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ABOUT THE COVER: ISAAC NEWTON, FATIO DE DUILLIER, AND ALCHEMY

GERALD L. ALEXANDERSON

To call Nicolas Fatio de Duillier colorful is an understatement. One of Newton's biographers, A. Rupert Hall, described him as unstable, a word that is probably more common in the 21st century than it was in the 17th. Others have called him a genius, a hypochondriac, an adventurer, a flatterer, and a sycophant.

A member of a minor aristocratic family in Switzerland, Fatio (sometimes written Facio or Faccio) was born on February 16, 1664, in Basel, two years before Newton's *annus mirabilis* during which he did major work in gravitation, mechanics, optics, and the calculus. Fatio exhibited precocious scientific talent by the age of 17 when he was communicating his theories and findings to scientists in Paris and other centers of learning. Having the means to travel, he set off to meet Christiaan Huygens in Amsterdam, G. W. Leibniz in Hanover, and the Marquis de l'Hôpital in Paris, all of whom were impressed. To add to his adventures, he learned of a plot by agents of Louis XIV to abduct William of Orange, the Dutch prince who would later become King William III of England, Ireland, and Scotland. Fatio informed the English of the plot and thereby paved the way for his being welcomed warmly to London in 1687, the year Newton published his masterpiece, the *Philosophiae Naturalis Principia Mathematica*. By then Fatio's scientific reputation had preceded him, so the following year, at the age of 24, he was made a member of the Royal Society. It was a remarkable achievement for one so young. (Newton had to wait for this honor until he was 30.)

An ardent admirer of the work of Newton, Fatio soon became one of the group of young mathematicians and scholars who gathered around the "master", but he quickly rose to a favored rank among them, leaving William Whiston, Samuel Clarke, John Locke, and others behind. In 1666 Newton, at the comparable age of 24, had enjoyed his *annus mirabilis*. So in some ways their stories were similar, separated in age by just 22 years. One authority on Newton, Frank Manuel, wrote that "Newton and Fatio had much in common: mathematics, astronomy, classical erudition, exposition of prophecy, alchemical mysteries, the concoction of remedies,

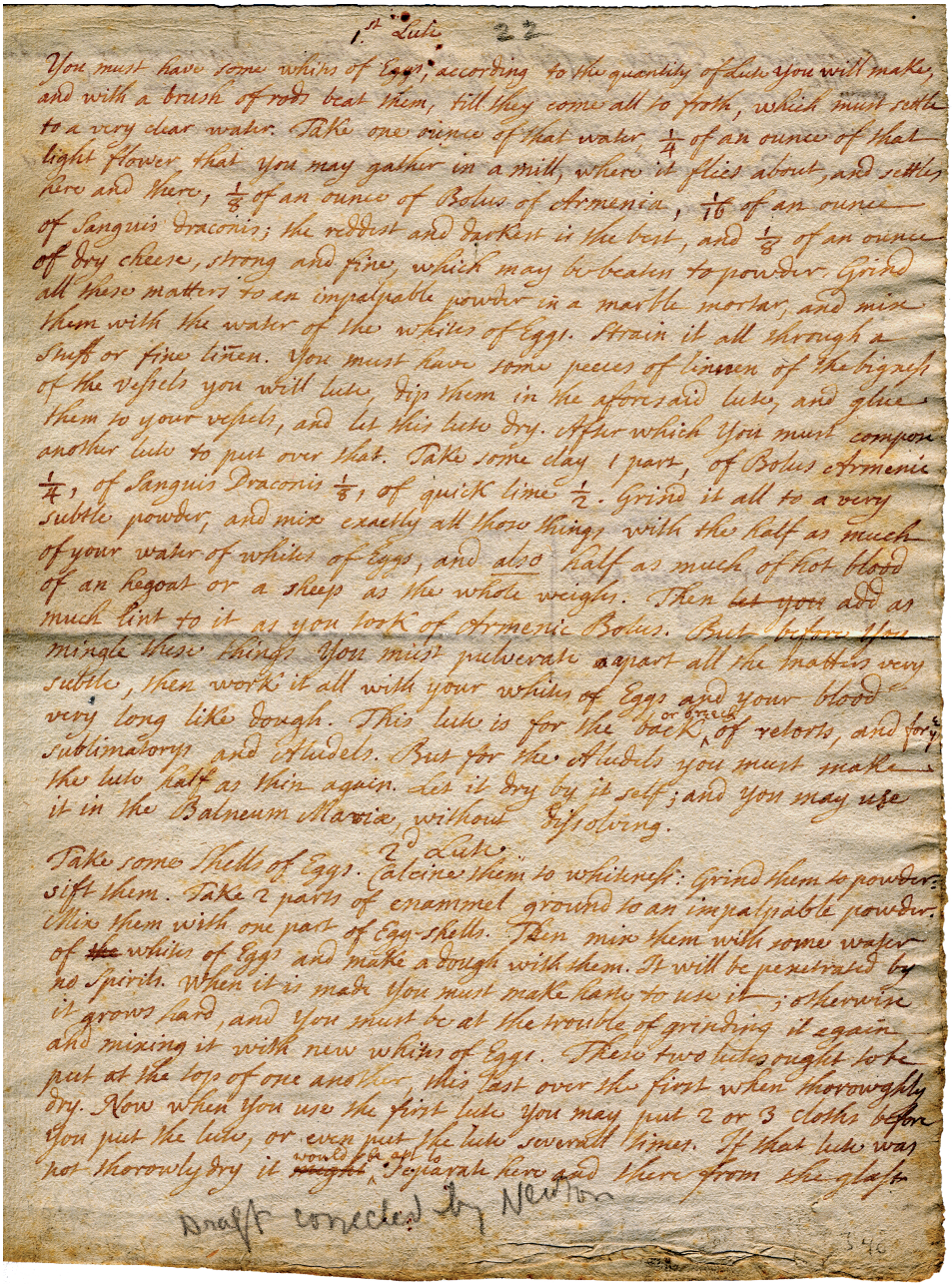
perhaps the elixir of life, a mechanical aptitude, even an interest in apples—Fatio later wrote a treatise on pomiculture which appeared with the imprimatur of the Royal Society" [3, p. 194]. (Did the interest in apples derive from the almost certainly spurious account of the falling apple?) Just how much of the list of common interests was contrived by Fatio to ingratiate himself to Newton we cannot really know.

Fatio's close relationship with Newton was enhanced early on by his devotion to the work in the *Principia*, which he widely championed. Much later he was a key figure in stirring up the priority dispute between Newton and Leibniz over the discovery of the calculus, though at times he boastfully claimed that his own versions of the theories were superior to Newton's. Fatio pointed out that Newton considered only the mechanics of gravitation whereas he attempted to explain the *cause* of gravitation. As early as 1690 Fatio expected to be chosen by Newton to produce the second edition of the *Principia* and was no doubt disappointed to learn that Newton had chosen Roger Cotes instead [2, pp. 298-99].

Both were interested in the interpretation of Biblical prophecy. Newton wrote two books on the subject, both published posthumously: *The Chronology of Ancient Kingdoms Amended* (1728) and *Observations Upon the Prophecies of Daniel and the Apocalypse of St. John* (1733). Fatio is reported to have believed that in reading prophecy one could interpret the serpent in Eden to be the Roman Empire, with Adam corresponding to the clergy and Eve the Church [1, p. 347]. As in the case of other potentially controversial ideas, Newton often remained circumspect, Fatio reckless. The 4th century Arian heresy of regarding Christ as someone created by God contradicted the doctrine of the Trinity. As early as 1673, Newton came to the conclusion that the idea of the Trinity was itself heretical and later at least two of his associates, Fatio and Whiston, defended unitarianism, the idea of one God, not the tripartite God of the Trinity [1, p. 470]. In 1710 Whiston, who had succeeded Newton as Lucasian Professor at Cambridge when Newton was made Warden of the Royal Mint, was expelled from his professorship for being a unitarian. (It is ironic that with such doubts about the Trinity, Newton should spend his career at Trinity College, Cambridge.)

For Newton a greater commitment was to alchemy. There has been much written on Newton's work in this area, including an hour-long *NOVA* program on television, "Newton's Dark Secrets". Newton, though dabbling in alchemy over many years, was nevertheless guarded about admitting to it. In fact, he criticized Robert Boyle for his lack of caution in carrying on alchemical experiments [3, p. 196]. Fatio knew about Newton's interest in alchemy as early as 1689, though others claimed to know of it as early as 1675. Manuel quotes a 1693 description by Fatio of an alchemical experiment in colorful terms: "If You be curious Sir of a metallick putrefaction and fermentation which lasts for a great while and turns to a vegetation producing a heap of golden trees, with their leaves and fruits I can acquaint you with it having seen it and having been told by the owner how he made it." He continues with vivid details of the transformation of the materials [3, p. 188].

The much less dramatic document shown on the cover and in Figure 1 is in Fatio's hand (with autograph corrections by Newton) ca. 1693 and reads in part: "You must have some whites of Eggs, according to the quantity of Lutes [there are two separate lutes described] you will make, and with a brush of rods beat them, till they come all to froth, which must settle to a very clear water. Take one


1st Lute 22

You must have some whites of Eggs, according to the quantity of Lute you will make, and with a brush of rods beat them, till they come all to froth, which must settle to a very clear water. Take one ounce of that water, $\frac{1}{4}$ of an ounce of that light flower that you may gather in a mill, where it flies about, and settles here and there, $\frac{1}{8}$ of an ounce of Bolus of Armenia, $\frac{1}{16}$ of an ounce of Sanguis draconis; the reddest and darkest is the best, and $\frac{1}{8}$ of an ounce of dry cheese, strong and fine, which may be beaten to powder. Grind all these matters to an impalpable powder in a marble mortar, and mix them with the water of the whites of Eggs. Strain it all through a stuff or fine linen. You must have some peeces of linnen of the bignes of the vessels you will lute, dip them in the aforesaid lute, and glue them to your vessels, and let this lute dry. After which You must compose another lute to put over that. Take some clay 1 part, of Bolus Armenic $\frac{1}{4}$, of Sanguis Draconis $\frac{1}{8}$, of quick lime $\frac{1}{2}$. Grind it all to a very subtle powder, and mix exactly all those things with the half as much of your water of whites of Eggs, and also half as much of hot blood of an hegoat or a sheep as the whole weighs. Then ~~let your~~ add as much lint to it as you took of Armenic Bolus. But before You mingle these things You must pulverize apart all the matters very subtle, then work it all with your whites of Eggs and your blood very long like dough. This lute is for the back or brest of retorts, and for Sublimatorys and Cucurbits. But for the Cucurbits you must make the lute half as thin again. Let it dry by it self; and You may use it in the Balneum Mariæ, without dissolving.

2d Lute

Take some Shells of Eggs. Calcine them to whiteness: Grind them to powder: sift them. Take 2 parts of enammel ground to an impalpable powder. Mix them with one part of Egg-shells. Then mix them with some water of ~~the~~ whites of Eggs and make a dough with them. It will be penetrated by no Spirits. When it is made You must make haste to use it; otherwise it grows hard, and You must be at the trouble of grinding it again and mixing it with new whites of Eggs. These two lutes ought to be put at the tops of one another, this last over the first when thorowghly dry. Now when You use the first lute You may put 2 or 3 cloths before You put the lute, or even put the lute severall times. If that lute was not thorowly dry it ~~might~~ would fly off to pieces here and there from the glass

Draft corrected by Newton

Figure 1. Fatio de Duillier alchemy manuscript with corrections by Isaac Newton

ounce of that water, one fourth of an ounce of that light flower [sic] that you may gather in a mill, where it flies about, and settles here and there, one-eighth of an ounce of Bolus of Armenia [Armenian clay], one sixteenth of an ounce of Sanguis Draconis [Dragon's Blood]; the reddest and darkest is the best, and one eighth of an ounce of dry cheese... Grind all these matters to an impalpable powder in a marble mortar...". And so it goes on and on. Other ingredients are quick lime, "hot blood of an hegoat or a sheep", enammel [sic], and Shells of Eggs. The outcome of all this mixing and grinding is not clear, but on the other side of the document, along with the signature of Nicolas Fatio de Duillier is a reference to Teguy [France] "where they dig out some excellent Antimony". I acquired this manuscript from the venerable London bookseller Pickering and Chatto in 1984. It is of no mathematical interest, but it displays the kind of alchemical experimentation going on at that time and makes one wonder why Newton spent his time on it.

Lest we be too quick to judge Newton and his contemporaries, however, we should keep in mind that we know a lot more about chemistry than did Newton and his friends. And we should not be too smug; many college students even now read their horoscopes every morning when planning their day.

The date of the manuscript was a critical year for Newton and for Fatio. In September 1692 Fatio was living in London, and he wrote to Newton that he had a lung infection that was not responding to treatment and he feared that he "had almost no hopes of seeing You [Newton] again". This was followed by an account in grim detail of his "feaver" and the state of his pulse, and he wrote of his "depart[ing] this life". Newton was highly distressed and promptly offered to send money, along with advice about physicians. Newton's reaction was out of character; he usually did not express such personal concern for anyone. Newton tried to convince Fatio to move back to Cambridge—the air was better than the air in London—and even went to London to see him. The relationship between Newton and Fatio has been the subject of considerable speculation [4, p. 438]. Newton appeared to enjoy Fatio's company but at the same time worried about Fatio's impetuous behavior. Michael White seems to sum it up neatly by claiming that Fatio was Newton's "scientific son" [5, p. 246].

Fatio soon wrote, however, that he was feeling better. It turns out that Newton need not have worried so much; Fatio went on to live for another 61 years!

Newton, by contrast, began in the fall of 1693 to complain about his own health, and for the remainder of the year he seemed to suffer a general breakdown. At about that time Fatio, having learned of the death of his mother, was writing to Newton to say that he was thinking of returning to Switzerland to collect his inheritance. There he planned to study medicine and become a doctor. This too distressed his mentor. Newton recovered, however, and went on with his work. Fatio did not pursue a career in medicine. Their last surviving letters concerned alchemy—a process for purifying mercury [1, p. 348]. Before that they corresponded occasionally though Fatio became increasingly erratic and involved with the Camisards, a radical group of mystics related to the Huguenots who had come to England from France following the Edict of Nantes. Like so many before and since, they prophesied the imminent end of the world. The political unrest they generated was supported by Fatio and it led to his conviction in 1707. He was publicly humiliated by being arrested and placed in pillories in Charing Cross and at the Royal Exchange. Among other Newton disciples Whiston was soon to be in trouble, but Samuel Clarke seems to

have avoided this episode, though he too held to some possibly heretical, or at least impolitic, ideas. Voltaire once remarked that Clarke would have made a great Archbishop of Canterbury, had he only been a Christian [2, p. 319].

Just as Copernicus had claimed that some of his discoveries had been known to Pythagoras, Newton may have had some such claim himself. Fatio claimed to Huygens that Newton believed that the inverse square law of gravitation had been known to Pythagoras and Plato. Of course behind this may have been the idea that it was safer politically to claim that he was not discovering new theories, only rediscovering things known in classical times. Fatio encouraged Newton in this notion [2, p. 346].

After Fatio's disgrace in the pillory, he retired to the country where he continued to write from Worcester until his death on May 12, 1753. (Newton had died in 1727.) There is little evidence that Fatio and Newton actually met again during the years after Newton took up his assignment of Warden (and later Master) of the Royal Mint in 1696, though Fatio continued to participate in the Newton-Leibniz priority controversy until 1700. In 1706 Newton acquiesced to the election of Fatio's brother John to the Royal Society [1, p. 469]. Meanwhile, Fatio spent his time developing a method for using rubies instead of some metal parts in watches (ever the Swiss watchmaker), and Newton acquired two of these new timepieces. In 1713 the long-delayed second edition of the *Principia* finally appeared, three years before Leibniz's death and fourteen before Newton's. In this edition recognition of Leibniz as co-discoverer of the calculus had largely disappeared and Roger Cotes, another of Newton's protégés, in his preface denounced Leibniz as a "miserable reptile". Fatio's campaign had paid off.

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Department of Mathematics and Computer Science, Santa Clara University, 500 El Camino Real, Santa Clara, California 95053-0290

E-mail address: galexand@math.scu.edu