Formal matters

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How to construct a poem: Descartes, Sidney

Shankar Raman

This chapter explores the intimate bonds in early modern Europe between the premier science of forms, geometry, and the premier art of forms, poetry. Their connection becomes especially evident in how these seemingly disparate (at least for us) domains re-envisage the relationship of form to content, inventing shapes to fit their specific concerns. I seek here to identify parallels that bespeak a broad, shared cultural response across the sixteenth and seventeenth centuries to an inherited Greek tradition, strongly marked by Aristotelian thought, in which the relation between what Sir Philip Sidney would call 'manner' and 'matter' played a fundamental role. My argument brings René Descartes and Sidney together as two key figures whose contributions to the theory and practice of mathematics and poetry respectively reveal vividly both the nature of this response and its implications for early modern selves and the worlds they sought to make.

Since the breadth of poetry's social and cultural aspirations may seem more immediately apparent than that of mathematics, let me begin with bolstering the case for the latter. The opening of Descartes's 1637 *Discourse on Method* outlines an emerging and influential conception of what it means to be rational:

> Common sense [*le bons sens*] is the most equitably divided thing [*la mieux partagée*] in the world, for everyone believes he is so well provided with it that even those who are the hardest to please in everything else usually do not want more of it than they have. It is not likely that everyone is mistaken in this matter; rather, this shows that the power to judge correctly and to distinguish the true from the false – which is, strictly speaking, what we mean by common sense or reason [*la raison*] – is naturally equal [*égale*] in all men. Hence the diversity of our opinions arises, not because some of us are more reasonable [*raisonnables*] than others, but only because we direct our thoughts along different paths, and consider different things. For it is not enough to have a good mind [*l'esprit bon*]; the principal thing is to apply it correctly [*bien*].[1]

A few features evident in these remarks are worth noting: first, the identification of reason with common or good sense and reasonableness; second, the postulate of a rational capacity presumed to be equally distributed, differences being ascribed on the basis of how this capacity is applied; and, finally, the characterization of rational capacity as power of good judgement, one able to distinguish the true from the false – indeed, as we shall see, Descartes will seek to re-articulate the very criteria for truth and intelligibility.

For our purposes it is necessary to recall that the *Discourse* was originally a prefatory text to three scientific treatises. While usually published (and discussed) today as a freestanding work, it first appeared with the *Optics* [*La Dioptrique*], the *Meteorology* [*Les Méteores*] and the *Geometry* [*La Géométrie*]. Its overarching claims about the right way to use one's reason thus envelop these more specific studies. For Descartes's mathematical exposition in particular, the making of geometrical space is closely allied with producing the forms of rationality implied by the passage cited above. And this coupling in turn demands re-forming selves in ways that make them adequate to these new demands. This dual emphasis takes us beyond the more narrowly technical achievements of early modern mathematics, underlining the extent to which a now recognizably modern scientific thinking was bound up from the very outset with ethical considerations in Aristotle's sense of the word, that is, with how human beings act in the world or behave towards others and themselves. Descartes's *Geometry* was never only a signal achievement in the history of mathematics – though it was this too. Its specifically mathematical dimensions are intertwined with the ethical question of how a geometer ought to *do* geometry, how he should comport himself as mathematician towards the nature of the mathematical objects that are his concern.

The connections between how one does mathematics and the making of things and selves through mathematics become yet broader when we consider the extent to which such reformation was understood through the (renovated) Aristotelian lens of *poesis* or making, a term that took on renewed significance in a range of early modern intellectual domains, including literature. An apt literary analogue may be found in a seminal (for the English context at least) sixteenth-century work of literary criticism, in which the assertion of the poet as maker takes centre stage: Sir Philip Sidney's *Defence of Poesy* (or *An Apology for Poetry*). In a moment that has not drawn much commentary,[2] Sidney defends comedy's predilection to imitate 'the common errors of our life' by drawing a parallel with mathematics:

> Now, as in geometry, the oblique must be known as well as the right, and in arithmetic, the odd as well as the even: so in the actions of our life, who seeth not the filthiness of evil, wanteth a great foil to perceive the beauty of virtue. This doth comedy handle so in our private and domestical matters, as with hearing it, we get, as it were, an experience [of] what is to be looked for.[3]

Sidney posits a curious equivalence between knowing obliqueness or oddness in mathematics and the poetic creation of images of evil: just as we need to understand the odd to perceive the even, the oblique to see the straight (or, as his resonant pun has it, 'the right'), so to do the 'actions of our life' demand poetic images of evil if virtue is to be visible.

But these images do not simply reflect the external world, for the *Defence* amplifies throughout what is already an undercurrent in the Aristotelian notion of *mimesis*: that imitation is itself a generative process, a making. When Sidney defines Aristotlean *mimesis* as 'a representing, counterfeiting, or figuring forth: to speak metaphorically, a speaking picture' (217), each additional term in this concatenation of definitions enlarges the ambit: from re-presenting of what is already there, to making something 'against' what is there, to drawing out a new figural reality. The two senses of mimetic production remain in tension in the *Defence*: on the one hand, the poet as a 'maker,' as in the famous early assertion that the poet 'disdaining to be tied to any such subjection [to nature], lifteth up with vigour of his own invention, doth grow in effect another nature in making things better than nature bringeth forth, or quite anew, forms such as never were in nature' (216); and, on the other hand, the poet as mere 'imitator' who 'counterfeit[s] only such faces as are set before' him (218), and 'deliver[s] to mankind' only that which has 'the works of nature for his principal object' (215–216).[4]

That Sidney should educe mathematical analogies in discussing how comedy functions to produce both knowledge and experience of the moral is by no means accidental, given the sustained interest in geometry documented in the poet's correspondence with his friend and preceptor Hubert Languet as well as his brother Robert.[5] The implications of 'making' or *poesis* teased out by Sidney spill over in the early modern period to the kind of knowledge that comes to characterize mathematics, whereby knowing its 'truths' becomes not simply a matter of discovering or imitating what is already there but increasingly that of *producing* those truths. David Lachterman's assertion about modernity in *The Ethics of Geometry* is worth stressing here: modernity's 'thinly-disguised "secret,"' he says, is 'the willed or willful coincidence of human making with truth or intelligibility.'[6]

Such an attitude is central to Cartesian geometry, contributing signally to the alteration in how mathematics was practised and understood in the early modern period. Conversely, the emerging mathematical attitude to which Descartes gives especially clear expression may already be glimpsed in the theory and practice of poetry espoused by Sidney. The implication of these claims is not, of course, that Sidney was a Descartes *avant la lettre*. Rather, I suggest that the commonalities and intersections in their approaches to their respective *métiers* reveal the changing contours of a conceptual terrain shared by mathematics and poetry before the two cultures. The intellectual currents these two practitioners so capably navigated had not yet been entirely divided. Their own contributions not only reveal the prevailing pressures of the tides but signal distinctively new destinations, mathematical and poetic, that reflect one another.

Two ways of completing the square: al-Khwarizmi and Descartes

To flesh out the renewed importance of *poesis* or making to the geometrical project, I would like to compare two approaches to what is essentially the same problem: that of solving a quadratic equation by 'completing the square' (described below). The first derives from a foundational Arabic mathematical treatise that builds on

Euclidean principles, *The Algebra of Al-Khowarizmi*. Written by the great ninth-century Arab mathematician Mohammed ibn Musa al-Khwarizmi, the work became available in the European world through its twelfth-century Latin translation by Robert of Chester. (Complicating this chain of transmission further, I will cite a twentieth-century translation of the Latin text.)[7] Descartes's 1637 *Géométrie* adopts a very different approach, one that has been credited with inspiring the modern mathematical domain of analytic geometry.[8] Both works proffer an algebraic problem set alongside its geometrical rendition, and I will be considering here the manner in which each text achieves its solution as well as the relationship it posits between algebra and geometry. I pick these two examples precisely because what we might call their 'truth value' is the same. Descartes's discussion of quadratic equations is not distinguished from al-Khwarizmi's by the nature of the problem and nor does his solution really mark a technical advance over what his ancient and medieval predecessors had achieved. What is new in the *Géométrie*'s approach is how it represents the problem. In Lachterman's words, at issue is 'the source of the intelligibility of the figure (or statement)' as such. Thus, the crucial distinction concerns the mode of knowing, which in turn 'entails a difference in the mode of being' of what may otherwise seem identical mathematical insights.[9]

In the fourth chapter of his treatise, al-Khwarizmi proposes finding the numerical value of a 'root,' that is, of an unknown quantity, when 'squares [of that root] and roots are equal to numbers.' The general case is represented through a specific instance. 'The question therefore in this type of equation,' he says, 'is as follows: what is the square which combined with ten of its roots will give a sum total of 39' (71). It is easier for us to understand al-Khwarizmi's *modus operandi* if we translate his verbal description into modern algebraic notation. But I should emphasize that to do so is already to distort the text, since one of its distinctive features is precisely that the problem is stated in prose, eschewing mathematical formalization. Throughout, problems and solutions are posed in everyday language and use determinate numbers rather than algebraic symbols. These features reflect al-Khwarizmi's ontological presuppositions: mathematical objects, such as numbers or geometrical shapes, are in an important sense real objects; their existence is of the same order as ours. Thus, for example, numbers are always positive. There is no conception here of such a thing as a negative number – to be a thing is, after all, to have a positive existence.

At any rate, with this caveat in mind, let us nonetheless translate al-Khwarizmi's narrative into symbolic notation. If we represent our 'root' or unknown by z, we are being asked to uncover its numerical value, given the following equation:

$$z^2 + 10z = 39 \tag{1}$$

In order to do so, al-Khwarizmi tells the reader how to complete the square. And this is one way we might do it today. Consider the square of $(z + 5)$, which we arrive at by multiplying the expression by itself.

$$(z + 5)^2 = (z + 5)*(z + 5) = z^2 + 5z + 5z + 25 = z^2 + 10z + 25 \quad (2)$$

Now, from the original equation (1), we know that $z^2 + 10z = 39$. Consequently, $(z + 5)^2$ must equal $39 + 25$, that is, 64. In short, by adding 25 to each side of the original equation we can 'complete the square' to get a numerical value for the expression $(z + 5)^2$ in (2) above. So, if, $z^2 + 10z = 39$ then

$$(z + 5)^2 = 64 \quad (3)$$

If we now take the square root of each side of this equation, we get

$$z + 5 = \sqrt{64} = 8 \quad (4)$$

and subtracting 5 from each side of this equation yields $z = 3$, producing a determinate value for the 'root' z.

As we shall shortly see, this logic can be applied in virtually the same manner to the problem that Descartes's *Geometry* will pose. But for the moment, let us linger with al-Khwarizmi. Notably, our Arab mathematician does not seek to explain algebraically – as I have done above – why completing the square yields the correct result. Instead, the statement of the problem is followed immediately by a description of procedure:

> The manner of solving this type of equation is to take one-half of the roots just mentioned. Now the roots in the problem before us are 10. Therefore take 5, which multiplied by itself gives 25, an amount which you add to 39, giving 64. Having taken then the square root of this, which is 8, subtract from it half of the roots, leaving 3. The number three therefore represents one root of this square, which itself, of course, is 9. (73)

What al-Khwarizmi provides is a step-by-step route to the desired solution – it is fitting, then, that the word *algorithm* derives from his name. As his many examples later in the book suggest, such instructions make the mathematical 'truth' operational by allowing them to be applied to mercantile transactions, the dividing of estates, and so on. However, explanatory force does not lie in algebra itself. The truly mathematical domain is not that of application but that of demonstration.

That privilege belongs to geometry alone. Corresponding to each of Al-Khwarizmi's algorithms is a set of geometrical diagrams aimed at proving the validity of the algebraic procedure – and, once legitimated thus, the method is freed as a practical technique useful for everyday life. Thus it is that the treatise soon recognizes that it has 'said enough … so far as numbers are concerned' about different types of quadratic equations, and, in the interests of verification, signals the turn to geometry: 'Now, however, it is necessary that we should demonstrate geometrically the truth of the same problems which we have explained in numbers' (77).

The 'proof' of the equation discussed above is ingenious, and testifies to the authoritative power of Euclidean geometry as an enduring model for establishing mathematical truth.[10] To this end, al-Khwarizmi first seeks to represent the terms on the left-hand side of original equation – that is, $z^2 + 10z$ – spatially. The term z^2 can simply be visualized as the area of square with side z, as in the upper part of Figure 10.1. To add to this square an area corresponding to $10z$, al-Khwarizmi attaches four rectangles, each of which takes one side of the square as its longer side and one-fourth of ten as its shorter (see the lower part of Figure 10.1). That is, each constructed rectangle has an area of $2.5*z$, and the four taken together yield the requisite term $10z$ of the original equation. The resulting figure 10.1 (lower) thus represents $z^2 + 10z$ geometrically, and its total area is 39, in accordance with the original equation.

Finally, we simply complete the square of figure 10.1 (lower), by filling in the four small squares at each corner (see Figure 10.2). The side of each of these squares is the same as that of the rectangle to which it is adjoined, namely, 2.5. Consequently, the area of each small square is 6.25, and the combined area of all four is 25. Recalling that the area corresponding to $z^2 + 10z$ – represented by the diagram in Figure 10.1 (lower) – is 39, the area of the completed square in Figure 10.2 must be $39 + 25$, that is, 64, which means in turn that the completed square has a side of 8. A quick look at Figure 10.2 shows that this side comprises the side of the original square of Figure 10.1 (upper) plus two of the sides of the small squares used to complete Figure 10.1 (lower), that is to say, the completed square has a side whose length is $z + 5$. Therefore we can see that is $z + 5 = 8$, and it follows that $z = 3$.

Al-Khwarizmi's figure is not particularly complicated in its execution. Nonetheless, it is worth dwelling briefly here on the complex status of such diagrams. As commentators have noted, mathematical drawings are prey in the Platonic tradition to a more general suspicion regarding images. Although mathematicians 'make use of the visible forms and talk about them,' says Socrates in *The Republic*,

> they are not thinking of them but of those things of which they are a likeness, pursuing their inquiry for the sake of the square as such and the diagonal as such, and not for the sake of the image of it which they draw … The very things that they mould and draw, which have shadows and images of themselves in water, are treated in their turn as only images, but they really seek to behold those realities that can be seen only by the mind. (510d–511a)[11]

According to Reviel Netz, by using particular visual instantiations to illustrate general mathematical propositions, Greek diagrams seek to convey the structure or topology rather than the visual appearance of the proposition under investigation.[12] Consequently, the diagram has minatory function; it seeks to block the viewer's treating the image as an accurate visual rendition of the mathematical configuration, directing focus away from sense perception and towards the intelligible. After all, geometry is, in Socrates' words, 'the knowledge of that which always is, and not of a something which at some time comes into being and passes away'[13] (527b). What matters, then, if I may put it thus, is not the visible matter of the image but the ideal mathematical object, which the diagram merely resembles.

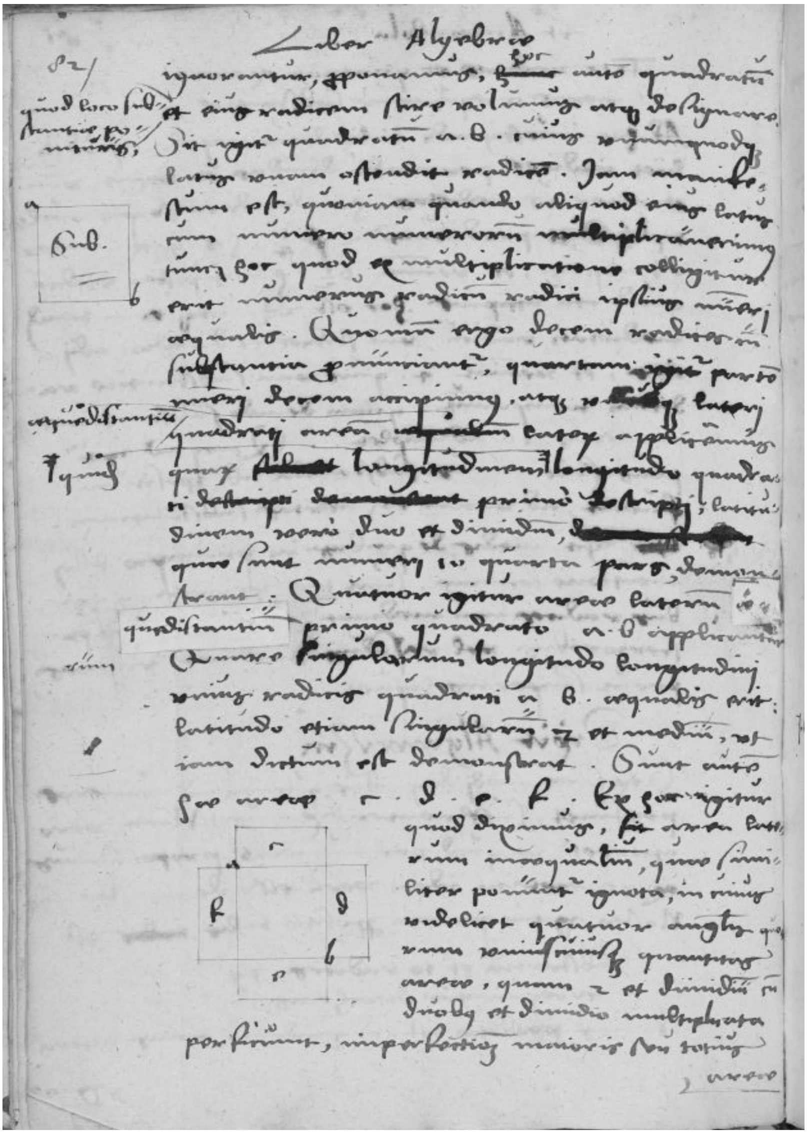


Figure 10.1 Johann Scheybl's 1550 transcription of Robert of Chester's *Algebra*, Columbia MS X512 Sch 2 F, 82. Upper left margin: Square of side z, with area z^2. Lower left margin: Constructed figure representing $z^2 + 10z$ (Reproduced with permission from the Columbia University Rare Book and Manuscript Library)

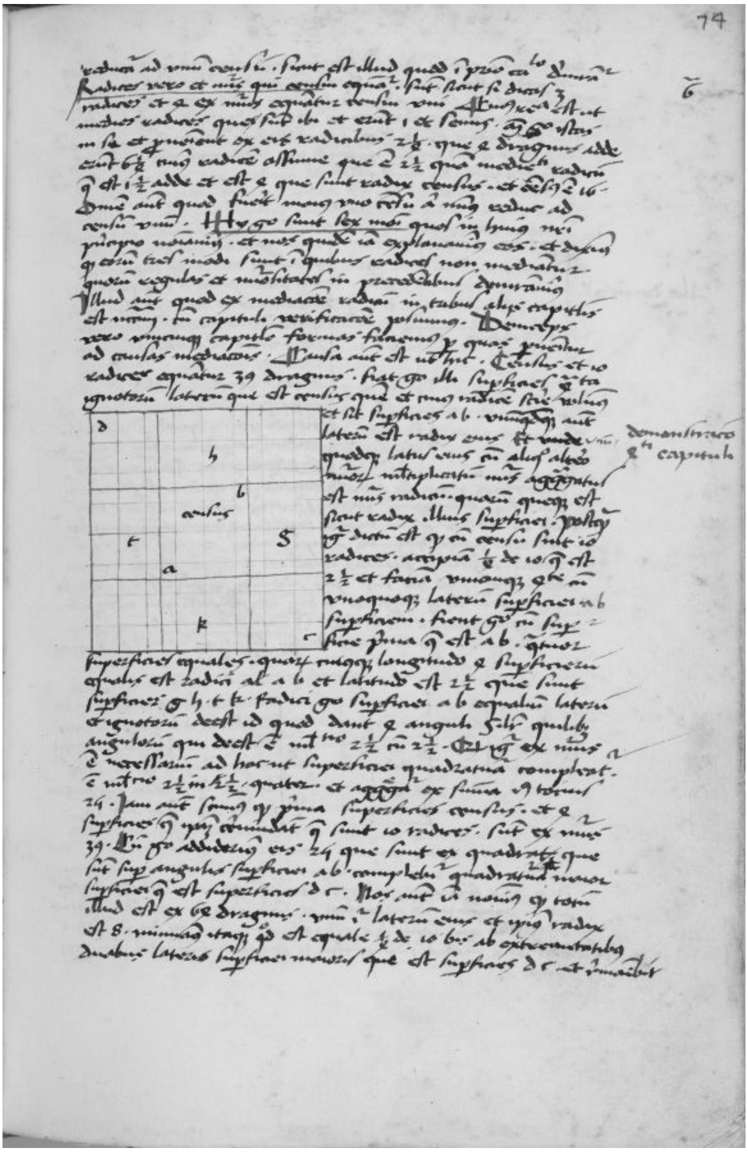


Figure 10.2 The completed square with side $z + 5$. From the partial translation of al-Khwarizmi's *Algebra* by Gerard of Cremona in Regiomontanus' codex *Flores arithmeticae*, MS Plimpton 188, fol 74v (Reproduced with permission from the Columbia University Rare Book and Manuscript Library, the Plimpton Collection)

In the case of al-Khwarizmi's *Algebra* – as for Robert of Chester's translation and the sixteenth-century transcriptions based on it – the import of diagrams is slightly but significantly different. Of the two manuscripts of Chester's translation that Karpinski collates, the Vienna has no figures at all, while the diagrams in the Dresden do not seem to be derived from the Arabic text (which exists as a unique manuscript, MS Hunt 214, in Oxford's Bodleian Library). Nonetheless, the medieval texts refer throughout either to existing figures or ones that could be drawn (e.g., 'Sit igitur quadratum *a b* cuius unumquodque latus unam ostendit radicem,' that is, 'Let therefore the square be *a b*, any one side of which exhibits the root' (76)). Indeed, the Dresden manuscript – like the later Scheybl and Plimpton manuscripts in Columbia University's Rare Book library, from which this chapter takes its images – includes diagrams that appear to be constructed on the basis of geometrical explanations the text provides. In line with the Greek tradition, such images are likenesses rather than accurate representations – for instance, there is no attempt to draw them to scale – and thus stand as particular visual instantiations of general mathematical truths. However, they do not point beyond themselves to the abstract domain of intelligibility, in the manner that Socrates commends. Instead, implicitly invoking geometry's privileged status as model of demonstrable truth, the diagrams function as material sites of verification, authenticating the specific algorithmic procedures they accompany.

The status of Descartes's diagrams is, of course, of primary interest to us here. So, keeping this background in mind, let us turn now to his *Géométrie*, which also begins with a simple quadratic equation. Unlike al-Khowarizmi, Descartes employs algebraic symbols from the outset, and is in theory indifferent to whether a number is positive or negative. Thus his ontological assumptions, be they in respect to algebra or to geometry, are different from his Arabic predecessor's. For instance, whereas the latter's Euclidean geometry is tied to the ontology of three-dimensional space, Cartesian geometry does not specify the nature of the being of its mathematical objects.[14] The same holds true for numbers as well – the symbolic language represents the numbers but without specifying any further what they are.

Descartes uses z to symbolize what al-Khwarizmi calls the 'root' of the quadratic equation – that is, the unknown whose value is to be determined. However, rather than using numbers for the known quantities in an equation, Descartes represents these symbolically as well, using a and b^2 to designate the quantities corresponding to 10 and 39 in al-Khwarizmi's case. These may be thought of, to use a felicitous distinction, as the 'known unknowns' in the equation. In other words, while a and b^2 also represent variable quantities, their values can be decided upon by the mathematician, and thus they can be treated as if they are numbers whose values are already known. The task at hand, then, is to determine the value of z – the true unknown – in terms of what are taken to be given: a, b^2, and ordinary numbers.

Descartes proposes to solve

$$z^2 = az + b \tag{5}$$

By subtracting az from each side, we can rewrite the equation in a form comparable to al-Khwarizmi's $z^2 + 10z = 39$:

$$z^2 - az = b \tag{6}$$

Now, we simply proceed in the manner already described earlier. Consider first the square of $\left(z - \frac{a}{2}\right)$, that is, $\left(z - \frac{a}{2}\right)$ multiplied by itself:

$$\left(z - \frac{a}{2}\right)^2 = z^2 - \frac{az}{2} - \frac{az}{2} + \left(\frac{a}{2}\right)^2 = z^2 - az + \left(\frac{a}{2}\right)^2 \tag{7}$$

But we know from equation 6 that $z^2 - az = b$. Therefore, completing the square by adding $\left(\frac{a}{2}\right)^2$ to both sides of equation 6, we get an expression for square of $\left(z - \frac{a}{2}\right)$ in terms of the given quantities a, b^2, and ordinary numbers:

$$\left(z - \frac{a}{2}\right)^2 = b^2 + \left(\frac{a}{2}\right)^2 \tag{8}$$

Finally, taking the square root of each side, we get:

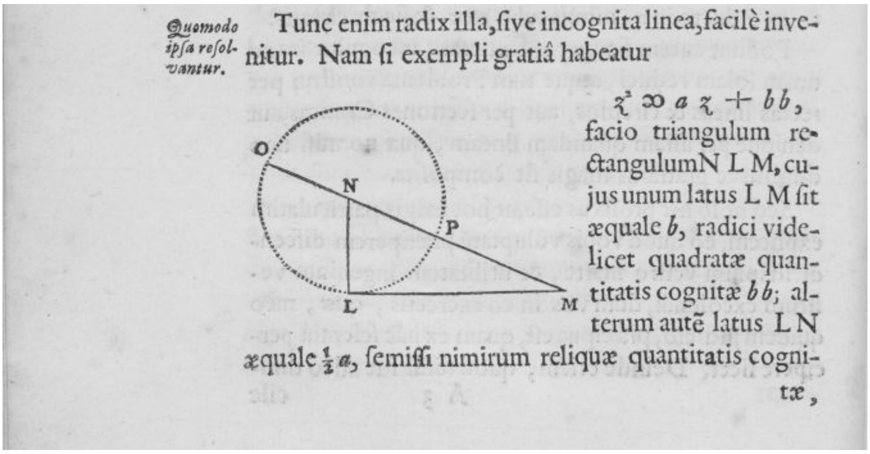
$$\left(z - \frac{a}{2}\right) = \sqrt{b^2 + \left(\frac{a}{2}\right)^2} \tag{9}$$

And this result allows us to express z in terms of the known quantities, yielding

$$z = \frac{a}{2} + \sqrt{b^2 + \left(\frac{a}{2}\right)^2} \tag{10}$$

While I have spelt out the algebraic logic of Descartes's solution in some detail, he himself skips over this exercise of completing the square, not even deigning to provide the kind of algorithm that al-Khwarizmi had offered. He will not 'pause here,' he tells us, 'to explain this in greater detail, because I should be depriving you of the pleasure of learning it for yourself, as well as the advantage of cultivating your mind by training yourself in it, which is, in my opinion, the principal advantage we can derive from this science [of algebra]' (18). This refusal is significant, for it brings into view a qualitative difference fundamental to Descartes's way of thinking: between such 'arithmeticians' who emphasize only formal procedures, focusing on narrowly directed mechanical processes of calculation and proof, and those who employ mathematics properly, doing it the right way. Briefly put, he draws a crucial distinction between merely performing mathematical acts and acting mathematically.[15]

The value of algebraic symbolization lies in its allowing us to see parts of the problem that would disappear were we to rely only on actual numbers. The



Quomodo ipſa reſolvantur. Tunc enim radix illa, ſive incognita linea, facilè invenitur. Nam ſi exempli gratiâ habeatur

$z^2 \infty az + bb$,

facio triangulum rectangulum N L M, cujus unum latus L M ſit æquale b, radici videlicet quadratæ quantitatis cognitæ bb; alterum autẽ latus L N æquale $\frac{1}{2}a$, ſemiſſi nimirum reliquæ quantitatis cognitæ,

Figure 10.3 Descartes's construction, from the 1649 Latin edition of the *Géométrie* (Reproduced with permission from the Columbia University Rare Book and Manuscript Library)

representational language enables us to follow the connection from one step in a solution process to another, by showing us how something develops and how it depends on what has been given or already established. Without due care, however, algebraic manipulation becomes a mere craft, simply a mode of calculation. Thus, even though symbolization is certainly an important step because it frees calculation from an attachment to specific numbers, it is not enough on its own. For Descartes, algebra's importance is as much social as it is conceptual: 'cultivating [the] mind' by 'training' it properly, it helps us act mathematically, and this potentially differentiates us from those who simply perform mathematical acts. But, ultimately, algebra remains too close to the idea of an algorithmic or technical procedure in al-Khwarizmi's sense to be able to sustain the philosophical, social, and ethical distinction so important to Descartes.

Consequently – and in contrast to al-Khwarizmi's celebration of algebra's power to solve a variety of practical problems – Descartes suppresses the algebraic process entirely. Instead, he immediately seeks to give his original equation 5 a geometrical interpretation and 'solve' the problem through an appropriate geometrical construction. But the use and implication of geometry here are very different from what obtains in al-Khwarizmi's example, where, as we saw, geometry was the locus of verification.

Unlike al-Khwarizmi, who uses the areas of squares and rectangles, Descartes relies on straight lines, circles and triangles (see Figure 10.3). This is how he describes his geometrical approach to the equation $z^2 = az + b$:

> I construct a right[-angled] triangle NLM in which the side LM is equal to b, the square root of the known quantity b^2, and the other side LN is [equal to] $\frac{1}{2}a$, [that is,] half the other known quantity which was multiplied by z. Then, prolonging

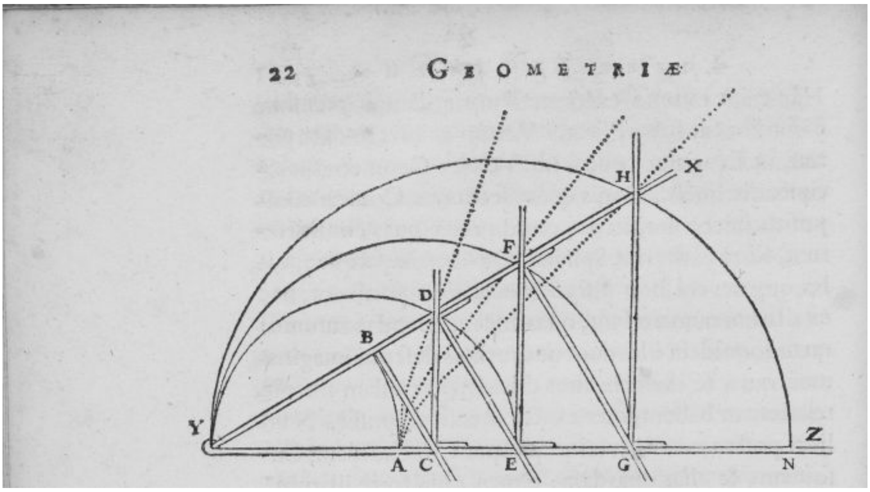


Figure 10.4 Descartes's construction, from the 1649 Latin edition of the *Géométrie* (Reproduced with permission from the Columbia University Rare Book and Manuscript Library)

> MN, the hypotenuse of this triangle, to O, such that NO may be equal to NL, [then] the whole [line] OM is the searched-for line z. And it is expressed in this manner: $z = \frac{a}{2} + \sqrt{b^2 + (\frac{a}{2})^2}$.[16]

Since $LM = b$ and $NL = \frac{a}{2}$, Pythagoras's theorem tells us that the side $NM = \sqrt{b^2 + (\frac{a}{2})^2}$. Thus NM represents the second term in the algebraic solution – see (10) – to the given equation. To represent the unknown z as a line, we have to add to NM a geometrical equivalent to the first term in the algebraic formula for z, that is, $\frac{a}{2}$. Since we have constructed the line NL with the length $\frac{a}{2}$, we need only construct a circle centred on N, with radius NL (see Figure 10.4). This construction ensures that the extension of the NM to touch that circle will be a line whose length corresponds to z in the algebraic solution. In other words, OM represents z and has the desired length of $\frac{a}{2} + \sqrt{b^2 + (\frac{a}{2})^2}$, as in (10).

For al-Khwarizmi, the geometrical construction demonstrated the truth of the algebraic procedure; it showed *why* that procedure worked. By contrast, Descartes's constructions show that, given a type of quadratic equation, we can *produce* its solution geometrically by constructing a right-angled triangle out of the known coefficients and extending the hypotenuse of that triangle appropriately. Rather than elaborating on the procedure of completing the square, then, Descartes simply supplies the outcome of the algebraic manipulation: the formula of equation 10. But the formula has no significance in and of itself. As Timothy Lenoir puts it, '[t]he only object of concern [for Descartes] was the geometric construction, and equations were employed simply as a shorthand way of performing time-consuming geometrical operations. Equations themselves had no ontological significance. They were only a useful symbolic language in which one could store geometrical constructions.'[17] The resultant line OM in Descartes's diagram is the geometrical result that corresponds to the algebraic solution, and the construction reveals how that result can be geometrically generated. In sum, the diagram does not *prove* the validity of the algebraic formula (or, as in al-Khwarizmi's case, of the algebraic process). Rather, the appropriate geometrical constructions – of drawing a triangle, extending the hypotenuse and so on – *makes real* or *materializes* a knowledge of the unknown. The otherwise opaque algebraic formula is thereby externalized, and the act of construction produces truth as intelligibility by making evident to the geometrician what the solution is.

Nor is the knowledge produced by geometry limited as with al-Khwarizmi to a single concrete example which we then generalize by analogy to similar cases; rather, it underpins the exuberant claim which comes at the end of Descartes's treatise: of being able to generate (as the formula already implicitly does) the solutions to an infinite number of related problems:

> But it is not my intention to write a thick book. Instead, I am trying rather to include much in a few words, as perhaps you will judge that I have done, if you consider that having reduced all the problems of a single class [*d'un mesme genre*] to a single construction [*une mesme construction*], I have at the same time given the method of reducing them to an infinity of other different problems, and thus solving each of them in an infinity of ways … We have only to follow the same method in order to construct all problems to an infinite degree of complexity. For in terms of mathematical progressions, once we have the first two terms, it is not difficult to find the others. (240)

In a sense, without deciding upon the numerical values for the known unknowns *a* and *b*, we cannot actually carry out the required construction in its full generality. But, even if imagined, the geometrical operations produce for Descartes an intuitive grasp of the general solution represented by the algebraic formula, and bring with it a mastery over the entire class of particular solutions generated by the infinite set of numerical values which can be ascribed to *a* and *b*. Central to Descartes's endeavour here is the notion that geometrical construction functions as a creative or generative source, infinitely capable of producing truth.

In this approach to the quadratic equation we begin to see a close link between constructibility – the geometrical equivalent of *poesis* – and the existence or objective reality, that is to say, the 'matter,' of mathematical concepts. The construction Descartes asks us to perform is a deliberate instrumental or mental operation aimed at producing an individual figure that is accessible to the intuition. This intuition bestows objectivity on the mathematical concept, bringing it in a manner of speaking into existence in a way that would not be possible without the construction.[18] For Descartes, all knowledge has to have the clarity and intuitive obviousness that our knowledge of the simplest truths possesses – and such knowledge is not simply there, in the nature of the object, but has to be constructed; it demands the inventiveness of the mind to make the mathematical concept real. It does not suffice to assent to the truth of something; it is necessary above all for that truth to be grasped with an intuitive immediacy.

In this sense, Descartes's geometry shifts the very status of mathematical objects in ways that reflect the tension I have pointed out to above in discussing Sidney's use of *mimesis* – briefly, the question of whether poetry (or in this case, geometrical construction) re-presents or re-makes the natures and matters to which it relates. Though already present in the Socratic dialogues, this tension can be more directly traced back to the foundational text of Western geometry, Euclid's *Elements*. An indication of the ultimately unresolved double perspective emerges in the two ways in which Euclidean propositions conclude: usually, QED [*Quod erat demonstrandum* or, in the original Greek, *hoper edei deixal*], but sometimes QEF [*Quod erat faciendum* or *hoper edei poesai*]. While Euclid himself does not remark on this distinction, it nonetheless implicitly raises two important questions that are still alive for Descartes: (1) what share should fall to making or *poesis* in the progressive unfolding of mathematical theorems or problems, and (2) how does the temporality of making bear upon the being of mathematical concepts themselves?[19]

That construction plays a different role in Euclidean geometry is suggested by the fact that the *Elements* almost invariably use the present perfect imperative to describe the constructive operation, so that bisecting a line segment is expressed as 'let it have been cut in two,' and so on. In other words, rather than giving the reader instructions (as Descartes does above) in how to carry out the operation, the text insists on the impersonality of what is being done. Moreover, the perfect tense marks the relevant construction as already having been executed prior to the reader's encounter with the proof. As Lachterman puts it,

> In a Euclidean proposition nothing moves or is moved save our eyes and, perhaps, minds as we follow the transition from step to step … The diagram we see exhibits the antecedently executed operations the outcome of which is now confronting us … The temporality figured in the student's coming to know the truth of a proposition by moving through its parts is not, or so it seems, inherited from a temporality intrinsic to the [mathematical] 'beings' on which Euclidean *mathesis* is focused.[20]

While Euclid is notoriously reticent in terms of providing philosophical interpretations that would allow us to pin him down, these aspects of his *Elements* imply that the movements of graphic construction does not '"create" or "realise"' the nature of a geometrical object. Rather, hewing closer to the Platonic attitude towards diagrams (sketched above), constructions 'evoke or allow it to make its intelligible presence "felt".'[21] In Descartes' *Géométrie*, by contrast, despite a wariness with regard to technical procedure, the constructions nonetheless partake of the making, endowing technical operations with poetic force, and are thus closely allied to the creation of the conceptual matter of mathematics.

The Cartesian emphasis on making objects – and thereby ourselves – leads us back to Sidney. The English poet consistently sees the arts and the sciences as fundamentally *human* endeavours, and therefore necessarily directed towards the same ends:

> Some an admirable delight drew to music, and some the certainty of demonstration to the mathematics; but all, one and other, having this scope: to know, and by knowledge to

> lift up the mind from the dungeon of the body to the enjoying of his own divine essence. (219)

However, knowledge is not valuable for its own sake: it must be directed towards virtuous action. In noting that the 'mathematician might draw forth a straight line with a crooked heart' (219), Sidney distinguishes between the local ends of a particular knowing and the final cause it serves: as with other arts and sciences, mathematics is directed to the 'highest end of mistress knowledge … which stands … in the knowledge of a man's self, in the ethic and politic consideration, with the end of well-doing, and not of well-knowing only' (219). What he voices, then, is an implicit understanding of mathematics too as a profoundly ethical and moral domain – and it is in on this basis that Sidney asserts poetry's superiority, as the art most apt to combine theory and practice, and by so doing shape human nature – thereby producing judgement not simply as a formal knowing but as 'lively knowledge':

> A perfect picture, I say, for he yieldeth to the powers of the mind an image of that whereof the philosopher bestoweth but a wordish description which doth never strike, pierce nor possess the sight of the soul so much as that other doth … Or of a gorgeous palace, and architector … might well make the hearer to repeat, as it were, by rote all he had heard, yet should never satisfy his inward conceit with being witness to itself of a true lively knowledge. But the same man, as soon as he might see … the house well in model, should straightaways grow without need of any description to a judicial comprehending of [it]. (221–222).

Geometry too is poetic in that it makes just such an image, and it is the ethical force of such making that connects Descartes and Sidney. As human beings, we are subject of course to inevitable limitations: 'the final end is to lead and draw us to as high a perfection as our degenerate souls, made worse by their clayey lodging, can be capable of' (219). Nevertheless, mathematics and literature, in their Cartesian and Sidneyan guises respectively, not only posit the shared capacity as human beings to reach toward knowledge but also instantiate poetic modes through which we re-form ourselves so as to be capable of creating and entering the spaces of social life.

Making poetry

But what poets (or philosophers) say is not necessarily what poets (or philosophers) do – or, at the very least, their doing is very rarely transparent to their saying. I would like therefore to turn to an instance of Sidney's practice, to illustrate one way in which he expresses – and indeed complicates – the alliance between geometry and poetry in the very form of his poetic matter. Let us consider the much-studied opening sonnet of the *Astrophil and Stella* sequence – a poem especially memorable for its penultimate image of the pregnant poet, 'helpless in [his] throes, biting [his] truant pen' (ll. 12–3).[22]

The poem's opening sestet famously deploys the classical rhetorical figure of the *gradatio* or ladder in the step-by-step movement through which the narrator imagines

Stella logically progressing to a stage where she might be willing to 'entertain' (l. 6) his desires.

> Loving in truth, and fain in verse my love to show,
> That she (dear she) might take some pleasure of my pain;
> Pleasure might cause her read, reading might make her know;
> Knowledge might pity win, pity grace obtain;
> I sought fit words to paint the blackest face of woe,
> Studying inventions fine, her wits to entertain.
>
> (ll. 1–6)

We begin by assuming a desired objective: a 'truth' evident to the poet – loving – needs to be expressed 'in verse.' However, this 'show[ing]' does not aim simply to express the self but to produce a pleasure in the other, since the poet further imagines that the addressee will derive an immediate pleasure from the mere production of the poem itself, seeing (sadistically) in the poetic object as such an index of the writer's pain.

As line 3 suggests, this pleasure is prior to actually reading the poem: before all else, the verse 'show[s],' the visual and performative implication of the verb being amplified in line 6 when the poet seeks the right language 'to paint' his 'woe.' In short, her act of reading does not automatically follow upon the writing, but has itself to be stimulated by the pleasure she takes in another's pain, to which the verse will point. Once the affect is set in motion thus, each successive link in the logical chain seems to follows rigorously upon its predecessor,[23] each action almost algorithmically generating the next, each proposition entailed by the one that came before: pleasure leads to reading, reading to knowing, knowing to winning pity, pity to obtaining grace. Step by step she climbs the ladder, raising him in turn as she advances. All that remains for the narrator is to execute this poetic programme – in all senses of the word – by turning to what others have already written, rifling through their 'leaves' (l. 7) to con their 'inventions fine' (l. 6).

However, here the projected process breaks down: studious imitation of others not only fails to aid the poet but actively hinders him, their verse stubbornly refusing appropriation: 'others' feet still seemed but strangers in my way' (l. 11). The result is a painful stasis, the poetic birth of the voice is forcibly checked, leaving the poet 'helpless in [his] throes.' The 'truant' pen refuses to be commanded, and agency is conceivable only in the circular form of self-flagellation, its energy directed entirely inwards. If the circle was, as the long tradition from Aristotle to Kepler maintained, a symbol of perfection, it had also become, especially with the advent of Hindu-Arabic numerals, the cipher of nothingness. And, tragically as well as comically, Sidney looks in both directions: in his end is his beginning (recall the comic conclusion to Sonnet 45, 'pity the tale of me') – and vice versa.

What the sonnet stages, then, before the volta of its concluding line – where his muse steps in to save the day – is an anatomy of failure. What the poem dissects, though, is not merely a contingent failure – that of this particular poet's endeavour here and now to win over this particular addressee. Rather, it lays before us the failure of a (poetic) mode. The inability to make a poem that can set the imagined algorithm into motion signals a failure internal to – and, indeed, constitutive of – the mimetic paradigm the narrator initially adopts (or at least of one influential understanding of that paradigm). It needs to be emphasized that the fundamental problem does not lie in the imagined concatenation of dependent events leading to the desired-for 'grace.' The centre of the poem focuses instead on the difficulty of the initial construction itself, which is meant to trigger the subsequent algorithmic process.

Captured in that multivalent word 'invention' (repeated thrice in lines 6–10), Sidney's difficulty reflects the tension I have identified above both in the *Defence* and in the contrasts among Euclidean, al-Khwarizmian and Cartesian construction. On the one hand, to study the 'inventions fine' of others in order 'to paint the blackest face of woe' construes invention as a discovery of what is already there, a finding-out on the basis of already produced poetic constructions. To invent in this sense is closer to the use of the verb and its variants in contemporary accounting manuals, where the discovery of gains and losses, what was coming in and what was going out, was achieved by taking inventory. Even more pertinently, in this aspect invention is allied with analysis in terms of the classical opposition between analysis as a method of discovery and synthesis as a deductive method of demonstration. In Aristotle's *Nicomachean Ethics*, for instance – a text with which Sidney was deeply familiar, as his correspondence shows – this distinction is formulated via the contrast between means and ends: analysis assumes the objective or end, taking it to be already given, in order to focus on the means whereby the end may be achieved. And precisely this attitude seems to governs the poem's first half, where the narrator assumes showing his 'truth' – loving – and its practical correlate – obtaining 'grace' – as his objectives, to turn his attention instead to the *techne* or praxis through which those objectives may be realized. The initial poetic construction – much like its geometrical counterpart in Euclid – is not meant to demonstrate something new – for instance, to show the poetic equivalent of a Euclidean theorem; rather it is a means, that which has to be made in order achieve a certain end.

But this notion of invention proves itself inadequate, and Sidney's turn away from copying others' constructions prefigures the Cartesian turn away from Euclidean construction. Descartes distinguishes, as we have seen, 'between acting geometrically and performing a geometrical act':

> Acting geometrically requires that one perform a geometrical act from knowledge of the underlying interconnections and that one chooses to do so given the end of creating more intuitive knowledge. A formally valid calculation or geometric construction might either be merely a geometrical act or be a product of acting geometrically.[24]

In other words, for Descartes, formal logical consequence or for that matter a step-by-step sequence in a proof may be necessary for producing certainty but it nonetheless falls short of the kind of clear and distinct evidence that truly characterizes knowledge. Even if I am certain of a relationship between A and E because I consent to the series of relations A:B, B:C, C:D, D:E, 'I do not on that account see what the relationship is between A and E, nor can the truths previously learnt give me a precise knowledge of it unless I recall them all.'[25] What is further needed is an intuitive – or, as Jones puts it, 'poetic' – grasp of the relationship between A and E, so that their interconnection possesses the kind of evidentiary vividness characteristic of our grasp of any of those intermediate relationships. And the limits Descartes attributes to the formal certainty of mathematical demonstrations – as does Sidney in the case of poetic demonstrations – shape his ambivalent response to the prior labours of others: 'In slavishly imitating and assenting to proof, one allows reason to "amuse" oneself and thereby one loses the habit of reasoning.'[26] Likewise, what Sidney loses in reasoning as he does is the habit of poetry itself.

To break out of the resulting impasse, Sidney must turn invention in *poesis* inside out, as Descartes does construction in geometry, making it instead the avenue of creation, a form bringing forth new matter: a 'heart-ravishing knowledge' as the *Defence* puts it, when recounting that the Romans called a poet '*vates*, which is as much as a diviner, foreseer, or prophet' (214). Thus, across its repeated iterations in lines 6–10, the meaning of invention shifts: the alliance between study and invention announced in line 6 ('[s]tudying inventions fine') mutates into disjunction in line 10, where invention as 'nature's child' is opposed to the martinet-like rigour of what has now become the false mother: 'Invention, nature's child, fled step-dame study's blows' (l. 10). Sidney's association of a transformed invention with nature's fecundity is already hinted by the intervening hope that '[s]ome fresh and fruitful showers' might 'flow' upon his 'sunburnt brain' (l. 7–8) – and this connection sets up, too, the situation which will result from *not* making use of invention's natural fertility: a pregnancy that refuses to end, suspending nature's issue. Indeed, the sonnet elegantly negotiates the shift between these two senses of invention in lines 6 and 10 respectively through the ambivalence expressed in the intermediate line 9: 'But words came halting forth, wanting invention's stay.' The multivalence of both 'wanting' – desiring and lacking – and 'stay' – delay and hindrance, but also support – captures the dynamic balance between different senses of invention, between mimesis as imitation and as creation.

The distinctness and clarity of poetic production in Sonnet 1 is conveyed by both the brevity and the tone of the muse's intervention, when it admonishes the poet by pointing out the obvious: '"Fool," said my muse to me; "look in thy heart, and write"' (l. 14). As in the *Defence*, the evidentiary vividness is located in the heart, for it is only by looking there that one can 'invent' the poem, and thereby act poetically (that is, write) rather than merely perform a poetic act (which the first six lines of the poem describe, and whose failure the next six recount). If, for Descartes, geometrical construction converts the formal logic of algebraic analysis into an intuitive grasp of truth akin to divination, the turn inward to the heart in this sonnet likewise achieves a re-vision; it changes the very mode of seeing: from the observation of a series of mechanical movements between causes and effects into an almost vatic insight into the totality of their deeper, underlying connectedness.

But this does not mean that the algebraic process, the concatenation of causes and effects in algorithmic fashion, is in itself a mistake. As I have suggested above, this is far from being the case. Indeed, for Descartes, the symbolic representation of geometric lines in order to produce a set of equations that can be solved is a crucial and necessary step, for it is through algebra that the gaps in the process leading from known things to unknown ones is filled. As Descartes puts it, while the algebraic movement does not being into being 'a new kind of identity' it nonetheless extends 'our entire knowledge of the question to the point where we perceive that the thing we are looking for participates in this way or that way in the nature of things given in the statement of the problem.'[27] Algebra is thus a necessary but temporary help to achieve the geometric construction, which truly does bring something new into being, not just visually but in that it produces a vivid knowledge of the interconnection among things, or among a set of geometrical objects.

Hence, Cartesian geometry in a strict sense *repeats* algebraic labour – if only ultimately to discard algebra as mere *techne*, excessive focus on which blocks understanding. This attitude is best captured by Descartes's famous compass (see Figure 10.4). Descartes envisions here a system of linked rulers. A pivot at Y connects the rulers YX and YZ, the latter remaining fixed while the former rotates. The ruler BC is fixed perpendicular to YX at B, while the remaining rulers parallel to it (DE and FG), slide perpendicularly along YX when pushed by DC and FE respectively. As the angle of the instrument XYZ is opened by rotating YX, 'the ruler BC … pushes toward Z the ruler CD, which slides along YZ always at right angles. In like manner, CD pushes DE, which slides along YX always parallel to BC; DE pushes EF; EF pushes FG; FG pushes GH; and so on.'[28] In short, the initial motion generates a series of curves. Point B (which is fixed on XY) traces a circle, while points D, F, and H (which slide along YX) trace other, more complex curves indicated by dotted lines in figure 10.4.[29] By translating the steps of the algebraic equation into appropriate curves through a continuous motion (or through several successive motions, each regulated by those that precede), Descartes's instrument shows that 'however composite a motion is, the resulting curve can be conceived in a clear and distinct way, and is therefore acceptable in geometry.'[30]

The overarching epistemological enterprise, in whose service this mechanical instrument was designed, demands, too, a constructive repetition of algebraic analysis:

> Algebraic work produces a formula. The newly created algebraic formula guides the construction of a machine, which draws a curve. This curve/machine complex makes the interconnection among the geometrical objects evident. In this process, algebra enables us to get to this geometric order. An algebraic formula, however, should not substitute for knowledge of the geometric order it can help produce.[31]

This Cartesian production of an epistemological difference in and through repetition points to a final implication of Sidney's understanding of *mimesis* and invention, and leads to another sense in which Sidney's ends and beginnings are intricated. For we should note that the muse's injunction in the sonnet's concluding line returns, through the poet's self-reflection, to the poem's beginning, since arguably the poem we have just read is the product of his having taken the muse's advice to heart. Just as geometrical construction repeats the algebraic, exposing both its truth and its limits in the production of intuitive knowledge, so too what is triggered by looking into the heart is a poem that rehearses its own failure in order vividly to express the difference internal to repetition, the other side of *mimesis*: invention as nature's child.

But even as Sidney's complex renegotiation of the relationship between poetic 'manner' and 'matter' reveals a quasi-mathematical logic that is cousin to the late Cartesian moment, the generic or contextual shift from the critical idiom of the *Defence* to the performative space of the sonnet sequence introduces a further twist. As Richard Young points out, the fact that the speaker in *Astrophil and Stella* is 'a poet rather than a critic' leads to the critical problem of the form/content relationship being raised instead as a rhetorical problem in the poetic sequence, so that the 'matter of the *Defence* … becomes part of the rhetorical manner of *Astrophel* [*sic*] *and Stella*.'[32] The place of 'matter' in the treatise – that is to say, the Nature or Reality that the poet is enjoined to 'imitate' – is repeatedly occupied in the poems by the formal literary conventions with and against which the speaker struggles (the examples are legion, but see, for instance, Sonnets 3, 9, and 15). The reason for this, Young perceptively suggests, lies in the early modern response, complexly shared by Sidney, to an Aristotelian heritage. '[Conventional poetry] follows a genre theory of poetic [*sic*], a shortcut in the Aristotelian process of mimesis: the place of the Nature to be imitated is taken by approved models, and the imitation itself is prescribed by rules of decorum.'[33] (Moreover, this redoubling of the matter/manner relation is further inflected by the fact that Astrophil is *not* Sidney but rather a dramatic persona internal to the sequence, one who is lent concretion by a self-consciously staged autobiographical association with the actual poet.)

The difference introduced by the rehearsal of the critical problem on a dramatic plane is given shape in the very second sonnet of the sequence, which repeats with a difference the quasi-mathematical logic of the opening sonnet; it re-materializes its precursor's poetic form in the negative, exposing it as itself conventional – even though Sonnet 1 had announced its circuitous form precisely as a break from convention leading the speaker to the 'true' subject matter behind inherited models. If the reverberating 'might' in the opening sonnet's algorithmic sequence (see lines 2–4) signals the speaker's residual uncertainty about Stella's reaction at each step in the imagined *gradatio*, Sonnet 2 begins by banishing all contingency where his own responses are concerned: 'Not at first sight, nor with a dribbed shot / Love gave the wound which while I breathe will bleed' (lines 1–2). These lines set up a second concatenation of events that counterbalances the earlier one in that its own algorithm is distinguished by an inexorable regression, repeatedly overriding the speaker's explicit refusal to accede to its logic:

I saw, and liked; I liked, but loved not;
I loved, but straight did not what love decreed:
At length to love's decrees, I, forced, agreed,
Yet with repining at so partial lot.

(lines 4–8)

Shifting attention from (the failure of) his affect on Stella to (the success of) hers on him, this reversed gradation leads downward to the present situation in which 'even that footstep of lost liberty / Is gone' and the speaker is reduced to a 'slave-born Muscovite' (lines 9–10). The minimal agency of complaint is denied him, and on this lowest rung of the ladder he is enforced to describe his condition as contrary to its reality ('I call it praise to suffer tyranny,' line 11) – and indeed to construct a fabulous world that, anticipating Descartes in his treatise on *The World* (see below), does not simply reflect 'the things that are actually in the true world' but 'that nevertheless could be created just as I will have feigned it.' And out of these strictures arises the memorable coincidence of opposites with which the poem concludes, the invention of a state of pleasure that simultaneously expresses a state of suffering: 'To make myself believe that all is well / While with feeling skill I paint my hell' (lines 13 and 14) – ironically completing a poetic rendition of 'the blackest face of woe' that the opening sonnet had presented either as unattainable or as mistaken. Through such dynamic repetitions – and disavowal of – their own conditions of possibility do both poetic and geometric constructions themselves come into being, reinventing themselves by inventing the techniques they will ultimately seek to displace.

Coda: fables to live by

Jean-Luc Nancy's rich if elusive essay on Descartes takes its title from Jan Weenix's 1647 portrait of the philosopher, which shows him holding an open book on whose left page is inscribed *mundus est fabula*, the world is a fable. The phrase ought not to be taken, Nancy argues, as repeating the Baroque commonplace that the world around us is illusory, no more real than fable. Rather, it points to the constitutive place of the fable in the Cartesian invention of the thinking subject, upon whose certitude all knowledge of the world is built.[34] The opening chapter of the *Discourse on the Method* makes this fabulatory motive explicit:

> Thus my design is not to teach here the method which everyone ought to follow in order to direct his reason well, but only to show how I have tried to direct my own ... But, putting forward this work as a history [*histoire*], or, if you prefer, as a fable [*fable*] in which, among a few examples one may imitate, one will perhaps find many others that one will be right not to follow, I hope that it will be useful to some without being harmful to any, and that all will be grateful to me for my frankness [*franchise*]. (83; translation modified)[35]

As Nancy perceptively notes, Descartes's text does not itself 'imitatively borrow the traits of a literary genre ... If fable here ... is to introduce *fiction*, it will do so through a completely different procedure. It will not introduce fiction "upon" truth or beside it, but *within* it.'[36] This distinction, wherein fiction-making enters into the very interior of truth, ought to be recognizable to us in Sidney's own justification for poetry's aptitude for (truthful) feigning – which is not, he emphasizes, tantamount to lying because it never purported to be literally true to begin with. Or, to cite again Descartes's defence of his invention of the world in *Le Monde*, it is not that one seeks to present 'the things that are actually in the true world,' but rather to 'feign[] one at random … that nevertheless could be created just as I will have feigned it.'[37]

The motif of the fable also opens a more unexpected connection between Sidney and Descartes. As is well known, in 1595 Sidney's *Defence* also appeared in a different edition and was called instead *An Apology for Poetry*. The implications of this alternative title are rich. Margaret Ferguson points out that the word *apology* derives from *apo*, meaning away and *logia* or speaking, and thus came to signify 'a speech in defense.' However, the Renaissance conflated this with the Greek word *apologos*, which meant story or fable, generalizing this term to apply to didactic allegories such as Aesop's fables. '[F]or Renaissance defenders of poetry, there was a special link between *apologos* and *apologia*, a link suggested not only by the fact that both terms were sometimes translated as "apologie" in sixteenth-century England, but also by a Platonic text that was crucial to Renaissance justifications of poetry,' Plato's *Republic*.[38]

References to Plato's banishing of poets from the ideal republic abound in Sidney's *Apology*. And the very first mention of Plato emphasizes the fabulous dimensions of his thought:

> And truly even Plato whoever well considereth shall find in the body of his work, though the inside and strength were philosophy, the skin, as it were, and beauty depended most on poetry: for all standeth upon dialogues, wherein he feigneth many honest burgesses of Athens to speak of such matters, that, if they had been set on the rack, they would never have confessed them. (213)

Not only does Sidney see the very dialogic form as inherently poetic, but he recognizes clearly the extent to which Platonic truth is communicated through invention: feigning their words extracts the 'honesty' of the Athenians beyond anything that torture can achieve. Plato's own recourse to fables and myths at key junctures in his dialogues – Sidney notes the strategic 'interlacing' of what might seem 'mere tales, as Gyges' ring and others' (213) – is echoed in the framing fable with which the *Apology* opens. In a gesture that anticipates the ostensible humility of Descartes's presenting his life as a fable, Sidney self-deprecatingly prefaces his own – unavoidably solipsistic – defence of poetry with the diverting story of John Pietro Pugliano, whose equestrian responsibilities led him excessively 'to exercise[] his speech in praise of his faculty.' 'Had I not been a piece of a logician before I came to him,' Sidney muses, 'I think he would have persuaded me to have wished myself a horse. But thus much at least his no few words drave into me, that self-love is better than any gilding to make us seem gorgeous wherein ourselves be parties' (212).

It is likewise through the fable of Descartes's own intellectual autobiography that the Cartesian thinking subject shows itself. Descartes refuses the position of authority from which his method can be taught, and even suggests that this frank display of himself may have only a very limited exemplary function as model to be fruitfully imitated. In fact, the *Discourse* distances itself even further from its potential use as imitative model:

> If my work has pleased me enough that I show you its model [*modèle*] here, it is not because I wish to advise anybody to imitate it. Those upon whom God has bestowed more of his graces will perhaps form designs more elevated; but I do fear that for many this [work itself] may already be too audacious. The sole resolve of undoing all the opinions that one has formerly received [*auparavant en sa créance*] is not an example that each man should follow. And the world may be said to be mainly composed of two sorts of minds to which it is not in the least suited. (90; translation modified)

Descartes's notion of the private and particular self is itself a product of an awareness of a collective, a 'public' for whom the author cannot in any direct sense serve as a model to be copied. Put another way, (auto)biography is itself created in the gesture that posits the subject's life as heuristic fiction.

The Cartesian fable thus appears a paradoxical beast, both exemplary and, in a fundamental sense, inimitable. And this double articulation is, I wish to suggest, distinctive of Sidney as well. To sharpen the paradox, we might say that both writers show themselves as imitable precisely in their inimitability. In other words, simply to copy what they do would be the equivalent of merely performing geometrical or poetical acts – the failure of which the opening sonnet of *Astrophil and Stella* stages. Truly to imitate them, by contrast, would be to take their very inimitability as model, that is to say, to inhabit (as they do) a process of invention whose characteristic is a distinctive internal swerve within inherited traditions, a repetition that produces difference in the form of singularity.[39] As Nancy writes apropos Descartes (in words that we could easily apply to Sidney's poetical practice as well), 'if the worlds of fiction and reality are not identical, what instead is identical – yielding Descartes' very identity – is the activity of invention and creation … The subject of true knowledge must be the inventor of his own fable.'[40]

Consequently, what one is enjoined to imitate is less either the 'matter' or the 'manner' (see p. 248) of their geometrical and/or poetical creations than something more like their attitude with respect to the very relationship between matter and manner. Young aptly describes the poet-lover of Sidney's sonnet sequence as a 'Janus-figure … looking in both directions: within the dramatic context toward the lady and beyond it toward a reader.'[41] While the dramatic fiction is lent solidity by Sidney's evocation of his own biography throughout the sonnet sequence, it is equally the sequence itself that invents the life, by creating and re-creating, for instance, the figure of Stella (and, concomitantly, the figure of Astrophil) from sonnet to sonnet. In turn, showing the self through the shapes it creates constitutes the mode of address outward:

the singular and virtuoso display of literary imitation turned inside out calls for an audience whose 'imitation' of the poet would ideally take the poet's singularity as model, reading it as – to borrow again Nancy's description of Descartes's *Discourse* – the 'fable of the generality of a singular and authentic action.'[42]

What *poesis* brings into being for Sidney, just as geometrical construction does for Descartes, is the degree to which the making of the verbal (or visual) image produces an exemplarity that is generalizable not via direct likeness but in the very mode of relating to the world that it exemplifies.

> But if the question be for your own use and learning, whether it be better to have it set down as it should be, or as it was, then certainly is more doctrinable the feigned Cyrus in Xenophon than the true Cyrus in Justin, and the feigned Aeneas in Virgil than the right Aeneas in Dares Phrygius. (224)

It is worth noting that the *Oxford English Dictionary* traces the first use of the word *individual* to signify 'a single human being, as opposed to Society, the Family, etc.' to the early seventeenth century.[43] One might say that Sidney and Descartes envisage the creation of this individual precisely through individual creation. And it is on the shifting sands of such a fabulous foundation that their geometrico-poetic worlds would be built.

Notes

1 René Descartes, *Discourse on Method*, in Elizabeth S. Haldane and G. R. T. Ross (trans. and eds), *The Philosophical Works of Descartes*, 2 vols (Cambridge: Cambridge University Press, 1955), I, pp. 82–83. Translation modified.

2 To the best of my knowledge, Henry S. Turner's *The English Renaissance Stage: Geometry, Poetics and the Practical Spatial Arts 1580–1630* (Oxford: Oxford University Press, 2006) is the only book explicitly to draw the connection between geometry and poetry in Sidney's *Defence*. My discussion here independently converges at times with Turner's, generally with respect to positions already well-established through the history of Sidney criticism – for instance, the importance of 'invention' or the the question of poetry's epistemological and ethical value. However, Turner focuses mostly on reconstructing geometry's status through title pages, prefaces, and selective evidence of reading practices. There is thus little acknowledgement of the momentous change in the very content of geometry – and in its relationship to algebra – from the mid sixteenth to the mid seventeenth century. Further, the discussion of Sidney's *Defence* does not attend to Sidney's own poetic practice, an odd absence given the parallel insistence that geometry's assimilation to the practical arts during this period opens up its connection to poetry.

3 Sir Philip Sidney, *The Defence of Poesy*, in Katherine Duncan-Jones (ed.), *Sir Philip Sidney: The Major Works* (Oxford: Oxford University Press, 1989), pp. 212–251, at p. 230. All subsequent citations of Sidney's *Defence* are indicated by page number in the body of this chapter.

4 From different perspectives, critics have often remarked upon this tension in Sidney's oeuvre. According to Sherrod Cooper, for instance, the poet swings between the claim that

art is a means to the end of 'representing nature accurately' and the countervailing position in which inspiration seems all: '[o]bviously,' writes Cooper, 'the practitioner and the theorist seem at odds with another.' *The Sonnets of* Astrophil and Stella*: A Stylistic Study* (The Hague: Mouton, 1968), pp. 14, 17. Kathy Eden's rich discussion emphasizes instead the duality in the poet's complex deployment of key Aristotelian texts: 'When Sidney defines poetry not only as an art of imitation but also as an instrument of knowledge, he does so in view of the *Poetics* and its tradition. When, on the other hand, he claims for poetry the special task of feigning images designed to inspire the will to virtuous action, he echoes the *De Anima* and its tradition.' *Poetic and Legal Fiction in the Aristotelian Tradition* (Princeton: Princeton University Press, 1986), p. 158.

5 In a 1574 reply to Languet, for instance, Sidney resists the Frenchman's advice that he give up studying geometry, promising to 'only look through the lattice (so to say) at the first principles of it.' *The Works of Sir Philip Sidney*, ed. Albert Feuillerat, 4 vols (Cambridge: Cambridge University Press, 1965), Vol. III, p. 84. In a 1580 letter, Sidney further advises his brother to 'take delight in the mathematicals,' and especially in arithmetic and geometry 'so as both in number and measure you might have a feeling and active judgement.' *The Correspondence of Philip Sidney and Hubert Languet*, ed. William Aspenwall Bradley (Boston: Merrymount Press, 1912), p. 223.

6 David Rapport Lachterman, *The Ethics of Geometry: A Genealogy of Modernity* (London: Routledge, 1989), p. ix.

7 *Robert of Chester's Latin Translation of the Algebra of Al-Khowarizmi*, ed. Louis Charles Karpinski (New York: The Macmillan Company, 1915). Further citations indicated by page number in body of essay. Karpinski's prefatory material shows how widely disseminated knowledge of al-Khwarizmi's work was from the late fifteenth century onwards – either directly, as in the case of Regiomontanus and Luca Pacioli, or through Robert of Chester's translation, as with Johann Scheybl, a professor of mathematics at Tübingen who in 1550 transcribed and prepared that translation for publication.

8 The question of whether Descartes did or did not invent analytical geometry has been much debated by historians of mathematics. There seems little doubt that analytical geometry shares a number of the mathematical techniques developed in the *Géométrie*, but, as Carl B. Boyer first argued, it remains unclear whether Descartes's mathematical thought was fully compatible with the basic notion undergirding analytical geometry: that algebraic equations define curves in space. See Boyer, *History of Analytic Geometry* (New York: Scripta Mathematica, 1956), pp. 102ff. 'The analytical geometer,' according to Timothy Lenoir, 'begins with an equation in two or three variables and, by a suitable choice of a coordinate frame, produces a geometric *interpretation* of that equation in two- or three-[dimensional] space.' In: 'Descartes and the geometrization of thought: the methodological background of Descartes' *Géométrie*', *Historia Mathematica*, 6 (1979), 355–379, at 356. While Descartes admits the necessity of algebra, he refuses to prioritize equations in this way. In fact, as H. J. M. Bos persuasively shows, how curves ought to be understood remained an open question for most seventeenth century mathematicians. Descartes intervenes here by introducing 'a sharp distinction between admissible and inadmissible curves precisely on the grounds of their constructibility. See Bos, 'On the representation of curves in Descartes' *Géométrie*', *Archive for History of Exact Sciences*, 24 (1981), 295–338.

9 Lachterman, *Ethics of Geometry*, pp. ix and xi.

10 As Karpinski points out, the 'Greek influence on Arabic geometry is revealed by the order of the letters employed on the geometrical figures.' These letters follow the natural Greek order rather than the Arabic, and 'the same is true … [for] the letters in the geometrical figures used by Al-Khowarizmi for verification of his solutions of quadratic equations … The Arabs were much more familiar with and grounded in Euclid than are mathematicians today, and it was entirely natural in constructing new figures that they should follow the order of lettering to which they had become accustomed in their study of Euclid.' See *The Algebra of Al-Khowarizmi*, p. 21.

11 Plato, *The Republic*, in *Plato in Twelve Volumes*, trans. Paul Shorey (Cambridge: Harvard University Press, 1969), Vol. 6, 510d–511a. Translation modified. I cite the Perseus Digital Library's text: www.perseus.tufts.edu/hopper/text?doc=Perseus:text:1999.01.0168. Last accessed 8 March 2012.

12 Reviel Netz, 'What did Greek mathematicians find beautiful?', *Classical Philology*, 105 (2010), 426–449.

13 Plato, *The Republic*, 527b.

14 Michael Mahoney insists that Descartes's essential contribution to algebra was that of abstracting mathematical operations from visual or physical space. Descartes's mathematics, he claims, is a science of pure structure, without any ontological foundation. See 'Die Anfänge der algebraischen Denkweise im 17. Jahrhundert', *Rete: Strukturgeschichte der Naturwissenschaften*, 1.1 (1971), 15–31, at 29. This is perhaps too strongly put, but there is no denying that Descartes seeks to separate his mathematics from the reference to physical space that underlies Euclidean geometry. Thus, for example, the multiplication of two lines in the *Géométrie* yields not a square (as in al-Khwarizmi's algebra) but another line.

15 For a fuller discussion of this distinction see Matthew L. Jones, *The Good Life in the Scientific Revolution: Descartes, Pascal, Leibniz, and the Cultivation of Virtue* (Chicago: University of Chicago Press, 2006), pp. 32–38.

16 René Descartes, *The Geometry of René Descartes*, trans. David Eugene Smith and Marcial L. Latham (London: The Open Court Publishing Company, 1925), p. 13. Translation modified. Further citations indicated by page number in body of chapter.

17 Lenoir, 'Descartes and the geometrization of thought', 356. The primary focus of Descartes's *Geometry* is his solution to the so-called Pappus problem, which he claimed had hitherto not been properly solved using the appropriate geometrical means. But in this preliminary discussion of quadratic equations, the attitude underlying the mathematical approach to that complex locus problem is already visible. There, as here, to cite Lenoir, 'the justification for his solution [lies] in the fact that each algebraic manipulation he made … corresponded to a definite geometrical operation' (358).

18 The distinction between the evidence of a proof and its formal certainty that Jones underscores in his reading of Descartes speaks centrally to this issue. '[F]ormal demonstrations, like syllogisms or other logical forms of proof, could, in [Descartes's] eyes, produce a kind of certainty. They did not, however, make *evident* the connections on was proving.' See Jones, *The Good Life*, p. 29. I return to this distinction in more detail below.

19 I draw here on Lachterman's detailed analysis of Euclid in *The Ethics of Geometry*, pp. 25–123.

20 Ibid., pp. 66–67.

21 Ibid., p. 121.
22 All quotations from Sidney's verse refer to Katherine Duncan-Jones's *Sir Philip Sidney: The Major Works* (Oxford: Oxford University Press, 1989).
23 I say 'seems' because the strength of the connection between each step is weakened by the reiterated 'might,' suggesting the residual uncertainty attending every transition. The tension between a strictly logical entailment and the possibility of a failure at each junction is perhaps heightened by the echo of the other primary meaning of 'might': power or force.
24 Jones, *The Good Life*, p. 32.
25 Descartes, 'Rules for the Direction of the Mind', in *The Philosophical Works*, Vol. I, p. 25.
26 Jones, *The Good Life*, p. 27.
27 René Descartes, *The Philosophical Writings of Descartes*, trans. John Cottingham, Robert Stoothoff, and Dugald Murdoch, 3 vols (Cambridge: Cambridge University Press, 1984–91), Vol. I, p. 56. Also cited in Jones, *The Good Life*, p. 33.
28 *The Geometry of René Descartes*, pp. 46–47.
29 With regard to the intermediate terms in a proof sequence connecting an initial term A to a final term E via the series of relations A:B, B:C, C:D, D:E, the compass generates a series of similar triangles – YBC, YDE, and so on – which make visible these mean proportionals characterizing the algebraic equation.
30 Bos, 'Curves in Descartes' *Géométrie*', 310. This was not the only compass Descartes dreamt up, for it only involved straight lines as the moving parts. He also envisioned other, more complex devices that combined the movement of straight lines with the motions of simpler curves.
31 Jones, *The Good Life*, p. 34. The compass, as a mechanical device, falls under the same injunction circumscribing algebra's role. In itself it is no more than an instrument, but through its appropriate use geometry reveals itself as *poesis*.
32 Richard B. Young, 'English Petrarke: a study of Astrophel and Stella,' in *Three Studies in the Renaissance: Sidney, Jonson, Milton* (New Haven: Yale University Press, 1958), pp. 5–88, at p. 6.
33 Ibid., p. 11.
34 Jean-Luc Nancy, 'Mundus est Fabula', *MLN*, 93 (1978), 635–653, at 635–637.
35 The motif of the fable recurs in the *Discourse* – for example, in the ensuing discussion of the learning of the Schools – as well as in *The World* [*Le Monde*], which was suppressed from publication by the author upon hearing of the condemnation of Galileo in 1632. In that earlier text, Descartes solicitously tells the reader that he wishes 'to envelop a part of it with the invention of a fable' so that 'you will find the length of this discourse less tedious.' Through this fable, he hopes 'that truth will always be sufficiently visible, and that it will be no less pleasant to behold than if I exposed it in all its nakedness.' Cited in Nancy, 'Mundus est Fabula', 639.
36 Ibid., 638.
37 Cited in ibid., 639.
38 Margaret W. Ferguson, *Trials of Desire: Renaissance Defenses of Poetry* (New Haven: Yale University Press, 1983), pp. 2–3.
39 Gilles Deleuze's distinction between generality and repetition is apposite here: '[I]t is not Federation day which commemorates or represents the fall of the Bastille, but the fall of the Bastille which celebrates and repeats in advance all the Federation days; or Monet's

first water lily which repeats all the others. Generality, as generality of the particular, thus stands opposed to repetition as universality of the singular. The repetition of a work of art is like a singularity without a concept, and it is not by accident that a poem must be learned by heart.' *Difference and Repetition* (London: The Athlone Press, 1994), p. 1.

40 Nancy, 'Mundus est Fabula', 639–640.

41 Young, 'English Petrarke', p. 9.

42 Nancy, 'Mundus est Fabula', 641.

43 The *OED* cites J. Yates's 1626 *Ibis ad Caesarem*: 'The Prophet saith not, God saw every particular man in his blood, or had compassion to say to every individual, *Thou shalt live*.' Entry under 3a, spelling modernized. My thanks to Diana Henderson for bringing this point to my attention.