

Principles of *Principia*

Some Notes on the Print Run for the First edition

JASON W. DEAN & JAMIE E. CUMBY PhD

Isaac Newton's *Philosophiæ Naturalis Principia Mathematica*, first printed in 1687, is one of the most famous books known, appearing in many notable bibliographies.¹ Perhaps a more immediate marker of its popularity is that a recent sale of the S-issue of the book by Sotheby's fetched £375,000.² If one were to ask a person on the sidewalk to name some rare books, he or she might come up with Shakespeare's first folio, first editions of the Harry Potter books or a comparable modern first. If any scientific texts were named, it would likely be one of these: Copernicus' *De Revolutionibus* of 1543, Galileo Galilei's *Sidereus Nuncius* of 1610, or Isaac Newton's *Principia*. Though all three are in Latin, and thus not widely readable by 21st century standards, they are of outsize importance not only to the History of Science but also to intellectual patrimony more broadly. Of the three, *Sidereus* is the most accessible; it describes the observations of the moon, stars, and moons around Jupiter, things we can see today. The other two texts – *De Revolutionibus* and *Principia* – rely in large part on complex mathematics. To us the importance of *De Revolutionibus* is evident: open the book at the now-famous geocentric diagram and a brief hushed silence hangs over the reader. The same is not as true in our experience with *Principia*, which is filled with mathematical diagrams and equations and is far less immediate to readers.

So why is *Principia* important? Why was it consumed so widely that shortly after its issue buyers had difficulty locating copies for sale? Its importance lies not in attractive diagrams or snappy observations of the moon, but in its complex mathematics. In the 493 pages of the text (paginated to 510 because of an error between the two printers of the book), Newton describes the mathematical tools we can use to understand and describe the universe around us. Perhaps of greatest import to us today are his assertions about the laws of motion and as his statements on universal gravitation. These laws and the concept of universal gravitation led to a transformative re-interpretation of the nature of motion and a deeper understanding of the

¹John Carter and Percy H. Muir, *Printing and the Mind of Man: a Descriptive Catalogue Illustrating the Impact of Print on the Evolution of Western Civilization During Five Centuries* (New York: Holt, Rinehart & Winston, 1967), pp 96-97. Harrison D. Horblit, *One Hundred Books Famous in Science* (New York: Grolier Club, 1964). Bern Dibner, *Heralds of Science* (New York: Burndy Library, 1980).

²"Music, Continental Books and Medieval Manuscripts" Sotheby's London, July 14, 2020. Lot number 74.

behavior of physical bodies in space. It is the foundational work in what today we call classical mechanics. *Principia*, then, gave us the mathematical language to describe, measure, and predict the motions of our solar system and universe. Not until the early 20th century would a transformation of the same impact occur, catalyzed by Albert Einstein, who remarked of *Principia* that it was ‘the greatest intellectual stride that it has ever been granted to any man to make.’³

Formal academic research on *Principia* runs at least as deep as its popular reputation, the one, unsurprisingly, feeding the other. Scholarly interest has by no means been limited to *Principia*’s content, intellectual climate and impact, but also to the particular circumstances of its appearance in print. Indeed, investigations into *Principia* are nearly as old as the field of English bibliography itself, and the flood of studies has not substantially abated since then, including notable attempts by A.N.L. Munby and Henry Macomber to survey existing copies.⁴ By the time D.T. Whiteside published his article dealing with *Principia*’s ‘prehistory’, he had ample grounds to remark ‘surely there can be nothing profoundly new to be said’ about its production.⁵ Most recently Mordechai Feingold and Andrej Svorenčik have published a preliminary census of known copies of the first edition, revising and updating Macomber’s work from 1953.⁶

This 2020 paper, issued as a work in progress, seeks to accomplish a core goal: to definitively argue that *Principia* was a more popular, more widely read book than its complexity might indicate. In effect, Feingold and Svorenčik are working to do for *Principia* what Owen Gingerich has done for the equally famous *De Revolutionibus*, with both his formal census of

³ Albert Einstein, ‘Maxwell’s Influence on the Development of the Conception of Physical Reality’, in *James Clark Maxwell: A Commemorative Volume 1831-1931* (New York: Macmillan, 1931), p. 69.

⁴ Henry P. Macomber, *A Census of Copies of the 1687 First Edition and the 1726 Presentation Issue of Newton’s ‘Principia’* (Portland: Anthoensen Press, 1953). Henry P. Macomber, ‘A Comparison of the Variations and Errors in Copies of the First Edition of Newton’s *Principia*, 1687’, *ISIS*, 42 (1951), 230–232. A. N. L. Munby, ‘The Distribution of the First Edition of Newton’s *Principia*’, *Notes and Records of The Royal Society, London*, 10 1 (1952), 28–39.

⁵ D.T. Whiteside, ‘The Prehistory of the *Principia* from 1644 to 1686’, *Notes and Records of the Royal Society London* 45 (1991), p. 11.

⁶ Mordechai Feingold and Andrej Svorenčik, ‘A Preliminary Census of Copies of the First Edition of Newton’s *Principia*’, *Annals of Science*, 77 (2020), 253–348. The Linda Hall Library is correctly identified as having two copies of the S-issue of the first edition, with the cancel title page. These are the only two copies in Kansas City, with the Spencer Research Library copy being located on the campus of the University of Kansas in Lawrence, Kansas.

surviving copies and his more popular narrative about its reception and use.⁷ The preface to their draft census does a handsome job of uniting the previous literature, which should be unsurprising given Feingold's substantial contributions to Newton scholarship, and of incorporating the well-traveled, published archival records that support it.⁸ They succeed in their primary aim which is to make a persuasive argument for *Principia's* popularity and genuine use, though description and detail is uneven across the items in the census. This can be forgiven, as the authors clearly state their intention to publish early in order to solicit input from librarians and collectors.⁹ It is in our capacity as History of Science librarians, and as custodians of two of the recorded copies of *Principia's* first edition, that we recommend amendments to a different feature of Feingold and Svorenčik's 2020 work: the original number of copies produced.

In addition to arguments that draw on readership and book trade evidence, Feingold and Svorenčik attempt a bibliographic argument about the size of the 1687 *Principia* print run. Their position is that, given the larger number of extant copies they have recorded, estimates of the print run must also increase, to between 600 and 650 copies.¹⁰ However, the particular metric that they use raises concerns from a book historical perspective. A print run describes the total number of copies produced for an edition at a given time, a figure determined by factors like projected sales, marketing, and funding; another key consideration was the total cost of the paper needed for printing.¹¹ Knowing an edition's print run is valuable for understanding financial aspects of printing and the book trade, but also to capture a sense of a book's popularity and the value ascribed to it at the time of publication. For example, when we read about late 17th almanacs produced by members of the Stationers Company in quantities of up to 30,000 copies at a time, we understand not just the incredible profitability of almanac printing, but also get a sense of the ubiquity of almanacs in everyday life for early modern Britons.¹² With some exceptions, print runs are notoriously poorly documented, and many attempts have been made to come up with satisfactory

⁷Owen Gingerich, *An Annotated Census of Copernicus' De Revolutionibus* (Boston: Brill, 2002). Owen Gingerich, *The Book Nobody Read: Chasing the Revolutions of Nicolaus Copernicus* (New York: Walker & Company, 2004).

⁸ Feingold has written too much to cite here, but his faculty page at CalTech provides a useful summary of his work [<https://www.hss.caltech.edu/people/mordechai-feingold>], accessed 25 May 2021.

⁹Feingold and Svorenčik, p. 264.

¹⁰Feingold and Svorenčik, p. 254.

¹¹ Philip Gaskell, *A New Introduction to Bibliography* (Oxford: Clarendon Press, 1972), pp. 162-3.

¹² Cyprian Blagden "The Distribution of Almanacks in the Second Half of the Seventeenth Century" (Studies in Bibliography 11 (1958), Table 1.

estimates.¹³ In this article, we question the methodology behind Feingold and Svorenčik's attempt, which is based on a combination of surviving copies and the contemporary price set by publishers. We take a closer look at the underpinning logic behind their print run model and evaluate its merits in the context of bibliographic research into edition survival. We question their reliance on comparisons of *Principia* to the survival of the first edition of *De Revolutionibus*, and return to Munby's earlier proposal that the print run of *Principia* was around 500 copies.

On page 254 of their recent article, Feingold and Svorenčik cite Owen Gingerich's work with the first and second editions of Copernicus' *De Revolutionibus* as the basis for their print run estimate.¹⁴ The claim is Gingerich's own, that the surviving copies of *Principia* that he could readily find, combined with the price of a copy at the time of publication indicates a proportionally higher print run than indicated previously. However well-intentioned this inference may be, there are important historical and bibliographic problems with transposing a model that works for the 1543 *De Revolutionibus* onto the 1687 *Principia*.

From a bibliographic perspective, a comparison between *De Revolutionibus* and *Principia* is a bit of an apples to oranges case. To begin with, the 1543 and 1566 editions of *De Revolutionibus* were both printed in folio, whereas *Principia* was printed in quarto. Where Gingerich talks about the higher cost of the 1543 *De Revolutionibus*, this is simply to be expected for a book that required nearly 40 per cent more sheets of paper per copy.¹⁵ This is, of course, not to dispute Gingerich's mastery of the production and transmission of *De Revolutionibus*. Rather, it is a reminder that bibliography and book history must be central to any discussion of books as material objects, and that this field has its own body of scholarship to draw on. In the case of *Principia*'s likely print run, bibliographic research gives us models to yield better estimates, and a deeper understanding of their value.

¹³ For seventeenth-century average print runs: Henri-Jean Martin, *Livre, pouvoirs et société à Paris au XVII^e siècle*, v. 1 pp. 377–378; Ian Maclean, *Scholarship. Commerce, Religion*, pp. 120–121. In England, print runs were technically restricted to 1,500 copies for 'ordinary' books between 1586 and 1637, but these regulations were often ignored. Gaskell, *New Introduction to Bibliography*, pp. 117, 162.

¹⁴ Their citation appears on p. 254, n. 5, citing pages 127–128 of Gingerich's book. The meat of Gingerich's discussion of print runs, including his discussion of *Principia*, falls on pages 126–129. Feingold and Svorenčik are not alone in using Gingerich's argument; notably, Dániel Margócsy, Mark Somos, & Stephen Joffe use it as the basis for their estimate of the *De corporis* print run in *The Fabrica of Andreas Vesalius: A worldwide Descriptive census, Ownership, and Annotations for the 1543 and 1555 Editions* (Leiden: Brill, 2018) pp. 8–10.

¹⁵*De Revolutionibus* required 101 sheets of paper per copy, and *Principia* required 63 sheets.

Despite the amount of research into *Principia's* production, no record has yet been located that clearly describes the number of copies in the print run of that first edition.¹⁶ While this is not unusual for other early modern editions, it is interesting that such an otherwise well-documented production process should exclude this valuable piece of information. It is doubly interesting because of where *Principia* fits in the Royal Society's early publishing history. *Principia* is the third monograph published under the imprimatur of the Royal Society – the first being Hooke's *Micrographia* (1665), and the second being Willughby's *Historia Piscium* of 1686, which was a financial failure both for the Society as a whole and the individual members that sponsored its publication.¹⁷ The past members and keepers of the Royal Society dutifully recorded the number of copies printed of *Historia Piscium*, 500, but did not follow this precedent for *Principia*, likely because it did not hold financial responsibility for the edition.¹⁸ The Society recognized the importance of Newton's work, but was unwilling to fund it in the aftermath of Willughby's book. Instead Samuel Pepys, the Society's President, assented to giving his and the society's imprimatur to the text, but left Edmund Halley, Fellow of the Royal Society, and later Astronomer Royal, with the financial responsibility. Given that print runs are determined by funding and given that there is no print run figure in Halley's papers, what little hope there may be for relevant records from the book trade could only come from the sudden and unlikely appearance of account books from its printer, Joseph Streater.¹⁹

¹⁶Confirmation of this absence is legion in Newton literature. The present authors confirmed the absence of print run information in the archives of the Royal Society, as well as in the papers of Edmund Halley, Samuel Pepys, and Newton himself.

¹⁷ Francis Willughby, *De Historia Piscium* (Oxford: E Theatro Sheldoniano, 1686). Sachiko Kusakawa, 'The 'Historia Piscium' (1686)', *Notes and Records of the Royal Society of London*, 54 2 (2000), 179–197. (In the print version of this article, the authors inadvertently left out *Micrographia*, and this oversight is corrected here.)

¹⁸On *Historia Piscium's* print run: Kusakawa, p.190, Thomas Birch, *The History of the Royal Society of London for Improving of Natural Knowledge* (London: Printed for A. Millar, 1756–1757), v. 4 p. 466; Royal Society meeting minutes 17 March 1686, Archives of the Royal Society CMO/2/60.

¹⁹ The records would be Streater's and not those of the Stationers' Company. Though Streater was a free member of the Stationers' Company, those institutional records neither include print runs, nor records of Royal Society publications. Indeed, the Royal Society was required in its charter of 1662–3 to employ members of the Stationer's Company for its printers, but their publications did not need to be entered at Stationer's Hall. Charles A. Rivington, "Early Printers to the Royal Society 1663–1708" *Notes and Records of the Royal Society* 39, 1 (1984), pp. 1–4. Noah Moxham, "The Uses of Licensing: Publishing Strategy and the Imprimatur at the Early Royal Society", in *The Institutionalization of Science in Early Modern Europe*, pp. 267–268.

Adding further complication to the matter, is that the first edition exists in two issues: one (B-issue), bearing the imprint

Londini: Jussu Societatis Regiae ac Typis Josephi Streater. Prostat apud plures Bibliopolas. Anno MDCLXXXVII.

and the second (S-issue) bearing the imprint

Londini, Jussu Societatis Regiae ac Typis Josephi Streater. Prostat apud Venales apud Sam. Smith ad insignia Principis Walliae in Coemiterio D. Pauli, aliosq, non nullos Bibliopolas. Anno MDCLXXXVII.

The collation of the two issues is almost identical, excepting the cancel title page in S-issue copies, as well as the location of the engraved folding plate depicting the orbit of the Comet of 1680. William B. Todd has written the authoritative bibliographical description of *Principia*, and we suggest his is the model for any revised and future census.²⁰ We note three small errors in his work – the cancel of the title page in the S-issue is lacking from his collation, and his use of the word variant for the two typesettings is better called issues.²¹ Furthermore, in a revision to the preliminary census, we suggest the use of ‘B-issue’ and ‘S-issue’ instead of ‘state’ as Feingold and Svorenčik use in their preliminary census.

²⁰ William B. Todd ‘A Bibliography of the ‘Principia’’, in Alexandre Koyré & I. Bernard Cohen, eds., *Isaac Newton’s Philosophiae Naturalis Principia Mathematica* (Cambridge: Harvard University Press, 1972) volume II pp. 851-883.

²¹ Our collation for the S-issue is:

Crown quarto: [A]⁴ (±[A]1) B-P⁴ (±P4) Q-V⁴ W⁴ X-2U⁴ 2W⁴ 2X-2Z⁴ **⁴ 3A-3O⁴ (3O3+χ¹).

PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore *J*. S. NEWTON, *Trin. Coll. Cantab. Soc. Mathefeos*
Professore Lucasiano, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, *Reg. Soc. PRÆSES.*

Julii 5. 1686.

Humbley

LONDINI,
Jussu Societatis Regiæ ac Typis Josephi Streater. Prostant Vena-
les apud Sam. Smith ad insignia Principis Walliæ in Cœmiterio
D. Pauli, aliosq; nonnullos Bibliopolas. Anno MDCLXXXVII.

(PLATE I, S-issue titlepage from Linda Hall Library copy 2 of Isaac Newton, *Philosophiæ Naturalis Principia Mathematica* (London: Joseph Streater, 1687). Courtesy of The Linda Hall Library of Science, Engineering & Technology)

PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore *ſ* S. NEWTON, *Trin. Coll. Cantab. Soc. Matheſeos*
Profefſore Lucaſiano, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, *Reg. Soc. PRÆSES.*

Julii 5. 1686.

Monny
J. Tuberti.
LONDINI,

Juſſu Societatis Regiæ ac Typis Joſephi Streater. Proſtat apud
plures Bibliopolas. Anno MDCLXXXVII.

(PLATE 2, B-issue titlepage from Stanford University Barchas Collection copy of Isaac Newton, *Philosophiæ Naturalis Principia Mathematica* (London: Joseph Streater, 1687). Courtesy of the Department of Special Collections, Stanford University Libraries)

The two separate issues of *Principia* have been the subject of much discussion, which Feingold and Svorenčik capitalize upon to substantiate their claims about the size of the print run. Building on an argument made by Henry Sotheran in Sotheran's catalog 804, Munby, Macomber and subsequent Newton bibliographers and enthusiasts understood the S-issue copies to be many fewer than the original B-issue, and almost exclusively intended for distribution on the Continent.²² The expanded scope of collections surveyed for the new census helps demonstrate that the percentage of S-issue copies had, predictably, been artificially deflated by Munby's and Macomber's reliance on British and American collections. Furthermore, the authors of the new census are quite right to point out that S-issue copies clearly circulated in Britain as well as on the Continent, and that Smith distributed some B-issue copies in addition to those under his name. Adding more S-issue copies certainly expands our understanding of *Principia*'s distribution and collecting, especially outside of England, but we are skeptical of Feingold and Svorenčik's related claim about how these new copies must necessarily raise our estimates of the print run overall. Indeed, notions of survival and under-reporting of copies do not have a direct bearing on print runs. The relationship between these two data points is not borne out by equivalent research into statistical modeling of survival, which finds that the size of its print run is not a measurable factor of whether or not copies of a given edition will survive.

Bibliographic explorations of 'lost' books in early modern Europe have used mathematical models to estimate the survival rate of a given edition.²³ These models intend to explore, in broad strokes, the effects of what William Blades famously described as the 'enemies of books', the natural and human elements that contribute to the destruction over time of printed books.²⁴ In a landscape of loss and survival of early printed books, *Principia* benefits from the 'bigger books linger longer' principle.²⁵ This particular way of describing how folios and books with large sheet counts tend to survive much better than more compact or ephemeral work comes, interestingly enough, from the very chapter in which Gingerich offers his *Principia*

²²Henry Sotheran & Co., *Annotated and Classified Catalogue of Rare and Standard Works on Astronomy, Comprising Chronology, Geodesy, Horology, Dialling, and Other Collateral Subjects, and Including the Library of the Late John Louis Emil Dreyer with an Appendix of the works of Sir Isaac Newton, and his Commentators, as Well as a Selection of Works From His Library* (London: Henry Sotheran & Co., 1927), p. 228. Macomber, 'Variations and Errors'. Munby, 'Distribution of *Principia*'.

²³ An excellent overview of this work appears in the contributions to Flavia Bruni and Andrew Pettegree, eds, *Lost Books: Reconstructing the Print World of Pre-Industrial Europe* (Leiden: Brill, 2016).

²⁴ William Blades, *The Enemies of Books* (London, Elliot Stock, 1888).

²⁵ Gingerich, pp. 113-144.

print run estimate. This straightforward point is borne out in all studies of survival and loss in print: expensive, sturdily constructed, and/or less portable books are less likely to be victims of incidental destruction or negligence. This is further compounded by language; Latin books, which are more likely to have scholarly or ecclesiastical content and to end up in institutional collections, also tend to survive better than vernacular works.²⁶ However, there is some indication that rates of survival change appreciably over time, which makes a good deal of sense when considering that newer books have had fewer opportunities to disappear.²⁷ Speaking broadly, quarto editions with *Principia's* sheet count have a 44 per cent chance of being lost for the 15th century, and a 24 per cent chance for the 17th century.²⁸

However, these studies are aimed at tracking the loss of *editions*, rather than loss of *copies*. They provide conjectural models for copies, of course, by extending the data further, but they are primarily designed with lost editions in mind. The likelihood of an edition's survival does not depend on its print run, though there is some suggested correlation between small print runs and high survival rates.²⁹ Changing the value for print run in edition loss equations does not have an appreciable effect on the data produced.³⁰ There is no neat equation to apply to the number of surviving copies that will say anything definitive or reliable about an edition's print run. For the purposes of this essay, scholarly work on survival is useful less for definitive counts of copies than as a lens for exploring the kinds of books that tend not to survive and those that, by contrast, survive well. The same factors that kept *Principia* from being lost can help us interpret its place in the landscape of print and think critically about what would have influenced the production decisions around its print run. Furthermore, for one of the

²⁶ Goran Proot, 'Survival Factors of Seventeenth-Century Hand-Press Books Published in the Southern Netherlands: The Importance of Sheet Counts, *Sammelbände* and the Role of Institutional Collections' in Bruni and Pettegree, eds, *Lost Books*, pp. 185-190. Neil Harris, 'Marin Sanudo, forerunner of Melzi: Parte I', *La Bibliofilia*, 95.1 (1993), pp. 22.

²⁷ See Goran Proot and Leo Egghe's work on the survival of seventeenth-century books, Proot, 'Survival Factors'; Leo Egghe and Goran Proot, 'The estimation of the number of lost multi-copy documents: A new type of infometrics theory', *Journal of Infometrics*, 1 (2007), 257-268. Goran Proot and Leo Egghe, 'Estimating editions on the basis of survivals: printed programmes of Jesuit plays in the Provincia Flandro-Belgica before 1773, with a note on the "Book Historical Law"', *The Papers of the Bibliographic Society of America*, 102 (2008), 149-174.

²⁸ Figures based on Jonathan Green and Frank McIntyre, 'Lost Incunable Editions: Closing in on an Estimate', in Bruni and Pettegree, eds, *Lost Books*, p. 65, and Proot, 'Survival Factors', p.181.

²⁹ Harris, 'Marin Sanudo, Parte I', pp. 19 n 23. Note that this is just an observable pattern, and not a reliable ratio for measuring survival, Green and McIntyre, 'Lost Incunable Editions', p. 57.

³⁰ This is very neatly demonstrated in: Proot, 'Survival Factors', pp. 161-166.

single most well-studied and well-documented books ever printed, the historical record has much to offer. The wealth of information surrounding *Principia*'s production history offers a number of useful context clues that temper the imprecision of mathematical modelling.

The absence of concrete archival evidence documenting its print run is fairly typical for early modern print. Indeed, *Principia* is distinctly atypical in the sheer amount that survives about its design and production. For the day-to-day business decisions of an early modern print shop, there are few concrete records, and figures for standard print run sizes are generally extrapolated from limited data. In addition to the incidental survival of contracts, wills, inventories, court proceedings, and the occasional personal letter, and one of the most reliable sources of print runs come from institutional commissions with limited applicability to other genres of print.³¹ The Plantin-Moretus operation, however, provides a sterling exception to this rule, and the firm's records often provide the basis for extrapolating how early modern printers and publishers ran their businesses. Edition sizes for the firm's seventeenth-century imprints show a pattern of decision making based on reams of paper, with most edition sizes falling between 1,000 and 1,500 copies, calculated in multiples of 25.³²

Recalling the ill-fated *Historia Piscium* production, it is worth pointing out that its print run reflects the lowest end of the edition sizes for Plantin-Moretus imprints. This makes good sense for a number of reasons, not just because of the more circumscribed customer base for high-level, expensive scientific books. The Royal Society adopted a publishing model that differed from major, for-profit houses like Plantin's. The English book world had operated differently from continent since the Stationers' Company was granted its formal monopoly in 1557.³³ The Stationers', and by extension London's, tight grip on production in England led to a unique model of highly centralized, highly-controlled print. The Royal Society had, beginning with its earliest ventures in publishing, set itself apart by financing its own projects. Though it was required to employ the Stationers as printers, the Society retained intellectual and financial control of the

³¹ Eric M. White, *A Census of Print Runs for Fifteenth-Century Books*, https://www.cerl.org/_media/resources/links_to_other_resources/15cprintruns.pdf, accessed June 2, 2021.

³²Proot, 'Survival Factors', pp. 165-166, n.5-6; For the Plantin firm's sixteenth-century edition sizes, Léon Voet, *The Golden Compasses: A History and Evaluation of the Printing and Publishing Activities of the Officina Plantiniana at Antwerp* (Antwerp: Routledge, 1969), v. 2, pp. 169-173. On

³³ Cyprian Blagden, 'Charter Trouble', *The Book Collector*, 6 4 (1957) 369-377. Peter W.M. Blayney, *The Stationers' Company and the Printers of London, 1501-1557* (Cambridge: Cambridge University Press, 2013).

projects.³⁴ Institutionally sponsored projects were different from printing projects undertaken by professional bookmen, especially when it came to decisions about upfront cost and saleability, critical factors in deciding a print run.

Principia was a similarly sponsored project, though funded by a single patron, Edmund Halley. What sets it apart from traditional, publisher-funded projects like *De Revolutionibus*, is its calculus of investment and profit. Books selected by printers and publishers for production were, as they are today, factored into the broader business of the workshop or company. When printers undertook large, technical, and/or esoteric books, such projects were often supported by any number of shorter, cheaper pamphlets or jobbing prints. These smaller projects helped keep a press solvent with quick profits, while waiting on the slower returns from the sale of larger books. Print runs for books selected by professional bookmen would have been determined by an understanding of the book as an investment; the choice of how much paper to expend would be weighed against the anticipated sales of the edition. However, because it was done on commission, the first edition of *Principia* functioned like a complicated piece of jobbing work for its printer, Joseph Streater. Halley hired Streater to complete a task, but Halley was not acting as a publisher in a traditional sense. While he may well have expected to realize some sort of profit or at least recoup his initial investment, based on the merits of Newton's work and a well-placed advertising campaign, *Principia* was not part of a broader network of business investments and smaller, more readily saleable printed works.³⁵

When conceptualizing decisions like how many copies ought to go to press, we have to consider Halley's financial commitment and personal agenda, rather than an understanding of 17th century printers' common business practices. Like the majority of the Royal Society's membership, with the notable exception of Robert Hooke, Halley was a gentleman.³⁶ However, among the Society's Fellows, Halley was a man of relatively modest means.³⁷ In 1686 when he undertook funding for *Principia*, he was

³⁴ Adrian Johns, *The Nature of the Book: Print and Knowledge in the Making* (Chicago: University of Chicago Press, 1998), pp. 462-465.

³⁵D.T. Whiteside even makes the claim that Halley turned a profit on *Principia*, but we ought to re-visit that claim in light of the cost of Newton's numerous corrections and re-prints over the course of production. Whiteside, 'The Prehistory of the Principia', pp. 59-61.

³⁶Johns pp. 467-472.

³⁷Angus Armitage, *Edmond Halley*, (London: Nelson and Sons, 1966), pp. 44-45, 48-49 ; Richard S. Westfall and Gerald Funk, 'Newton, Halley, and the System of Patronage', in Norman J.W. Thrower, ed., *Standing on the Shoulders of Giants* (Berkeley: University of California Press, 1985), pp. 3-4, 9-10, 12-13c n. 1. Eugene Fairfield Pike, *Hevelius*,

enmeshed in ongoing legal troubles stemming from the settlement of his fathers' estates.³⁸ Even if he was seeking a profit, larger print runs required a larger initial investment, which would have eaten even further into Haley's limited and legally contested annual income. A rough estimate, based on the cost of paper and printing for *Historia Piscium* and a print run of 500, puts *Principia* at a cost of about 62 pounds, not considering expenses incurred for the comet plate, the woodcut diagrams, or the cost of Halley's well-placed advertisements.³⁹ This was within Halley's means, but certainly tested the limits of his income.⁴⁰ Furthermore, in the case of *Principia*, the desire to avoid the Stationers' 'combinations' was more about intellectual control over the text itself than the business potential of unregulated publishing.⁴¹ Intellectual control was a major motivator of self-publishing and other forms of privately-funded publishing, especially for works with a circumscribed audience, much like the motivations behind the Royal Society's own publishing program.⁴² Therefore, it seems highly unlikely that Haley would have paid for a run of more than 500 copies.

Flamsteed and Halley; Three Contemporary Astronomers and Their Mutual Relations (London: Taylor and Francis, 1937), pp. 36, 45.

³⁸These are well-described in Alan Cook, "Edmond Halley and Newton's *Principia*" *Notes and Records of the Royal Society* 45(2) (1991) pp. 129-138. Records of the legal disputes surrounding Halley's father's estates are held in the Chancery Court records at the National Archives.

³⁹The letterpress text for *Historia Piscium* amounts to 99 sheets, and the Society paid 45 pounds 5s for paper and 51 pounds 16s 6d for printing. Kusakawa, '*Historia Piscium*', pp. 191-192. Such a price is, as has been noted by Cook and Whiteside, consistent with the 5s price for a copy in unbound sheets. Cook, '*Halley and Principia*', p. 133, Whiteside pp. 60-61.

⁴⁰Information is patchy regarding what supplemental income Halley had in addition to his father's estates, but *Principia* may have represented as much as a third of his annual income. Cook, '*Halley and Principia*', pp. 133-135.

⁴¹Isaac Newton, *Correspondence* (Cambridge: Royal Society, 1959-1977), v. II, p. 482.

⁴²On general self-funded scholarly publishing: Ian Maclean, *Scholarship, Commerce, Religion*, pp 48-50. Authorial acquisition of privileges began as early as the first privileges themselves, see Elizabeth Armstrong, *Before Copyright: The French Book-Privilege System 1498-1526* (New York: Cambridge University Press, 1990). In publishing genres with niche audiences: there are numerous examples: for composers self-publishing music in response to declining interest from commercial publishers, including similar cases where self-publishers partnered with booksellers to sell finished books, see Stephen Rose, 'The Composer as Self-Publisher in Seventeenth-Century Germany', in Erik Jkellberg, ed., *The Dissemination of Music in Seventeenth-century Europe* (Bern: Peter Lang, 2010), pp. 239-58. We also see a rush of self-published science once restrictions against it were lifted in France, see Marie Felton, 'The Case of Self-Publishing Science Amateurs and their Quest for Authority in 18th-Century Paris: An Introduction to "Fringe Science in Print: Authority, Knowledge, and Publication, 16th-19th Century"', *Mémoires du livre*, 6.1 (2014), pp. 4, 7.

The consuming audience for *Principia* would have looked very different than it would have for *De Revolutionibus*. In the middle of the 16th century when Copernicus's book came off the press, word of the book spread largely through two avenues – the book fairs and their attendant catalogs/advertisements, as well as through the correspondence networks of mathematicians and astronomers throughout Europe. As a result of these informal networks, a number of prominent mathematicians and astronomers all praised or adopted Copernicus's argument, such as Michael Maestlin, and Erasmus Reinhold.⁴³ The market for such a technical book was poorly identified, and was largely sold through word of mouth among those scholars whose work overlapped with Copernicus.

In contrast, *Principia* arrived in a very different consumer context. At the time of its publication, two notable scientific academies existed: the Royal Society in London and the Académie des Sciences in Paris. Though the members of these societies would not describe themselves as scientists, the activities of these (and later allied societies) codified and popularized what we today know as the scientific method. Indeed, the most obvious signal for this is the motto for the Royal Society: *Nullius in Verba*, or 'Take nobody's word for it'. At their second meeting on 5 December 1660, members of the as yet unnamed Royal Society agreed that their aim would be 'to consult and debate concerning the promoting of experimental learning.'⁴⁴ Observation and experimentation were key, and those involved formed the first group of what we today call scientists. Twenty-seven years after the founding of the Society, it had grown to 153 fellows, among them Isaac Newton and Edmond Halley.⁴⁵ Outside of these societies, a number of journals that dealt with science in depth either as their main focus or as one of a part of areas dedicated to scholarly pursuits existed in 1687 that did not exist in 1543. The Royal Society's own *Philosophical Transactions* was preceded by *Acta Eruditorum* and these were joined in 1686 by *Bibliothèque Universelle et Historique*. The existence of these journals and societies presented a much more obvious consuming and promotional group for challenging mathematical and scientific works, and also created new networks for the promotion of works of that ilk.

Furthermore, the publication and promotional structures for the two books were different. As Gingerich recounts, the printing and publication of *De Revolutionibus* was the result of a joint effort of a somewhat reluctant

⁴³ Gingerich, *The Book Nobody Read*, pp 154–159, 53–54.

⁴⁴ Thomas Birch, *The History of the Royal Society of London for Improving of Natural Knowledge* (London: Printed for A. Millar, 1756–1757), v. 1 p. 5.

⁴⁵ Michael Hunter, *The Royal Society and its Fellows, 1660–1700* (Chalfont St Giles: British Society for the History of Science, 1982), 112.

Copernicus, Georg Rheticus and Johannes Petreius.⁴⁶ In this arrangement, the publisher (Petreius) bore the bulk of the capital costs associated with the production of the book, and was also responsible for its marketing and distribution. Outside of the informal praise through communication networks, *De Revolutionibus* had no professional promotional apparatus beyond the book fairs Petreius participated in. In marked contrast is the title page of *Principia*: ‘Imprimatur S. Pepys, Reg. soc. præses.’ It was published under the official printed imprimatur of the Royal Society, whose president’s name is printed on the title page. One would be hard pressed to find a more forceful endorsement and recommendation of a scientific work of the time. The Royal Society, thanks to its *Philosophical Transactions*, was the preeminent learned scientific society of the time, and its obvious sponsorship and approval of the book bore great weight. As mentioned above, Edmond Halley paid for the production of the work, and penned a dedicatory poem at the beginning of the work, lending even more gravitas to *Principia*. *De Revolutionibus* lacked these promotional structures, further obviating the differences between the production of the two books.

This essay is both an examination of the first edition of *Principia* and a tacit reminder that book history and bibliography is foundational to any discussion of first editions, and to any durable census of books. These are disciplines practiced and studied by individuals within and without the academy, with a diversity of backgrounds and education. We stand ready – as equal partners in this work – to lend our expertise and experience to scholarship that engages with books as material objects. Our essay is a reminder that bibliography and book history must be central to any discussion of books as material objects, and that this field has its own body of scholarship to draw on. In the case of *Principia*’s likely print run, bibliographic research gives us models to yield better estimates, and a deeper understanding of their value. The present essay lays this bare. While there is no issue or quarrel with the quality of Feingold’s mastery of the life and impact of Isaac Newton, a lack of attention to research on book production, survival, and collecting limits the quality and usefulness of an otherwise promising census project. Thoughtfully, Feingold and Svorenčik issue an open call for dialogue around their recent census, which we hope this essay will be a part of. We argue against the expansion of the estimation of copies in the first edition of *Principia*, and conclude that Munby’s assertion of 500 copies in the first edition is likely correct.

⁴⁶ Owen Gingerich, *An Annotated Census of Copernicus' De Revolutionibus* (Boston: Brill, 2002), XII–XV.

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