as a means to rhetorically distance himself from the sort of natural philosophy professed by Cartesian philosophy which accepted the introduction of imaginary hypotheses.[124]

In manuscript material (CUL Add. Ms. 9597.2.11: f. 2^{r} and f. 3^{r}), composed roughly around the same time (1713-1715) as the General Scholium, Newton added several other points of criticism on Leibniz's Cartesianism (and Cartesian philosophy in general) than those which are commonly documented.[125]

Mind that Newton's objections in this manuscript material against Leibniz and Cartesianism were not only physical or formulated from an "experimental philosophy" point of view, as is clear from published material.[126] Firstly, Newton rejected Descartes's innatism. Newton stressed that all our knowledge, including ideas, derives from phenomena. In the following passage we see Newton adopting an empiricist approach on sensory perception:

> But if, what is taught in metaphysics [pertains to metaphysics?], and [what] religion[127] is, is by itself deduced from divine revelation, [and] if what is deduced from phenomena by means of the five senses pertains to physics, then, from the knowledge of the internal actions of our mind by the faculty of reflection, philosophy concerns the unique human mind and by its ideas (as if internal phenomena) likewise pertains to physics. On the objects of ideas [one can] dispute, unless from the moment these phenomena are a dream. In all philosophy we have to

[123] Shapiro, "Newton's "Experimental Philosophy"", p. 186. Newton was quite incensed by Leibniz's letter to Nicolas Hartsoeker which was published in *Mémoirs des Trévoux* on 5 May 1712 (according to Shapiro Newton came across a translation of this letter only ten days before he sent his final changes to Roger Cotes on 28 March 1713) (*ibid.*, p. 201; for Leibniz's letter, see Newton, *Philosophical Writings*, ed. Janiak, pp. 109-114). The earliest usage of "experimental philosophy" Shapiro has found dates back to 1706 in a draft of a paragraph in *Query 23* (CUL Add. Ms. 3970: f. 243^{r}) (*ibid.*, p. 189). In this period Newton also started characterizing his method in terms of "analysis and synthesis" (1703-1704) (*ibid.*, p. 191), "the method of induction" (1717) (*ibid.*, p. 197), and "deduction from phenomena" (1713) (*ibid.*, pp. 211-215). Snobelen has also pointed to the effect of Leibniz's 1712 attack on Newton (Snobelen, "God of Gods, and Lord of Lords", p. 174; see also Westfall, *Never at Rest*, pp. 729-732).

[124] Cartesian natural philosophy was therefore "hypothetical philosophy" (Letter to Cotes, March 1713, Newton, *Philosophical Writings*, ed. Janiak, p. 121). On CUL Add. Ms. 3968: f. 586^{v}, Newton mocked Leibniz and pointed out that "M^{r} Leibniz never found but a new experiment in all his life" (quoted from Shapiro, "Newton's "Experimental Philosophy"", p. 205).

[125] See Newton's *An Account of the Book Entitled Commercium Epistolicum* (1715) (reproduced in Newton, *Philosophical Writings*, ed. Janiak, pp. 123-127), his unpublished letter to the editor of *Mémoirs des Trévoux* (May 1712) (reproduced in *ibid.*, pp. 114-117; Shapiro, "Newton's "Experimental Philosophy"", p. 201 [for the reconciliation of this date and his interpretation]), his letter to Cotes on 28 March 1713 (reproduced in *ibid.*, pp. 118-122) and, of course, the General Scholium.

[126] The famous first line of the General Scholium is: "The hypothesis of vortices is beset with many problems." (Newton, *The Principia*, p. 939).

[127] In Keynes Ms. 6 (*Seven Statements on Religion*, post-1710): f. 1^{r}, Newton stated that religion and philosophy are to be "preserved distinct": "We are not to introduce divine revelations into Philosophy, nor philosophical opinions into religion".

> start from the phenomena, and we [must] not admit any principles, causes or explanations of things, unless they are established by phenomena.[128]

Here Newton argued that since ideas can be considered as internal phenomena[129] they are part of physics, i.e. the study of phenomena. In CUL Add. Ms. 9597.2.14, Newton synthesized his objections against Cartesian natural philosophy and metaphysics in a very strong way. Again Newton expressed his dissatisfaction with Descartes's doctrine of innate ideas:

> [...] the author [Leibniz[130]] hopes that the philosophy of Newton ([which] is founded on mathematical demonstrations from phenomena) is rejected and all at last unite in a philosophy which they will found on adapted hypotheses [to arrive] at geometrical [and] healthy metaphysical notions.[131] [This] metaphysics is based on innate ideas; the philosophy of Newton on phenomena through mathematical demonstrations. Innate ideas are hypotheses and does our author wish to found natural philosophy on phenomena and demonstrations [drawn] from metaphysical hypotheses; [...][132]

Here Newton's rejection of Cartesianism was based on an empiricist epistemological criterion. As proper natural philosophy is based on experience alone, no room was left for the hypothesis of innate ideas. But Newton's concerns were not only

---

[128] Author's translation of : "Quod in Metafysica docetur <& se a relevatione [illegible word; probably "divina"] deducitur religio esse>, si a Phaenomenis per sensus quinque externos, ~~deducitur~~ a Physicā pertinet, ~~si a revelatione divina, religio <est>~~; si a cognitione actionum internarum mentis nostrae per sensum reflexionis, philosophia est de sola mente humana & ejus ideis <tanquam Phaenomenes internas> & ad Physicam <item> pertinet. De Idearum objectis disputare nisi quatenus sunt phaenomena ~~somniamus~~ <somnium est>. ~~Ideoque a Phaenomenis in omni Philosophia incipiendum est.~~ In omni Philosophia incipere debemus a Phaenomenis, & nullla admittere <rerum> principia nullas causas nullas explicationes nisi quae per phaenomena stabiliuntur." (CUL Add. Ms. 9597.2.11: f. 2[r]).

[129] Newton interpreted the notion "phenomena" broadly as to include not only what can be known by the five senses but also "things internal which we contemplate in our minds by thinking" (McGuire, *Tradition and Innovation*, p. 132; *cf.* CUL Add. Ms. 3970: f. 621[v] quoted in Shapiro, "Newton's "Experimental Philosophy"", p. 198).

[130] The author conjecture that Newton refers to Leibniz here, since this material is related to Newton's attack on Leibniz elsewhere (see the material referred to in footnote 125).

[131] It was precisely the lack of proper (mathematical) demonstrations that led to the downfall of proper natural philosophy: "Defectu demonstrationibus haec philosophia intermissa fuit eandemque non inveni sed vi demonstrationum in lucem tantum revocare conatus sunt." (CUL Add. Ms. 3965.9: f. 109[r]).

[132] Author's translation of: "[...] sperat Author ut Philosophia Newtoni in Phaenomenis per Demonstrationes Mathematicas fundata rejiciatur & omnes tandem conveniant in Philosophia quam Geometrae in Hypothesibus ad notiones Metaphysicae sanae aptatis fundabunt. Metaphysica in ~~In Hypothesibus Idearum~~ Idaeis innatis, Philo<so>phia Newtoni in Phaenomenis <per mathematicis Demonstrationibus> fundatur. Idaeae innatae sunt hypotheses & vult author noster Philosophiam naturalem in ~~hypothesibus metaphysicis fundari. Et~~ phaenomenis ac demonstrationibis per hypotheses metaphysicas fundari; [...]" (CUL Add. Ms. 9597.2.14: f. 4[r]).

epistemological, he had severe theological, metaphysical[133] and physical reasons for rejecting Cartesianism:

> And under a sane Cartesian metaphysics one [Descartes/Leibniz] understands [the following]: [a sane metaphysics is a metaphysics in] which it is asserted everywhere that an absolutely perfect Entity exists, and Descartes approves its [existence] from the idea of it, [and] from its absolute necessity [which is] included in this idea, and from man having an maker. That this true Entity, by procreating everything from the utmost wise nature and by doing nothing in vain, is distinct [from his creation] he nowhere shows. That is to say, in his metaphysics the author himself wants this Maker to be God; in his *Principles of Philosophy* (Part III, section 47[134]) matter is posited in whatever form, [and] is assumed to be able to take all [possible] forms successively with the help of the laws of nature, and finally he poses that [this order[135] will] direct [us] to that [order] which belongs to this world. So Descartes has nowhere shown that a force or faculty of thinking is *res cogitans* or that all extended things are extension, or all things mobile are extension, or that the movement of bodies only consists in relative translation without inherent force, or that *res cogitans* is present nowhere in space, or that God is not substantially omnipresent, or that [, finally,] we have ideas of the substances [i.e. the essences] [of things]. These are mere hypotheses.[136]

---

[133] See Howard Stein, "Newton's metaphysics", in I. Bernard Cohen and George E. Smith (eds.) *The Cambridge Companion to Newton*, Cambridge University Press: Cambridge, 2002, pp. 256-307.

[134] Descartes's words are: "Quae pauca sufficere mihi videntur, ut ex iis tanquam causis omnes qui in hoc mundo apparent effectus secundum leges naturae supra expositas oriantur. Et non puto alia simpliciora, vel intellectu faciliora, vel etiam probabiliora rerum principia posse excogitari. Etsi enim forte etiam ex Chao per leges naturae idem ille ordo qui jam est in rebus deduci posset, idque olim susceperim explicandum; quia tamen confusio minus videtur convenire cum summa Dei rerum creatoris perfectione, quam proportio vel ordo, & minus distincte etiam a nobis percipi potest, nullaqua proportio, nullusve ordo simplicior est, & congenitu facilior, qua ille qui constat omnimoda aequalitate : idcirco hic suppono omnes materiae particulas initio fuisse, tam in magnitudine quam in motu, inter se aequales, & nullam in universo inaequalitatem relinquo, praeter illam quae est in situ Fixarum, & quae unicuique coelum noctu intuenti tam clare apparet, ut negari plane non possit. Atque omnino parum refert, quid hoc pacto supponatur, quia postea juxta leges naturae est mutantum. Et vix aliquid supponi potest, ex quo non idem effectus (quanquam fortasse operosius) per easdam naturae leges deduci possit : cum enim illarum ope materia formas omnies quarum est capax, successive assumat, si formas istas ordine consideremus, tandem ad illam quae est hujus mundi poterimus devenire : adeo ut hic nihil erroris ex falsa suppositione sit timendum." (Charles Adam and Paul Tannery, *Œuvres de Descartes*, Léopold Cerf: Paris, 1905, vol. 8, pp. 101-103).

[135] For a justification of this insertion, see Descartes's text in the preceding footnote.

[136] Author's translation of: "Et Metaphysicam sanam intelligit Cartesianam: Qua ubique asseritur Ens absolute perfectum existere, idque ab ejus Idaea, ab existentia necessaria in Idaea illa inclusâ & ab homine authorem habente Cartesius probat. Verum Ens illud a Natura sapientissima omnia procreante & nihil frustra faciente, diversum esse nusquam demonstrat. Scilicet in Metaphysica sua se authorem habere istumque Authorem esse Deum; in *Principijs Philosophiae* (Part III sect 47) materiam in forma quacunque positam, ope legum naturae formas omnes quarum est capax successive assumere, tandemque ad illam quae est hujus mundi devenire statuit. Sic nec vim aut facultatem cogitandi rem cogitantem esse aut rem omnem extensam extentionem esse, aut existentionem rem mobilem esse, aut motum corporum in sola translatione relativa sine vi inertiae consistere, aut rem cogitantem nulli spatio praesentem esse, aut Deum

Newton also rejected Descartes's account of motion and extension, his account of *res cogitans*/*res extensa* and his treatment of God. Note that Newton's argumentation on this matter is similar to some of the arguments given in *De Gravitatione*.[137] As is well known, Descartes needed three different ontological levels to explain reality: *res cogitans*, *res extensa* and *deus*. The *prima causa* of all motion of the material is God who has created matter and maintains the amount of motion by conservation-laws.[138] Descartes derived these laws from the constancy of God.[139] It appears – that is certainly the way Newton interpreted it – that God, after having created matter and having installed the conservation laws, does not directly intervene in the world. After the aforementioned critiques, Newton went on and claimed that Cartesian philosophy was in fact an anti-Mosaic idolatry that ultimately derived from ancient theogony:

> [This] metaphysics has it origin in the ancient Theogony of nations, in which they everywhere ascribed either parts of the highest God or His powers to the Sun, the Moon, the stars, the elements, intelligences, humane and animal spirits, and everything which is in nature. From this it follows that nature herself is the highest God. Hereby, the people of nations founded their idolatrous philosophy. And Moses, by abolishing [this] cult of [these] parts of the world, condemned this philosophy and established God our Lord as omnipresent in nature and distinct.[140]

Newton's fear was that in the Cartesian *systema mundi* matter would be self-propelling and God's substantial omnipresence could not be guaranteed. Newton was reiterating the concerns of Cambridge Platonist Henry More here. Although Henry More[141] was

---

non esse omnipraesentem per substantiam suam aut nos Idaeas habere substantiarum Cartesius alicubi probavit. Haec omnia sunt merae hypotheses." (CUL Add. Ms. 9597.2.14: f. 4[r]).

[137] See Newton, *Philosophical Writings*, ed. Janiak, pp. 14-22. For the most recent view on the utmost difficult problem of dating *De Gravitatione*, see A. Rupert Hall, "Pitfalls in the Editing of Newton's Papers", *History of Science*, 40(4), 2002, pp. 407-424.

[138] Descartes's ideas on motion can be found in *Le Monde* (1632), but are perhaps presented more clearly in the *Principia philosophiae* (1644). According to Descartes, motion is the translation from one body from one area surrounded by bodies to another area. For a good presentation of Descartes's conservation laws, see Daniel Garber, *Descartes' Metaphysical Physics*, Chicago University Press: Chicago, 1992, (esp. chapters 6 to 9).

[139] Descartes, *Œuvres*, vol. 8, pp. 62-65.

[140] Author's translation of: "~~Metaphysicae~~ Metaphysica <~~ubique~~> ab antiqua Gentium Theogonia originem habuit qua ubique Gentes Solem Lunam Stellas, <Elementa> ~~Deos omnes,~~ <Intelligentias> animas humanas animalia & omnia ~~mundi [illegible word]~~ quae in rerum natura sunt vel partes esse Dei summi vel <ejus> potentias <esse> fingebant. ~~adeoque naturam ipsam esse Deum~~ Unde consequens est quod ipsa rerum Natura sit Deus summus. In hac Philosophiam <Gentes> idolatriam suam fundebant. Et Moses ~~[illegible word]~~ <abrogando> cultum ~~partium [illegible word] a Dêo conditarum hanc Philosophiam damnavit stellarum~~ partium mundi, damnavit hanc philosophiam ac Dom. Deum omnipraesentem a ~~Natura~~ rerum natura diversum stabilivit." (CUL Add. Ms. 9597.2.14: f. 4[r]).

[141] For a recent biography on Henry More, see Robert Crocker, *Henry More, 1614-1687: a Biography of the Cambridge Platonist*, International Archives of the History of Ideas (vol. 185), Kluwer: Dordrecht, 2003.

initially enthusiastic for Descartes's philosophy[142], he later came to reject his philosophy as it could not provide place for the "Spirit(s)" in the physical realm[143], and, therefore, moved away from the true Mosaic philosophy. Such idolatry would yield religious and moral corruption. Cartesianism was ultimately a heretical movement. Newton strongly believed that scientific progress would also be accompanied by moral and spiritual progress. On the final pages of *The Opticks*[144], Newton wrote:

> And no doubt, if the Worship of false Gods has not blinded the Heathen, their moral philosophy would have gone farther than to the four Cardinal Virtues; and instead of teaching the Transmigration of Souls, and to worship the Sun and Moon, and dead Heroes, they would have taught us to worship our true Author and Benefactor, as their Ancestors did under the Government of *Noah* and his Sons before they corrupted themselves.[145]

Descartes's *systema mundi* (and Leibniz's adaptation of it) was basically pagan idolatry reinstalled. It could only remove us further and further from the original *prisca sapientia*.[146] We have seen that Newton's objections against Leibniz/Descartes were manifold: they were physical, but equally metaphysical, epistemological, theological, methodological and religious.

---

[142] More wrote: "*For that admirable Master of Mechanics* Des-Cartes *has improved this way to the highest, I dare say, that the wit of man can reach to in such* Phaenomena *as he has attempted to render the causes of*." (Henry More, *The Immortality of the Soul, So farre forth as it is demonstrable from the Knowledge of nature and the Light of Reason*, Printed by J. Flesher: London, 1659, *Preface*, p. 32). See also More's utterance that "Moses has been aforehand with *Cartesius*" (Henry More, *Conjectura Cabbalistica or, a Conjectural Essay of Interpreting the Minde of Moses According to a threefold Cabbala: viz. Literal, Philosophical, Mystical, or, Divinely Moral*, Printed by J. Flesher: London, 1653, p. 151).

[143] In the Cartesian *systema mundi* God would be nowhere ("nullibi"). More therefore called René Descartes a "nullibist". See Ernst Cassirer, *The Platonic Renaissance in England*, translated by James P. PetteGrove, Gordian: New York, 1970 [1953], p. 149 (originally: Ernst Cassirer, *Die platonische Renaissance in England und die Schule von Cambridge*, Teubner: Leipzig, 1932); Alexandre Koyré, *From the Closed World to the Infinite Universe*, The John Hopkins Press: Baltimore/Londen, 1968, p. 139 (originally: Alexandre Koyré, *Du monde clos à l'univers infini*, Presses Universitaires de France: Paris, 1952).

[144] In a currently unpublished manuscript, Stephen D. Snobelen explores in more detail the theological context of *Query 31*. See Stephen D. Snobelen, ""The Light of Nature": God and Natural Philosophy in Isaac Newton's *Opticks*".

[145] Newton, *The Opticks*, pp. 405-406.

[146] On Newton's belief in the *prisca sapientia*, see e.g. McGuire and Rattansi, Newton and the 'Pipes of Pan', pp. 126-134; Frank Manuel, *The Religion of Isaac Newton*, Clarendon Press: Oxford, 1974; the articles in the following two volumes: James E. Force and Richard H. Popkin (eds.), *Newton and Religion, Context, Nature and Influence*, International Archives of the History of Ideas (vol. 161), Kluwer: Dordrecht/Boston/London, 1999 and John Fauvel, Raymond Flood, Michael Shortland and Robin Wilson (eds.), *Let Newton Be!*, Oxford University Press: Oxford, 1988; for a recent overview, see David Boyd Haycock, "The long-lost truth: Sir Isaac Newton and the Newtonian pursuit of ancient knowledge", *Studies in History and Philosophy of Science*, Part A, 35(3), 2004, pp. 605-623.

3. In Conclusion: "The Flow of Influence"

Looking back on the themes we discussed in the previous section, it is now clear that the General Scholium reflects a cornucopia of Newton's differing intellectual endeavours. It highlights aspects that were central to Newton's natural philosophy in general: matters of experimentation (found in Newton's attempts to deduce other non-gravitational forces from phenomena), methodological issues (related to clarifying the explanatory status of gravitation), theological matters (building a secure basis for natural philosophy compatible with Newton's conception of a God *Pantokrator*), matters related to the instauration of *prisca sapientia*, epistemological claims central to Newton's empiricism, and, finally, metaphysical issues (Newton's treatment of motion, space, substance, etc.). For Newton these matters were closely interwoven. The evolution of the material related to the General Scholium testifies of the varying ways in which Newton tried to combine these endeavours into a *unified* account of natural philosophy.

Rob Iliffe has correctly warned against the *a priori* assumption that "the individual 'Isaac Newton' was the undifferentiated author of a group of writings that were *all coherent or unified at some level*" and called attention to Newton's sensitivity to disciplinary compartimentalisation within his natural philosophy.[147] Although Iliffe does not deal with the relation between Newton's theology and his natural philosophy, "the recognition of disciplinary compartimentalisation within his analyses of the natural world has ramifications for larger claims about the unity of his entire *oeuvre*, or for sorts of connection between different areas of his research".[148] What Iliffe proposes is essentially a bottom-up approach towards ascertaining the unity in Newton's *oeuvre*: we should begin by taking Newton's disciplinary differentiation seriously and by studying the ontological, epistemological and methodological uniqueness of each discipline. Once such detailed studies have been made, we can *a posteriori* begin searching for "conceptual links between different areas of Newton's work".[149] The existence of several conceptual links between Newton's theology and his natural philosophy has been demonstrated and studied.[150]

Amos Funkenstein considers Newton's philosophy of nature as ''a secular theology in the sense that it was oriented ad speculum''.[151] Problems in natural philosophy were also religious problems.[152] Besides their obvious physical meaning space and time for instance have theological meaning. The general thesis of Funkenstein is indeed that the ''scientists'' of the 17th century often defended scientific ideas by

---

[147] Rob Iliffe, "Abstract considerations: disciplines and the incoherence of Newton's natural philosophy", *Studies in History and Philosophy of Science*, Part A, 35(3), 2004, pp. 427-454, p. 428.

[148] *Ibid.*

[149] *Ibid.*, p. 451.

[150] For an overview, see Snobelen, "God of Gods, and Lord of Lords", pp. 198-206.

[151] Amos Funkenstein, *Theology and the Scientific Imagination*, Princeton University Press, p. 5

[152] Richard S. Westfall notes on Newton's interest for theology: ''Newton's interest in theology was not a private idiosyncrasy but a reflection of a general problem that occupied nearly every scientist of the late seventeenth century and every thinking person beyond the scientific community.'' R. S. Westfall, ''Newton's Scientific Personality",' *Journal for the History of Ideas* 4 (1987): pp. 51-70, p. 565.

means of theological arguments and, *vice versa*, that their statements on the divine often had physical consequences. Funkenstein stresses that the Newtonian space and time is homogenous, absolute, and infinite because of three important theological reasons. Space and time are homogenous because ''the same forces can act everywhere in the same manner". They are also absolute in order to suppose ''unequivocal causality'': God's activity is then unequivocal. Both have also to be infinite to render Newton's first law valid correct.[153]

As is widely known, Richard S. Westfall remained unconvinced that it is valid to speak of a theological influence, by which he means "the influence of Newton's central Arian position and his allied view of the prophecies", on Newton's science, rather "we are more likely to find the flow of influence moving from science, the rising enterprise, toward theology, the old and (as we know from hindsight) fading one"[154]. Westfall added: "even if we grant the influence, we remain still on a plane of *high generality* from which it is difficult if not impossible to demonstrate an influence on some *concrete* element of his science"[155]. James E. Force has argued otherwise and urges that Newton's theology "influenced his science every bit as much as his science influences the rigorous textual scholarship of his theology":

> I maintain that Newton's God of Dominion is the key to understanding how he finally integrates his world and his theories in whatever field into a synthetic unity of a startling coherence. [...] I claim only that Newton's view concerning God's dominion – a theory in which Newton emphasizes God's totally free will in conjunction with his absolute power – finally becomes the common denominator in all his intellectual work of whatever shade or hue and so provides the key to understanding the systematic unity and coherence of his thought [including his theology (including doctrinal, prophetic and Christological aspects), natural philosophy and politics[156]].[157]

He further claims that "for Newton, God's real and absolute dominion profoundly affects his metaphysical view of nature and of how we can know nature"[158] and that the "metaphysics of the *Principia* is absolutely pervaded by Newton's God"[159]. Snobelen endorses a similar position, for he claims that "interpenetration existed at a fundamental level between the cognitive content of the theological and the natural

---

[153] Funkenstein, *Theology and the Scientific Imagination*, pp. 90-96.

[154] Richard S. Westfall, "Newton's Theological Manuscripts", in: Zev Bechler (ed.), *Contemporary Newtonian Research*, Reidel: Dordrecht, 1982, pp. 129-43, pp. 139-140.

[155] *Ibid.*, p. 140 (emphasis added).

[156] Force, "Newton's God of Dominion", p. 94.

[157] *Ibid.*, p. 78. In a recent paper Force reiterated this opinion. *Cf.* " [...] what ties together Newton's "holy alliance" of science and religion, I answer that it is his particular conception of the one supremely powerful Lord God, a doctrine witnessed by the generally provident handiwork of the heavens and by the supreme scriptural commandment to have no other "gods"." (Force, "The Nature of Newton's "Holy Alliance"", p. 263).

[158] Force, "Newton's God of Dominion", p. 83. Newton's experimentalism is neatly aligned with his voluntaristic theology. According to Newton, humans cannot get to know God's creation on purely rational grounds (*a priori*), but solely *a posteriori*. (*cf. ibid.*, p. 89).

[159] *Ibid.*, p. 87.

philosophical features of Newton's grand study"[160] and that "Newton's theological concerns (...) made a not insignificant impact on both the methodological and cognitive dimensions of his philosophy"[161].

The author contends that this discussion can only proceed fruitfully if we clearly indicate *at which level* Newton's theological doctrines influenced his doctrines in natural philosophy. For this purpose the author finds it useful to conceptually distinguish between *influences on general features* of Newton's natural philosophy and *influences on specific features* of his natural philosophy.[162] Let us clarify what the author has in mind. General features are features on a meta-level: the way natural philosophy is understood and conceptualized (i.e., the conception of natural philosophy as articulated by Newton). They pertain to the most general and abstract level of science. Specific features refer to knowledge about how natural philosophy is actually done (i.e., the actual scientific praxis that is followed to gain concrete knowledge about nature). Such general influences can easily be traced in Newton's natural philosophy; specific ones only rarely.[163] Based on our current understanding of Newton's natural philosophy, it is quite safe to say that Newton's theological beliefs were influential only at a general level. There is at least one example of such general influence which easily comes to mind. Suppose we accept that Newton's first and second *regulae philosophandi*[164] are based on the theological views Newton expressed on Yahuda 1.1. In this treatise on revelation Newton wrote:

> To ~~prefer~~ <choose> those ~~interpretations~~ <constructions> w^{ch} without straining reduce things to the greatest simplicity. The reason of this is manifest by the precedent Rule. Truth is ever to be found in simplicity, & not in y^{e} multiplicity & confusion of things. As y^{e} world, w^{ch} to y^{e} naked eye exhibits the greatest variety of objects, appears very simple in its internall constitution when surveyed by a philosophic understanding, & so much y^{e} simpler by how much the better it is understood, so much it is in these visions. It is y^{e} perfection of God's works that are (all[165]) done wth y^{e} greatest simplicity. He is y^{e} God of order and not confusion. And therefore as they that would understand y^{e} frame of y^{e} world must endeavour to reduce their knowledge to all possible simplicity, so it must be in seeking to understand these visions.[166]

[160] Snobelen, "God of Gods, and Lord of Lords", p. 197.

[161] *Ibid.*, p. 204.

[162] *Cf.* Ducheyne, "Newton's Training in the Aristotelian Textbook Tradition", p. 217.

[163] Raquel Delgado-Moreira, "Newton's treatise on Revelation: the use of a mathematical discourse", *Historical Research*, 79(204) (2006), pp. 224-246, p. 225, p. 244.

[164] Rule 1 goes: "No more causes of natural things should be admitted than are both true and sufficient to explain their phenomena." (Newton, *The Principia*, p. 794). Rule 2: "Therefore, the causes assigned to the natural effects of the same kind must be, so far as possible, the same." (*ibid.*, p. 795).

[165] Cancelled.

[166] Yahuda 1.1 (composed ca. 1670s-1680s): f. 14^{r}.

It is easy to show, as is done elsewhere, how these rules are required to establish Newton's argument of universal gravitation.[167] So in this case we might reasonably assert that we have traced a clear example of how Newton's theological doctrines influenced some *specific features* of his natural philosophy, i.e. how these theologically inspired rules were used in the establishment of Newton's argument for universal gravitation. We conclude that such systematic differentiation between *general* and *specific* influences of Newton's theology on his natural philosophy will be helpful in our understanding of "the flow of influence".

APPENDICES

The following four appendices either contain transcriptions of unpublished manuscripts or some kind of catalogue or inventory to the material dealt with in this paper. The majority of the material comes from the Portsmouth Collection (CUL Add. Ms. 3958-4007).[168]

Appendix A contains the transcriptions of four unpublished manuscripts (one from the Portsmouth Collection and three from the Macclesfield Collection).

Appendix B is an inventory of the drafts of the General Scholium. In a paragraph-by-paragraph way, the author summarizes the content of the published version of the General Scholium. Subsequently, he provides a paragraph-by-paragraph overview of the draft-versions (of which two of the five versions have been transcribed and translated in Hall and Hall, *Unpublished Scientific Papers*). In this way, we will be able to systematically collect all relevant differences between the drafts and the published version.

Appendix C contains a paragraph-by-paragraph inventory of the folios containing the suppressed *Preface* and *Conclusio* to the first edition of the *Principia* (these manuscripts have been transcribed and translated in Hall and Hall, *Unpublished Scientific Papers*). They are especially relevant to see the evolution in Newton's thought on the non-gravitational forces in nature. For the reader's convenience, The author have chosen to provide the original Latin text of some crucial passages.

---

[167] Ducheyne, "The Argument(s) for Universal Gravitation", pp. 18-20; *idem.*, "Newton's Notion and Practice of Unification", *Studies in History and Philosophy of Science*, Part A, 36 (1), 2006, pp. 61-78, p. 67, p. 70, p. 76.

[168] For the sake of completeness, we should mention that Maurizio Mamiani and Emanuela Trucco have made CUL Add. Ms. 3970: f. 236^{r} [which deals with the electric spirit as being a cause of muscular movement and perception] and ff. 237^{r-v}, 238^{r-v} and 240^{r-v} [which deals with the electric spirit as being the cause of attractive and repellent forces at small distances, attractive forces during chemical reactions, fermentation, putrefaction, the growth of animal and vegetal life, the formation of stones and minerals] available (Mamiani and Trucco, "Newton E I Fenomeni della Vita", pp. 78-87). According to Mamiani and Trucco, these were written at the time the General Scholium was written. The manuscript material confirms Liam Dempsey's thesis that Newton saw mental causation in close analogy with forces as gravity and electricity (Dempsey, "Written in the flesh: Newton on the mind-body relation").

Appendix D contains all manuscript material from the Portsmouth collection related to the Classical Scholia. we document the relevant differences.

APPENDIX A: SOME UNPUBLISHED MANUSCRIPTS RELATING TO THE GENERAL SCHOLIUM

[A.1] *CUL Add. Ms. 3965.9: f. 109*$^{r\text{-}v}$ [early 1710s]:[169]

> [f. 109^{r}] [170] Geometria Veteres quaesita investigabant per Analysin, inventa demonstrabant per Synthesin, demonstrata edebant <ut> in Geometriam reciperentur. Resoluta non statim recipiebantur in Geometriam: opus erat solutione per compositionem demonstrationum. Nam Geometriae vis et laus omnis in certitudine rerum, certitudo in demonstrationibus luculenter compositis constabat. In hac scientia non tam breviati ~~quam~~ scribendi quam certitudini rerum consulendum est. Ideoque [~~illegible word~~] in sequenti Tractatu Propositiones per Analysis inventas demonstravi synthetice.
>
> Geometria Veterum versabatur quidem circa magnitudines; sed Propositiones de magnitudinibus non[n]unquam demonstrabantur ~~per~~ <mediante> motu locali: ut cum triangulorum aequalitas in Propositione quarta libri primi *Elementorum* [171] Euclidis demonstraretur transferendo tr[i]angulum alterutrum in locum alterius. Sed et genesis magnitidinum per motum continuum recepta fuit in Geometria: ut cum linea recta duceretur in lineam rectam ad generandam aream, & area recta duceretur in lineam rectam ad generandum solidum. Si recta quae in aliam ducitur datae sit longitudinis generabitur area parallelogramma. Si longitudo ejus lege aliqua certa continuo mutetur generabitur area curvilinea. <Si magnitudo areae in rectam ductae continuo mutetur generabitur solidum supperficie curva terminatum.> Si tempora, vires, motus et velocitates motuum exponantur <~~per>~~ ~~longitudines~~ lineas ~~vel <per> magnitudines~~ <~~angulorum~~> areas solida <vel angulos>, tractari etiam possunt hae quantitates in Geometria.[172]
>
> Quantitates continuo fluxu crescentes vocamus fluentes & velocitates crescendo vocamus fluxiones, & incrementa momentanea vocamus momenta, et methodum

[169] A draft of this manuscript can be found at CUL Add. Ms. 9597.2.11: ff. 1$^{r\text{-}v}$-3$^{r\text{-}v}$.

[170] D.T. Whiteside has provided a partial transcription of this manuscript – unfortunately omitting the last 2 paragraphs (D.T. Whiteside (eds.), *The Mathematical Papers of Isaac Newton*, (8 vol.), Cambridge University Press: Cambridge, vol. 8, 1697-1722, 1981, pp. 452-459). We have chosen to reproduce the entire manuscript, since it has nowhere been reproduced in its entirety and Whiteside's transcription includes some minor inaccuracies and does not allow one to ascertain the sections that have been crossed out or the ones that were inserted later. The pointed brackets (<...>) indicate that the text in between them was inserted from above. The square brackets ([...]) indicate my own insertions. A complete translation of this manuscript is provided by I. Bernard Cohen (Cohen, *The Principia*, pp. 49-54). It was composed in the late 1710s. This manuscript contains an unpublished *Preface* to the *Principia*. However, the last two paragraphs are highly relevant to understand Newton's General Scholium.

[171] Italics added.

[172] *Cf*. the Leibniz scholium already included in the first edition (Newton, *The Principia*, pp. 649-650).

qua tractamus ejusmodi quantitates vocamus methodum fluxionum et momentorum: estque haec methodus vel synthetica vel analytica.[173]

Methodus Synthetica fluxionum et momentorum in Tractatu sequente passim occurrit, et ejus elementa posui in Lemmatibus undecim primis Libri primi & Lemmate secundo Libri secundi.

Methodus analyticae <specimina> occurrunt in Prop XLV & Schol Prop XCII Lib. I & Prop X & XIV Lib. II. <Et praeterea describitur in Scholio ad Lem. II Lib.> II. Sed et ex demonstrationibus compositis Analysis qua Propositiones inventae fuerunt[174], addisci potest regrediendo. [Et praeterea <describitur in Scholio ad Lem. II Lib: II.> [Tractatum de hac Analysi ex chartis antea editis desumptam, Libro Principiorum subjunxi.][175]

Scopus Libri Principiorum non fuit ut methodos mathematicas edocerem, non ut difficilia omnia ad magnitudinis ~~figuras~~ motus & vires spectantia ~~tractarem~~ eruerem; sed ut ea tantum tractarem quae ad Philosophiam naturalem et apprime ad motus coelorum spectarent ideoque quae ad hunc finem parum conducerent, vel penibus omisi, vel leviter tantum attigi, omissis demonstrationibus.

In Libris duobus primis vires generaliter tractavi, easque si in centrum aliquod seu immotum seu mobile tendunt, centripetas ~~vocavi~~ (nomine generali) vocavi, non inquirendo in causas vel species virium, sed earum quantitates determinationes & effectus tantum considerando. In Libro tertio quam primum didici ~~Lunam in~~ vires – quibus Planeta in orbibus suis retinentur, recedendo a Planetis in quorum centra vires illae tendunt, decrescere in duplicata ratione [~~illegible letters~~] distantiarum a centris, & vim qua Luna retinetur in Orbe suo circum Terram, descendendo ad superficiem Terrae aequalem evadere vi gravitatis nostrae, ~~caepi gravitatem tractare ut vim quae corpora coelestia~~ adeoque vel gravitatem esse vim [f. 109^{v}] vim gravitatis duplicare: caepi gravitatem tractare ut vim qua corpora coelestia in orbibus suis retineantur. Et in eo versatur Liber iste <tertius> ~~tertius~~, ut Gravitatis propietates, vires, directiones & effectus edoceat.[176]

Planetas in orbibus fere concentricis & Cometas in orbibus valde excentricis circum Solem revolvi, Chaldaei olim crediderunt, Et hanc Philosophiam P~~h~~ythgorei in Graeciam [introduxerunt] invexerunt.[177] Sed et Lunam gravem esse in Terram, <& stellas graves esse in se mutuo>, et corpora omnia in vacuo aequali cum velocitate in Terram ~~descend~~ cadere, adeoque gravia esse pro quantitate materiae in

[173] Here we notice the clear influence of the priority debate with Leibniz (on this matter see Rupert A. Hall, *Philosophers at War, The Quarrel between Newton and Leibniz*, Cambridge University Press: Cambridge, 1980; Domenico Bertoloni Meli, *Equivalence and Priority: Newton vs. Leibniz*, Oxford University Press: Oxford, 1993; Richard S. Westfall, *Never at Rest*, pp. 698-780). In 1713, Roger Cotes wrote to Richard Bentley to ask him to persuade Newton to annul submitting these potentially polemic parts making such overt reference to the priority debate (Westfall, *Never at Rest*, p. 749).

[174] Newton himself promoted the myth that he had used his analytical method of fluxions to arrive at his discoveries in the *Principia* in order to ensure his claim of priority over Leibniz. A. Rupert Hall's accurate assessment goes as follows: "the tool he was developing from the autumn of 1684 onwards and brought to fruition in the final text of the *Principia* was an idiosyncratic geometry in which infinitesimal increments of lines and areas perform the functions of first and second order differentials, a geometry intimately integrated with his dynamical principles." (Rupert A. Hall, *Isaac Newton, Adventurer in Thought*, Cambridge University Press: Cambridge, [1992] 2003, p. 213).

[175] These squares are Newton's.

[176] Newton, *The Principia*, p. 382, p. 793.

[177] *Cf*. Newton, *The Opticks*, p. 369.

singulis notum fuit Veteribus. Defectu demonstrationibus haec philosophia intermissa fuit eandemque non inveni sed vi demonstrationum in lucem tantum revocare conatus sunt. Sed et Praecessionem Æquinoxiorum, & fluxum & refluxum maris et motus inaequalis Luna ~~illegible word~~ et orbes Cometarum & perturbationem orbis Saturni per gravitatem ejus in Jovem ab ijsdem Principijs consequi, et quae ab his Principijs consequuntur cum Phaenomenis probe congruere, his ostensum est. Causam gravitatis ex phaenomenis nondum didici.

Qui leges et effectus Virium electricarum pari successu et certitudine eruerit, philosophiam multum promovebit, etsi <forte> causam harum Virium ignoraverit. ~~Nam~~ Phaenomena <observanda> primo ~~<spectanda> consideranda~~ <sunt>, dein horum causae proximae, & postea causae causarum ~~eruenda~~ eruenda; ac tandem a causis <supremis causarum> per phaenomena stabilitis, ad <~~causas~~> ~~caus phaenomena~~ <eorum effectus>, <~~eorum causas proximas~~> argumentando a priori, descendere licebit. ~~Et inter Phaenomena numerandae sunt actiones mentis quae nobis innotescunt quarum conscij sumus~~ Philosophia naturalis non in opinionibus Metaphysicis, sed in Principiis propijs fundanda est; & haec [end]

[A.2] *CUL Add. Ms. 9597.2.11: f. 2*^{r} [1713-1715]:[178]

Quod in Metafysica docetur <& se a relevatione [illegible word; probably "divina"] deducitur religio esse>, si a Phaenomenis per sensus quinque externos, ~~deducitur~~ a Physicā pertinet, ~~si a revelatione divina, religio <est>~~; si a cognitione actionum internarum mentis nostrae per sensum reflexionis, philosophia est de sola mente humana & ejus ideis <tanquam Phaenomenes internas> & ad Physicam <item> pertinet. De Idearum objectis disputare nisi quatenus sunt phaenomena ~~somniamus~~ <somnium est>. ~~Ideoque a Phaenomenis in omni Philosophia incipiendum est.~~ In omni Philosophia incipere debemus a Phaenomenis, & nullla admittere <rerum> principia nullas causas nullas explicationes nisi quae per phaenomena stabiliuntur. Et quamvis tota philosophia non statim pateat, tamen satius est aliquid indies addiscere quam hypotheseωn praejudicijs mentes hominum preoccupare.

[A.3] *CUL Add. Ms. 9597.2.11: f. 3*^{r} [post-1690]:[179]

[...][180] Alias nullum om[n]ino phaenomenon <per causam suam> recte explicari posset nisi causa <hujus> causae, & causa ~~priori~~ causae prioris redderetur & sic deinceps usque donec ad causam primam deventum sit.

Mechanicam gravitatis causam D. Fatio[181] olim excogitavit, sed veram esse non probavit. Hypothesis erat, & in Philosophia experimentali hypotheses non considerantur. Argumenta hic desumuntur ab experimentis per Inductione. Et

[178] The draft of this paragraph contains no noticeable variation. Therefore, we have chosen only to reproduce this paragraph. It was probably composed in the same period as the drafts to the General Scholium. The same editorial rules as in the previous transcription apply.

[179] Again, author only reproduces the relevant variant paragraphs near the end of this draft.

[180] The preceding lines are about how forces (electrical, magnetic and gravitational) can be understood as causes of phenomena.

[181] This reference show that this fragment is definitely post-1690. See Nicolas Fatio De Duillier, *De la cause de la pesanteur. Mémoire de Nicolas Fatio de Duillier présenté à la Royal Society le 26 février 1690,* (edited and introducted by) Bernard Gagnebin in *Notes and Records of the Royal Society of London*, 1948-49, 6 (2), pp. 105-160; also see Cohen, *Introduction to Newton's Principia*, p. 177.

argumentum ab inductione[182] <licet demonstratio perfecta non sit tamen> fortius est quam argumentum ab Hypothesi sola. Et quo plura sint experimenta vel Phaenomena a quibus deducitur eo fortius evadit. Hypothesis igitur in hoc Tractatu non fingimus neque argumenta inde desumimus, cum cedant argumentis ab inductione [end]

[A.4] *CUL Add. Ms. 9597.2.14: f. 4*^{r} [1713-1715]:[183]

In Metaphysicae sane notionibus][184] id est, sperat Author ut Philosophia Newtoni in Phaenomenis per Demonstrationes Mathematicas fundata rejiciatur & omnes tandem conveniant in Philosophia quam Geometrae in Hypothesibus ad notiones Metaphysicae sanae aptatis fundabunt. Metaphysica in ~~In Hypothesibus Idearum~~ Idaeis innatis, Philo<so>phia Newtoni in Phaenomenis <per mathematicis Demonstrationibus> fundatur. Idaeae innatae sunt hypotheses & vult author noster Philosophiam naturalem in ~~hypothesibus metaphysicis fundari. Et~~ phaenomenis ac demonstrationibis per hypotheses metaphysicas fundari; Et Metaphysicam sanam intelligit Cartesianam: Qua ubique asseritur Ens absolute perfectum existere, idque ab ejus Idaea, ab existentia necessaria in Idaea illa inclusâ & ab homine authorem habente Cartesius probat. Verum Ens illud a Natura sapientissima omnia procreante & nihil frustra faciente, diversum esse nusquam demonstrat. Scilicet in Metaphysica sua se authorem habere istumque Authorem esse Deum; in *Principijs Philosophiae*[185] (Part III sect 47) materiam in forma quacunque positam, ope legum naturae formas omnes quarum est capax successive assumere, tandemque ad illam quae est hujus mundi devenire statuit. Sic nec vim aut facultatem cogitandi rem cogitantem esse aut rem omnem extensam extentionem esse, aut existentionem rem mobilem esse, aut motum corporum in sola translatione relativa sine vi inertiae consistere, aut rem cogitantem nulli spatio praesentem esse, aut Deum non esse omnipraesentem per substantiam suam aut nos Idaeas habere substantiarum Cartesius alicubi probavit. Haec omnia sunt merae hypotheses. ~~Metaphysicae~~ Metaphysica <~~ubique~~> ab antiqua Gentium Theogonia originem habuit qua ubique Gentes Solem Lunam Stellas, <Elementa> ~~Deos omnes,~~ <Intelligentias> animas humanas animalia & omnia ~~mundi [illegible word]~~ quae in rerum natura sunt vel partes esse Dei summi vel <ejus> potentias <esse> fingebant. ~~adeoque naturam ipsam esse Deum~~ Unde consequens est quod ipsa rerum Natura sit Deus summus. In hac Philosophiam <Gentes> idolatriam suam fundebant. Et Moses ~~[illegible word]~~ <abrogando> cultum ~~partium [illegible word] a Dêo conditarum hanc Philosophiam damnavit stellarum~~ partium mundi, damnavit hanc philosophiam ac Dom. Deum omnipraesentem a ~~Natura~~ rerum natura diversum stabilivit.

APPENDIX B: CATALOGUE OF THE MANUSCRIPT MATERIAL DIRECTLY RELATED TO THE GENERAL SCHOLIUM

[182] Newton's phrasing is very similar to his letter to Roger Cotes composed on March 1713 (Newton, *Philosophical Writings*, ed. Janiak, pp. 119-122).

[183] This manuscript is part of the Macclesfield Collection (CUL Add. Ms. 9597; 9597.2 contains the *Newtonia*). The text is on a separate sheet torn in half and contains "2" in the right corner. It is blank on the backside. It was probably composed in the same period as the drafts to the General Scholium.

[184] This square bracket is in the original.

[185] Italics added.

Before we get started with this detailed comparison between the various drafts and the printed result, let us for the reader's convenience give a paragraph-by-paragraph overview of the General Scholium based on Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 759-765:[186]

> ¶ 1: Newton stated that Descartes's vortical mechanics is incongruent with the observed celestial phenomena. The celestial phenomena cannot be accounted for unless vortices are eliminated ("nisi vortices tollantur" [187]).
> ¶ 2: Newton further explained that the celestial motions, above our atmosphere, occur in a Boylean vacuum ("in vacuo *Boyliano*"). He added, although that the celestial bodies persevere in their orbits according to the law of universal gravitation, they "could not originally have acquired the regular position of the orbits by these laws [of universal gravitation]".[188]
> ¶ 3: Newton illustrated the previous point by showing that the primary and secondary planets revolve in concentric circles, in the same direction and very nearly on the same plane. The swiftness and ease by which comets pass in all parts of the heavens showed that these motions cannot be caused by "mechanical causes" as Descartes would want it ("originem non habent ex causis mechanicis"[189]). He continued that the construction of "this most elegant system of the sun [elegantissima haecce solis]" arises from the "design and dominion of an intelligent and powerful being [consilio & dominio entis intelligentis]", i.e. the "dominion of *One*" ("*Unius* dominio").[190]
> ¶ 4: Then Newton stated his famous Hebraic credo of God as a *Pantokrator*, that is, a universal ruler. God's godhood (deitas) lies in the lordship of God, "not over his own body as is supposed by those for whom God is the world soul"[191], but over his servants. The designations (appellationes) "eternal", "infinite", "perfect", "omniscient" and "omnipotent" are subordinate to (and derive from) God's dominion. Newton clarified that God is not eternity, infinity, (absolute) space and time, but "by existing always and everywhere he constitutes duration and space" [192]. He follows up on his credo and points out that God is omnipresent not only virtually but also *substantially* in his creation, but that "the bodies feel no resistance from God's omnipresence". [193] Subsequently, he observed that we cannot know the inner substances of bodies: we can only know their external attributes and properties. Similarly, we cannot have any idea of the substance of God, but only of his attributes. We can only know God "by his properties and attributes

[186] For the translation see Cohen, *The Principia*, pp. 939-944.
[187] Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 759.
[188] Cohen, *The Principia*, p. 940.
[189] Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 760.
[190] Cohen, *The Principia*, p. 940.
[191] *Ibid.*
[192] *Ibid.*, p. 941.
[193] *Ibid.*, pp. 941-942.

and by the wisest and best construction of things and their final causes". [194] Correspondingly, Newton concluded this paragraph by claiming that "to treat of God from phenomena is certainly a part of natural philosophy".[195]

¶ 5: Here Newton explained how he had deduced from phenomena the force of gravity (but not yet assigned a cause to it) and how he had shown that this force acts in proportion to the quantity of matter (and not to the quantity of the surfaces of bodies, as the Cartesians claimed). In experimental philosophy, whatever is not deduced from phenomena is a hypothesis. As Newton had not succeeded in deducing from phenomena the cause of gravity, he preferred to remain silent on this matter (*cf.* Newton's famous *dictum* "hypotheses non fingo").

¶ 6: Newton concluded the General Scholium with some remarks on a certain subtle, electric[196] spirit "pervading gross bodies and lying hidden in them"[197] which caused attractive and repellent forces at small distances, electricity, the emission, reflection, refraction and inflexion of light, heath, sensory perception, and muscular movement. The laws governing the actions of this spirit are yet unknown and in want of further experimental scrutiny

We will use this division into paragraphs in what follows. Hereafter, follows my paragraph-by-paragraph description of Newton's drafts of the General Scholium.[198]

[B.1] *CUL Add. Ms. 3965.12: f. 357^{r-v} and f. 358^{r}* [1712/3] (= A-version):[199]

Transcribed and translated in Hall and Hall, *Unpublished Scientific Papers*, pp. 349-352, *cf.* 352-355.

¶ 1 corresponds[200] to ¶ 2 in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 759

¶ 2 corresponds roughly[201] to ¶ 3 in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 759-760

---

[194] *Ibid.*, p. 942.

[195] *Ibid.*, p. 943.

[196] *Ibid.*, p. 944, footnote pp.

[197] *Ibid.*, p. 943.

[198] The numbering of the paragraphs, both in the manuscripts and in Cohen's edition of the *Principia*, are mine. They have been chosen purely for the reader's convenience.

[199] All five holograph drafts to the *Principia* were all written before January 1712/13 (Hall and Hall, *Unpublished Scientific Papers*, p. 349). Only CUL Add. Ms. 3965.12: ff. 357^{r-v}-358^{v} (= the A-version) and ff. 361^{r-v}-363^{r-v} (= the C-version) have been transcribed and translated. See A. Rupert Hall and Marie B. Hall, *Unpublished Manuscripts: A Selection from the Portsmouth Collection*, Cambridge University Press: Cambridge, pp. 348-355. I have followed their division into paragraphs. In Cohen's recent translation the division in paragraphs differs slightly.

[200] A relevant variation occurs near the end of the paragraph where Newton wrote, but later crossed out: "~~At motus illi <sub initia> ex causis mere mechanicis sub initia oriri non potuere.~~" (CUL Add. Ms. 3965.12: f. 357^{r}).

¶ 3 consists of two sentences[202] which are included in ¶ 5 in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 764
¶ 4 corresponds roughly[203] to ¶ 1 in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 759
¶ 5 corresponds roughly to ¶ 5 in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 764
¶ 6 corresponds roughly[204] to ¶ 6 in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 764-765
¶ 7-9 are unique paragraphs which were not included in the printed version of the *Principia*.[205] For the reader's convenience, we provide the original text of these last three paragraphs:

> [¶ 7] Si vitra duo plana & polita & quam proxime contigua soperficiebus parallelis in aquam stagnantem immergantur; aqua inter vitra ascendit supra superficiem aquae stagnantis & altitudo ascencus erit reciproce ut distantia vitrorum. Et hoc experimentum succeedit [*sic*] in vacuo Boyliano ideoque a gravitate atmospherae incumbentis non pendet. Partes vitri ad superficiem aquae ascenditis attrahi[un]t aquam ipsis proximam & inferiorem & ascendere faci[un]t. Attractio eadem est in variis distantiis vitrorum & idem pondus aquae attolit, ideoque aquam eo altius ascendere facit quo minor est distantia vitrorum Et simili de causa aqua ascendit in tubulis tenuibus vitreis idque eo altius quo tenuiores sunt tubulae, et liquores omnes ascendunt in substantiis spongiosis.[206]
>
> [¶ 8] Vitra duo plana et polita longitudine viginti digitorum latitudine [ ] parabantur. Horum alterum horizonti parallelum jacebat, & ad unum ejus terminum gutta erat olei malorum citriorum. Alterum priori sic imponebatur ut vitra ad alterum eorum extremum se mutuo contingeret, ad alterum vero ubi gutta jacebat, a se invicem distarent intervallo quasi decimae sextae partis digiti, & vitrum superis contigeret guttam. Quo facto gutta statim incipiebat moveri versus concursum vitriorum eo velocius movebatur. Succesit etiam hoc experimentum in vacuo. Et ortus est hic motus ab attractione vitrorum.
>
> [¶ 9] Si vitra ad concursum suum paululum attollerentur ut vitrum inferius inclinaretur ad horizontem gutta ascenderet, & vitrum superius

---

[201] It should be noted that this manuscript contains but a small portion on God's dominion: "Hic omnia regit non ut anima mundi sed ut ~~natura De~~ universorum Dominus. Omnipraesens est et in ipso <continentur &> moventur universa idque sine resistentia cum <sit Ens non corporeus neque> corpore restiatur." (CUL Add. Ms. 3965.12: f. 357[r]).

[202] Namely these two: "Caeterum causam gravitatis nondum exposui neque exponendā suscepi siquidem ex phaenomenis colligere nondum potui <enim>. Non oritur ex vi centrifuga vorticis alicujus siquidem ~~non~~ tendit non ad axem vorticis sed ad centrum Planetae." (CUL Add. Ms. 3965.12: f. 357[r]).

[203] A noticable difference is: "Nam hypotheses seu physicas ~~seu mechanicas~~ seu qualitatum occultarum ~~fugiunt praejudica~~ fugio. Praejudicia sunt et scientiam pariunt." (CUL Add. Ms. 3965.12: f. 357[v]; *cf.* Hall and Hall, *Unpublished Scientific Papers*, p. 353).

[204] Newton points to the similarity between electricity and gravity as inter-particular forces.

[205] These experiments are not included in any further version. See Hall and Hall, *Unpublished Scientific Papers*, pp. 354-355.

[206] *Cf.* Newton, *Opticks*, pp. 392-394.

positionem suam ad vitrum inferius servaret: gutta ascendendo tardius movebitur quam prius & quo major esset vitri inferioris inclinatio eo tardior erat motus guttae donec gutta quiesceret, pondere ejus attractionem vitrorum aequante. Sic ex inclinatione vitri inferioris dabatur pondus guttae et ex pondere guttae dabatur attractio vitrorum. Inclinationes autem vitri inferioris quibus gutta stabat in aequilibrio et distantiae guttae a concursu vitrorum exhibentur in Tabula sequente.[207]

[B.2] *CUL Add. Ms. 3965.12: f. 359$^{r\text{-}v}$ and f. 360^{r}* [1712/3] (= B-version):

Currently unpublished.

¶ 1 corresponds exactly to ¶ 1, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 759
¶ 2 corresponds exactly to ¶ 2, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 759
¶ 3 corresponds almost[208] exactly to ¶ 3, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 759-760
¶ 4 corresponds almost[209] exactly to ¶ 4, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 760-764
¶ 5 corresponds exactly to ¶ 5, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 764
¶ 6 corresponds exactly to ¶ 6, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 764-765

[B.3] *CUL Add. Ms. 3965.12: f. 361$^{r\text{-}v}$ and f. 362$^{r\text{-}v}$* [1712/3] (C-version):[210]

---

[207] Hall and Hall, *Unpublished Scientific Papers*, pp. 350-351, *cf.* pp. 354-355.

[208] In the published version, one sentence at the end of the paragraph is added: "Et ne fixarum systemata per gravitatem suam in se mutuo cadant, his eadem immensam ab invicem distantiam posuerit." (Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 760).

[209] It contains several sentences on the dominion and omnipresence of God. Newton wrote that "simili consilio constructa, suberunt Unius dominio" [Newton initially wrote "unius" and later decided to capitalized it] (f. 359^{r}). On f. 359^{v}, one relevant sentence is added: "Et haec de Deo, de quo utique ex Phaenomenis disserere, ad Philosophiam experimentalem pertinet. Ex Phaenomenis prodeunt proximae rerum causae: ex his causae superiores donec ad causam summā perveniatur." (*ibid.*; *cf.* Hall and Hall, *Unpublished Scientific Papers*, p. 348). The penultimate sentence is somewhat different (but not relevantly different) from the published version and the paragraph is shorter than the published version. Hence, in ¶ 4 between the penultimate and the last sentence of the B-version, the following text is omitted: "A caeca necessitate metaphysica, quae utique eadem est semper et ubique, nulla oritur rerum variatio. Tota rerum conditarum pro locis ac temporibus diversitas, ad ideis & voluntate entis necessario existentis solummodo oriri potuit. Dicitur autem deus per allegoriam videre, audere, loqui, ridere, amare, odio habere, cupere, dare, accipere, gaudere, irasci, pugnare, fabricare, condere, construere. Nam sermo omnis de deo a rebus humanis per similitudinem aliquam desumitur, non perfectam quidem, sed aliqualem tamen." (Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 763-764). (A scrap-draft of this omitted text can separately be found on CUL 3965.13: f. 543$^{r\text{-}v}$.) Newton refers to the following scriptural references: "Act. 17.27, 28, Deut 4.39. & 10.14. I King. 8.27. Job. 22.12. Psal. 139.7. Jer. 23.23, 24." (CUL Add. Ms. 3965.12: f. 359^{v}).

Transcribed and translated in Hall and Hall, *Unpublished Scientific Papers*, pp. 355-359, *cf*. 359-364.

¶ 1 corresponds exactly to ¶ 1, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 759
¶ 2 corresponds exactly to ¶ 2, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 759
¶ 3 corresponds roughly to ¶ 3, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 759-760
¶ 4 corresponds roughly[211] to ¶ 5, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 764
¶ 5 corresponds roughly[212] to ¶ 4 and ¶ 5, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 763, p. 764
¶ 6 corresponds roughly[213] to ¶ 4 and ¶ 5, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 763, p. 764
¶ 7 corresponds roughly[214] to ¶ 4 and ¶ 5, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 763, p. 764
¶ 8 is redundant and repeats the previous paragraph
¶ 9-15[215] contain several propositions on the electric force causing short-rang attractions between small particles

---

[210] This is the C-version (see Hall and Hall, *Unpublished Scientific Papers*, pp. 355-359).

[211] This paragraph is shorter than the published version and continues of f. 361^{v}. The most notable sentences are: "Causam vero harum proprietatum ejus ex phaenomenis nondum potui invenire. Nam hypotheses seu mechanicas seu qualitatum occultorum [occultarum] fugio. Praejudicae sunt et scientiam pariunt. ~~Sufficiat~~ <Satis est> quod gravitas revera detur, & agat secundum leges a nobis expositas & ad ~~maris nostri~~ corporum coelestium et maris nostri ~~sifficiat~~ motus omnes sufficiat." (CUL Add. Ms. 3965.12: f. 361^{v}; *cf*. Hall and Hall, *Unpublished Scientific Papers*, p. 356). On a separate scrap, Newton wrote: "Leges motuum ex phaenomenis & proprietates gravitatis ex alijs Phaenomenis his Legibus per Inductionem in haec philosophia & vero generalibus habentur cum nulla occurat Objectio ex Phaenomenis derivantur." (CUL Add. Ms. 3965.13: f. 544^{r}).

[212] It is shorter and essentially makes two points: that we do not know the substances of things ("Substantias rerum non cognoscimus. Nullas habemus earum ideas." (CUL Add. Ms. 3965.12: f. 361^{r}); see Hall and Hall, *Unpublished Scientific Papers*, p. 356) and that we only know the properties of things ("earum proprietates solas"; see *ibid*.).

[213] It adds nothing essential to the previous paragraph.

[214] This paragraph adds to the previous two paragraphs that we only see the figures and colours of things, hear but sounds, touch but the external surfaces of objects, smell but the odours, and taste but their tastes.

[215] For the transcription of these propositions, i.e. ¶ 9-15, see Hall and Hall, *Unpublished Scientific Papers*, p. 357. Newton gives only the propositions themselves not their proofs. After having shown that gravity exists and acts according to the inverse-square law, Newton also wished to establish the laws and effects of other attractive forces, viz. electricity and magnetism (*cf*. "superest ut vires reliquas attractivas, vis scilicet electrica et vis magnetica, examinentur, ut earum leges et effectus [*varias*] ad motus [*minimarum particularum materiae corporeae*] minimorum corporum in dissulatione, fermentatione, vegetatione, [*digestione, praecipitatione, separatione*,] & similibus operationibus [*observentur*] inveniantur" (A. Rupert, Hall & Laura, Tilling (eds.), *The*

¶ 16 corresponds roughly[216] to ¶ 4, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 760-764
¶ 17 corresponds roughly[217] to ¶ 2, ¶ 3 and ¶ 4, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 759, p. 759-760, p. 763
¶ 18[218] corresponds to ¶ 4, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 762-763
¶ 19[219] contains one proposition on the vibration of light on human eyes
¶ 20 contains one proposition on the electric spirit that causes animal motion
¶ 21 contains one proposition on the fact that the vibrations of the electric spirit are faster than light itself
¶ 22 contains one proposition on the emission, refraction, reflection and inflection of light caused by the electric spirit
¶ 23 contains one proposition on the fact that homogeneous bodies are held together and heterogeneous bodies are separated by the electric spirit
¶ 24 contains one proposition on the fact that nutrition is caused by electric attraction

[B.4] *CUL Add. Ms. 3965.12: f. 363*$^{r\text{-}v}$ [1712/3] (= D-version):[220]

Currently unpublished.

¶ 1 corresponds exactly to ¶ 1, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 759
¶ 2 corresponds exactly to ¶ 2, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 759
¶ 3 corresponds[221] to ¶ 4, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 759-760

Correspondence of Isaac Newton (7 vol.), Cambridge University Press: Cambridge, 1975, vol. 5, p. 113). These propositions reveal Newton's endeavour to do so. Newton lists five experiments: "1. Vitrorum parallelorum. 2. Inclinatorum. 3. fistularum. 4. Spongiarum. 5. Olei malorum citriorum." (f. 361^{v}).

[216] This paragraph starts on f. 362^{r}. The biblical references Newton referred to are: "Act. 17.27, 28, Psal. 139.7. Deut 4.39. & 10.14. I King. 8.27 Job. 22.12. Jer. 23.23, 24. + [VI] John 1.18 & 5.37 1 John 4.12. 1 Tim. 1.17 & 6.16. Col. 1.15" and, additionally, "Exod. 28.4", "Deut. 4.12, 15, 16", and "Isa 40.18, 19" (CUL Add. Ms. 3965.12: f. 362^{r}).

[217] The main point is that the motion of the celestial bodies can only be explained by postulating attraction over great distances. Newton noted in the middle of this paragraph: "certe causae finales in Philosophia naturali locum habent" (*ibid.*; *cf.* Hall and Hall, *Unpublished Scientific Papers*, p. 358).

[218] This paragraph continues upside-down on f. 362^{r}.

[219] ¶ 19-24, which only state the propositions themselves and provide no demonstrations of them, are mentioned in ¶ 6 of the published version (Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 764-765). For a transcription of these propositions, see Hall and Hall, *Unpublished Scientific Papers*, p. 359.

[220] This is the D-version. Folio 364$^{r\text{-}v}$ is blank.

¶ 4 corresponds[222] to ¶ 5, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 760-764
¶ 5 corresponds roughly[223] to ¶ 5, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 764
¶ 6[224] corresponds roughly[225] to ¶ 4, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 762-763
¶ 7 corresponds roughly[226] to ¶ 4, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 761-762

[B.5] *CUL Add. Ms. 3965.12: f. 365*$^{r\text{-}v}$ [1712/3] (= E-version):[227]

Currently unpublished.

¶ 1 corresponds exactly to ¶ 1 in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 759
¶ 2 corresponds exactly to ¶ 2 in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 759
¶ 3 corresponds[228] to ¶ 3 in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 759-760
¶ 4 corresponds[229] to ¶ 4 in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 760-764

---

[221] It is identical to the published text but the paragraph is left unfinished and ends with: "Et si stellae fixae sint centra similium systematum ~~suberunt~~ haec omnia <simili consilio constructa ~~suberunt~~ suberunt> unius dominio." (CUL Add. Ms. 3965.12: f. 363^{r}).

[222] Newton noted the following biblical references: "Act. 17.27, 28 Deut 4.39, & 10.14. I King. 8.27. Job. 22.12. Psal. 139.7. Jer. 23. 23,24." (CUL Add. Ms. 3965.13: f. 363^{r}). On f. 363^{v}, Newton gives additional references: "6 John 1.18 & 5.37. Col. 1.15. 1 Tim. 1.17 & 6.16. 1 John 4.12.".

[223] The content of this paragraph is, albeit identical to the published version, much shorter – especially, near the end of the paragraph. It does not yet contain Newton's famous line: "Rationem vero harum gravitatis proprietatum ex phaenomenis nondum potui deducere, & hypotheses non fingo." (Koyré, Cohen and Whitman, *Principia mathematica*, ii. p. 764).

[224] The D-version ends with two additional paragraphs.

[225] This paragraph is much shorter than the paragraph in which it appears in the published version.

[226] The text of this paragraph is almost identical to the final version, but it is much briefer. It starts with: "Nam Deus est vox relativa & ad servos referetur: & Deitas est dominio Dei in servos." (CUL Add. Ms. 3965.12: f. 363^{r}) and ends with "*Æ*ternus est & infinitus, omnipotens & omnisciens, id est [:] durat ab aeterno in aeternum, & adest ab infinito infinitum." (*ibid*.).

[227] This is the final E-version.

[228] It is identical to the published text but the paragraph is left unfinished and ends with: "Et si stellae fixae sint centra similium systematum, haec omnia simili consilio constructa suberunt <u>Unius</u> dominio: praesertim & [end]" (CUL Add. Ms. 3965.12: f. 365^{r}; *cf*. Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 760).

[229] The text is identical to the published version, but breaks of earlier and ends with: "Hunc cognoscimus solummodo per ejus proprietates & attributa et per elegantes & opt[imas] rerum structuras & causas finales." (CUL Add. Ms. 3965.12: f. 365^{v}; *cf*. Koyré, Cohen and Whitman,

¶ 5 corresponds[230] to ¶ 5 in Koyré, Cohen and Whitman, *Principia mathematica*, ii, p. 764

[B.6] *CUL Add. Ms. 3965.13: f. 539*$^{r\text{-}v}$ [1712/3?]:[231]

Currently unpublished.

¶ 1 corresponds exactly[232] to ¶ 4, in Koyré, Cohen and Whitman, *Principia mathematica*, ii, pp. 760-764

APPENDIX C: A PARAGRAPH-BY-PARAGRAPH INVENTORY OF THE SUPPRESSED *PREFACE* AND *CONCLUSIO* TO THE FIRST EDITION OF THE *PRINCIPIA*

[C.1] *CUL Add. Ms. 3965: f. 620*$^{r\text{-}v}$ [1687[233]]:

Published and translated in Hall and Hall, *Unpublished Scientific Papers*, pp. 302-308.

¶ 1 is a rather long paragraph that begins with very similar material[234] as the published preface[235] to the first edition of the *Principia*. Newton begins by pointing out the main purpose of the *Principia*: to derive the gravitational forces that cause the motion of the planets, the comets, the Moon and the tides in Book III by means of the mathematically demonstrated propositions delivered in Book I. In the published version Newton simply expressed his hope to derive the (non-gravitational) forces of coherence and repellence of particles from mechanical principles "by the same kind of reasoning", without giving any further comment.[236] In

---

Principia mathematica, ii, p. 763). Newton lists the following biblical references: "Act. 17.27, 28, Deut. 4.39, & 10.14. I King. 8.27. Job 22.12. Psal. 139.7. Jer. 23.23, 24" (*ibid.*).

[230] It is somewhat shorter than the published version and the sole relevant difference is: "Causam vero harum gravitatis proprietatum ex phaenomenis nondum potui deducere, & hypotheses seu mechanicas seu qualitatum occultarum non sequor." (CUL Add. Ms. 3965.12: f. 365^{v}).

[231] Given its similarity with the drafts of the General Scholium it was most likely written in the same period.

[232] CUL Add. Ms. 3965.13: f. 539^{r} further contains two redundant sentences. An identical paragraph can be found in Newton's *Corrigenda et addenda in Lib. III. Princip.* (CUL Add. Ms. 3965.13: f. 526$^{r\text{-}v}$).

[233] This manuscript was composed in the spring of 1687 and contains some material that was included in the *Preface* to the first edition of the *Principia* (Hall and Hall, *Unpublished Scientific Papers*, p. 302).

[234] *Ibid*., pp. 302-303.

[235] Koyré, Cohen and Whitman, *Principia mathematica*, i, p. 16.

[236] In the published version Newton wrote: "Nam multa me movent, ut nonnihil suspicer ea omnia ex viribus quibusdam pendere posse, quibus corporum particulae per causas nondum cognitas vel in se mutuo impelluntur & secundum figuras regulares cohaerent, vel ab invicem

this partial draft Newton provided more detail. The forces of coherence and repellence (at small distances) determine how solvents (*menstrua*), salts (*sales*), spirits (*spiriti*) and bodies (*corpora*) will interact with each other and explain how particles coalesce into regular figures (such as snow or salts) and not just irregularly.[237] The force of coherence gets stronger as substances are agitated by vibratory motions. This happens in processes such as fermentation, the growth of animal and vegetal life, and the formation of stones and salts.[238] Newton merely introduces these examples to illustrate his ideas; there is yet no sign of any attempt to experimentally demonstrate or to quantitatively describe such forces. Newton ends this paragraph by appealing to the analogy of nature: as nature is simple it might be reasonably expected that the non-gravitational forces will act similarly as the gravitational forces Newton had established. He wrote:

> Nam si Natura simplex sit et sibi ipsi satis consona, idem erit causarum tenor in phaenomenis universis ut quemadmodum motus majorum corporum a majori illa vi gravitatis regantur sic etiam motus omnes naturales tam minorum a [vir]ibus quibusdam minoribus pendeant.[239] Superest igitur ut per experimenta commoda quaeramus an extent ejusmodi vires in rerum natura[e] dein quaenam sint earum proprietates quantitates et effectus. Nam si motus omnes naturales tam minorum quam majorum corporum per ejusmodi vires explicari possint, nihil amplius restabit quam ut causas gravitatis, attractionis magneticae[240] et aliarum virium quaeremus.[241]

¶ 2 is a paragraph in which Newton thanks Edmund Halley for his assistance in correcting the *Principia*.[242]

¶ 3 contains some notes on the mathematical procedures used Book I (Proposition VII, the Corollaries to Proposition LXVI and Sections IV and V).

---

fugantur & recedunt: quibus viribus ignotis, philosophi hactenus naturam frustra tentarunt. Spero autem quod vel huic philosophandi modo, vel veriori alicui, principia hic posita lucem aliquam praebebunt." (Koyré, Cohen and Whitman, *Principia mathematica*, i, p. 16).

[237] Hall and Hall, *Unpublished Scientific Papers*, p. 303.

[238] *Ibid*., p. 304.

[239] *Cf*. CUL Add. Ms. 3965.17: f. 619^{r}.

[240] Newton was clearly aware of the different properties of magnetism: "Gravitatem diversi generic esse à vi magnetica." (Isaac Newton, *Philosophia Naturalis Principia Mathematica*, Royal Society: London, 1687, p. 411). In Corollary 5 (third edition of the *Principia*) to Proposition VI, Book III, Newton wrote: "The force of gravity is of a different kind from the magnetic force. For magnetic attraction is not proportional to the [quantity of] matter attracted. Some bodies are attracted [by a magnet] more [than in proportion to their quantity of matter], and others less, while most bodies are not attracted [by a magnet at all]. And the magnetic force in one and the same body can be intended and remitted [i.e., increased and decreased] and is sometimes greater in proportion to the quantity of matter than the force of gravity; and this force, in receding form the magnet, decreases not as the square but almost as the cube of the distance, as far as I have been able to tell from certain rough observations." (Newton, *The Principia*, p. 810).

[241] Hall and Hall, *Unpublished Scientific Papers*, p. 304, *cf*. p. 307.

[242] *Ibid.*, pp. 304-305, pp. 307-308.

[C.2] *CUL Add. Ms. 4005: ff. 25-28, ff. 30-37* [1687]:[243]

Published and translated in Hall and Hall, *Unpublished Scientific Papers*, pp. 320-347. These folios were probably composed after CUL Add. Ms. 3965: f. 620^{r-v} (as the list of observations adduced is far more elaborate; see [C.1]) and contain the suppressed *Conclusio* which was to be added to the first edition of the *Principia*. Newton adduced several observations involving the forces of attraction during chemical processes, and gave other examples of attraction and repulsion at small distances.[244]

¶ 1: Here Newton begins with appealing to the analogy of nature:

> Hactenus explicui Systema hujus Mundi aspectabilis quoad motus majores qui facile sentiri possunt. Sunt autem alij motus locales innumeri qui ob parvitatem corpusculorum moventium, sentiri nequeunt, uti motus particularum in corporibus calidis, in fermentantibus, in putrescentibus, in vegetantibus, in organis sensuum et similibus. Hos omnes siquis feliciter aperuerit, naturam prope dixerim totam corpoream quoad rerum causas mechanicas detexerit. Philosophiam hac in parte excolere minime suscepi. Dicam tamen breviter quod natura valde simplex est et sibi consona. Quam rationem tenet in majoribus motibus, eandem in minoribus tenere debebit. Illi a majoribus corporum viribus attractivis pendent, hos a minoribus particularum insensibilium viribus nondum animadversis pendere suspicor. Nam varia esse virium naturalium genera ex viribus gravitantibus, magneticis, et electricis manifestum est, et adhuc plura esse posse non est timere [*sic*] negandum. Viribus istis majora corpora in se mutuo agere notissimum est, et cur minora viribus similibus se invicem non agitent, plane non video.[245]

Next, Newton listed several chemical reactions during the course of which we observe that particles rush together (*congressus*), i.e. that they attract one another. Newton used a very loose sense (*vulgo loquor*) of attraction here: it simply refers to distant particles coming closer together.[246]

¶ 2-3: In these paragraphs Newton continued adding several other chemical reactions.[247]

---

[243] Folios 25-28 are the drafts of folios 30-37. These were initially intended for publication of the fist edition of the *Principia* (*ibid.*, p. 320). Presumably whey were written in the spring of 1687 (*ibid.*, p. 320).

[244] *Cf.* CUL Add. Ms. 3970.3: ff. 337-338, reproduced in Whiteside, *The Mathematical Papers*, 6, pp. 425-426, footnote 10; *cf.* Newton, *The Opticks*, p. 399, p. 401 [for other correspondence with *The Opticks*, see the notes in Hall and Hall, *Unpublished Scientific Papers*, pp. 333-347].

[245] Hall and Hall, *Unpublished Scientific Papers*, p. 321, *cf.* p. 333.

[246] *Ibid.*, p. 322.

[247] Much of this material is similar to Newton's 1692 *De natura acidorum* (I. Bernard Cohen, *Isaac Newton's Papers and letters on Natural Philosophy*, Harvard University Press: Cambridge (Massuchusetts)/ London, 1978, pp. 256-258).

¶ 4 discusses the cohesive forces between homogeneous bodies. Newton pointed to the fact that whenever the particles of quicksilver are contiguous to each other in a Torricellian tube[248], the quicksilver can be suspended to a vertical height of 40-60 inches and more.
¶ 5 contains a long paragraph containing several illustrations of repulsion at small distances.
¶ 6: Here Newton clarified the purpose of the experiments:

> Haec breviter exposui non ut vires particularum attractivas et expulsivas extare temere affirmem sed ut ansam darem experimenta plura excogitandi per quae tandem certius constet utrum extent[249] necne. Nam si veras esse constiterit, reliquum erit ut earum causas et proprietates diligenter investigemus, tanquam vera principia a quibus omnes particularum minimarum secreterioribus motus secundum rationes Geomentricas non minus oriantur quam motus majorum corporum ex legibus Gravitatis in praecedentibus derivari videmus.[250]

¶ 7 contains a long paragraph on how bodies expel particles of light (*particulas lucis excutiunt*) when heated.
¶ 8: In this additional paragraph Newton admits that the digressions on the non-gravitational forces are not yet proven:

> Vera quidem esse minime affirmo, et valde imperfecta esse agnosco, simplicia tamen sunt et conceptu facilia, et ejusdem generis cum philosophia Naturali systematis cosmici a maiorum corporum viribus attractivis pendente.[251]

¶ 9-10: These related additional paragraphs speculated on the vibratory motion propagated by various forces.

APPENDIX D: MANUSCRIPTS FROM THE PORTSMOUTH COLLECTION RELATED TO THE CLASSICAL SCHOLIA

[D.1] *CUL Add. Ms. 3965.12: ff. 268$^{r\text{-}v}$-269$^{r\text{-}v}$* [1692/3]:[252]

Currently unpublished.

The content of this item is as follows:

¶ 1 corresponds exactly[253] to ¶ 1 in CUL Add. Ms. 3965.12: f. 270^{r}[254]

---

[248] Also see Hall and Hall, *Unpublished Scientific Papers*, p. 303.
[249] *Cf*. "For me must learn from Phaenomena of Nature what Bodies tend toward one another, and what are their Laws and Properties of the Attraction, before we enquire the Cause by which the Attraction is perform'd." (Newton, *The Opticks*, p. 376).
[250] Hall and Hall, *Unpublished Scientific Papers*, p. 327, *cf*. p. 341.
[251] *Ibid.*, pp. 331-332, *cf*. p. 345.
[252] This is clearly the draft to CUL Add. Ms. 3965.12: f. 270^{r}, f. 271^{r} and f. 272^{r}.

¶ 2 corresponds almost exactly[255] to ¶ 2 in CUL Add. Ms. 3965.12: f. 270^{v}-271^{v}

¶ 3 correspond almost exactly[256] to ¶ 4 in CUL Add. Ms. 3965.12: f. 271^{v}[257]

¶ 4[258] corresponds roughly[259] to Royal Society, Gregory Ms. 247: ff. 11-12[260]

¶ 5 is a unique paragraph[261]

¶ 6 corresponds roughly to CUL Add. Ms. 3965.12: f. 271^{r}

¶ 7[262] is a small piece of draft of Royal Society, Gregory Ms. 247: f. 11^{r}[263]

¶ 8 is a small piece of draft of Royal Society, Gregory Ms. 247: f. 12^{r}[264]

¶ 9 is a draft to ¶ 1 of CUL Add. Ms. 3965.12: ff. 268^{v}

[D.2] *CUL Add. Ms. 3965.12: f. 270^{r}, f. 271^{r} and f. 272^{r}* [1692/3]:[265]

All paragraphs of this manuscript has been fully transcribed and discussed, in Casini, *Newton: The Classical Scholia*, pp. 36-38.

[D.3] *CUL Add. Ms. 3965.12: f. 277^{r-v} and 278^{r-v}* [1692/3]:

Currently unpublished.

¶ 1 on f. 277^{r} is a draft of Royal Society, Gregory Ms. 247: f. 6^{r}[266]

---

[253] Albeit that this paragraph it is shorter. The text stops at "Haec enim Lucretius ex mente veterum discuit Lib I vers 601." (CUL Add. Ms. 3965.12: f. 268^{r}).

[254] For CUL Add. Ms. 3965.12: ff. 270 and 271, see [D.2].

[255] In the middle of the paragraph the text breaks of and Newton wrote "see y^{e} backside". The paragraph is continued on CUL Add. Ms. 3965.12: f. 268^{v}. There is a slight variation at the end: "Et hic est motus declinationis quem Epicurus dedit atomos" (*ibid.*; compare with Casini, "Newton: The Classical Scholia", p. 37).

[256] It is continued on CUL Add. Ms. 3965.12: f. 269^{r}.

[257] This paragraph is transcribed in Casini, "Newton: The Classical Scholia", p. 38.

[258] The following two paragraphs are on CUL Add. Ms. 3965.12: f. 268^{v}.

[259] It is most likely a draft to Royal Society, Gregory Ms. 247: ff. 11-12, since it omits much of the ancient references (for the translation of this piece, see McGuire and Rattansi, *Newton and the 'Pipes of Pan'*, pp. 115-117). A notable variation is: "Talis erat mystica illa Veterum Philosophia: estque hypothesis omnium simplicissima et eo nomine maxime philosophica. Sed et pia satis, si modo omnis huic Spiritui intelligendi et volendi potestas conedatur, astris autem nulla. Imò pientissima quatenus Deum a Philosophia naturali abesse non sinit." (CUL Add. Ms. 3965.12: f. 268^{v}).

[260] Schüller, "Newton's *Scholia*", pp. 230-238.

[261] It contains a note on the ancient rites of the Egyptians and the significance of snakes in these rites.

[262] The following three paragraphs are actually three separate notes (the last one being written upside down).

[263] *Ibid.*, pp. 230-232.

[264] *Ibid*., pp. 234-236.

[265] Note that folios CUL Add. Ms. 3965.12: f. 270^{v}, f. 271^{v} and f. 272^{v} are left blank.

¶ 1 on f. 277^{v} is an almost exact copy[267] of Royal Society, Gregory Ms. 247: f. 9^{r}[268]

¶ 2 on f. 277^{v} is a draft[269] of f. 1^{r} of the additional leaves inserted between pages 412-413 of Newton's private first edition of the *Principia* (CUL Adv. b.39.1)

¶ 1[270] on f. 278^{r} is a draft of Royal Society, Gregory Ms. 247: f. 11$^{r\text{-}v}$[271]

¶ 2 on f. 278^{r} is a draft[272] of Royal Society, Gregory Ms. 247: f. 12$^{r\text{-}v}$

¶ 3[273] on f. 278^{v} is an almost exact copy of Royal Society, Gregory Ms. 247: f. 12$^{r\text{-}v}$[274]

[D.4] *CUL Add. Ms. 3965.17: f. 640*$^{r\text{-}v}$ [1692/3]:

Currently unpublished.

¶ 1 is a draft[275] of Royal Society, Gregory Ms. 247: f. 9^{r}

¶ 2[276] corresponds roughly[277] to Royal Society, Gregory Ms. 247: f. 6^{v}

¶ 3-6[278] discuss light and heavy elements

---

[266] For its transcription, see Casini, "Newton: The Classical Scholia", pp. 27-28 and Schüller, "Newton's *Scholia*", pp. 222-223.

[267] The last paragraph ends abruptly and misses some of the final sentences of the corresponding first paragraph in Gregory Ms. 247: f. 9^{r}.

[268] See Casini, "Newton: The Classical Scholia", pp. 25-26; Schüller, "Newton's *Scholia*", pp. 218-220.

[269] The text has been shuffled but no relevant differences can be found. It is similar to Royal Society, London, Gregory Ms. 247, f. 8^{r} and f. 9^{r} (in reverse order). For the transcription, see Casini, "Newton: The Classical Scholia", pp. 25-27; Schüller, "Newton's *Scholia*", p. 218, p. 220, p. 222.

[270] The first paragraph on this folio contains Newton's remarks on Proposition VII of Book III of the *Principia*. The second paragraph contains Newton's remarks on Proposition VIII.

[271] See Casini, "Newton: The Classical Scholia", pp. 30-31; Schüller, "Newton's *Scholia*", pp. 230-231.

[272] It misses the references to Macrobius, Proclus, and Eusebius (Casini, "Newton: The Classical Scholia", p. 31) – however these are given in a separate paragraph on CUL Add. Ms. 3965.12: f. 278^{v}.

[273] As Newton used the envelope of a letter sent to him to take these notes, this paragraph continued in several directions on the folio: horizontally, vertically and upside-down.

[274] See Casini, "Newton: The Classical Scholia", pp. 31-32; Schüller, "Newton's *Scholia*", pp. 234-235.

[275] This paragraph is shorter, but contains no relevant variations.

[276] This paragraph is continued on CUL Add. Ms. 3965.13: f. 640^{v}.

[277] It omits several sentences and quotes from Lucretius.

[278] The last two paragraphs have been crossed out.