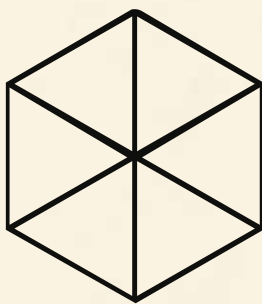




*Dedicated to my daughter Aja Sophia,  
who embodies the wisdom of love and beauty.*



SNEZANA LAWRENCE



ART  
*of*  
MATHEMATICS

**Lannoo**



ARITHME-  
TICA.

an. Sadler sculp. et excud.

M. de Vos figura.

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*A woman doing bookkeeping, representing Arithmetic.  
Engraving by Jan Sadeler, after Maerten de Vos,  
16th century. Welcome Collection, London.*

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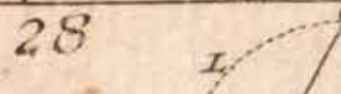
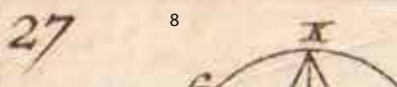
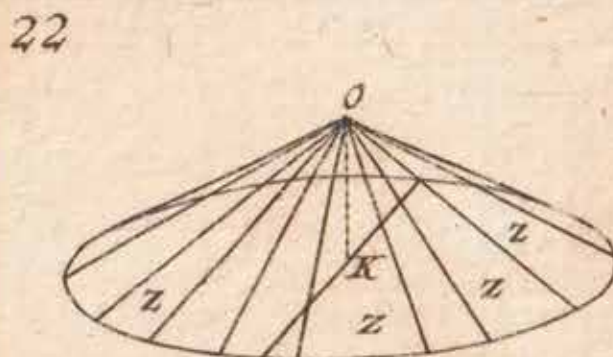
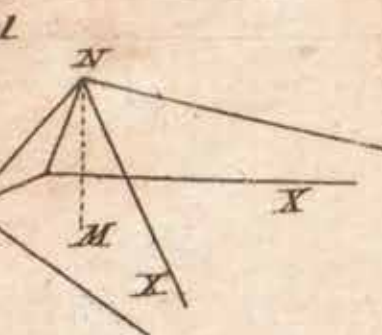
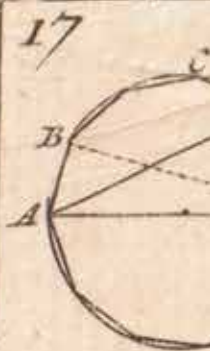
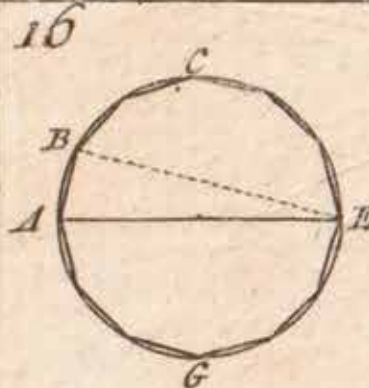
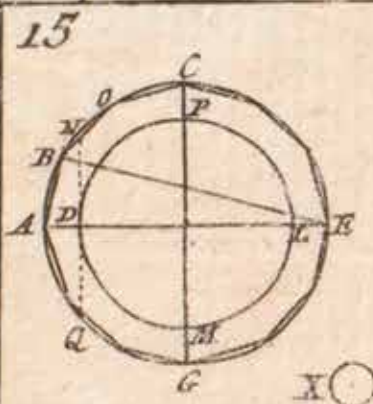
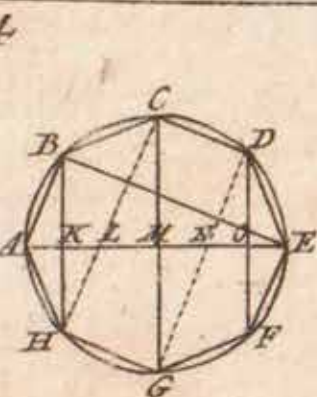
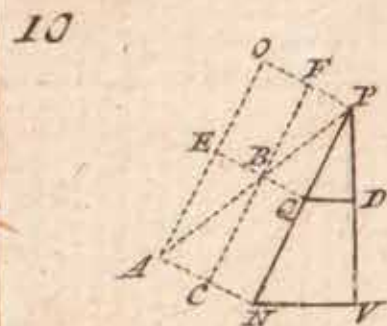
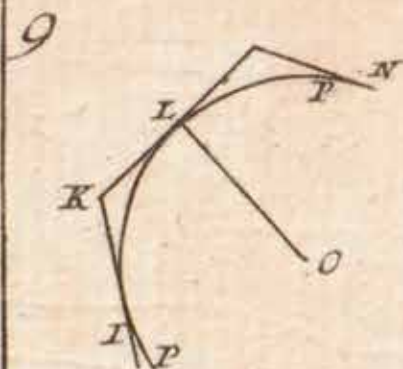
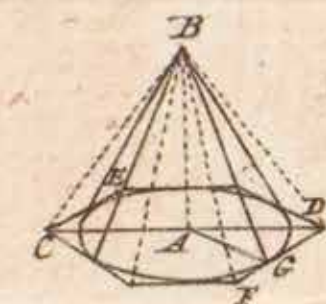
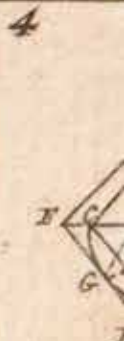
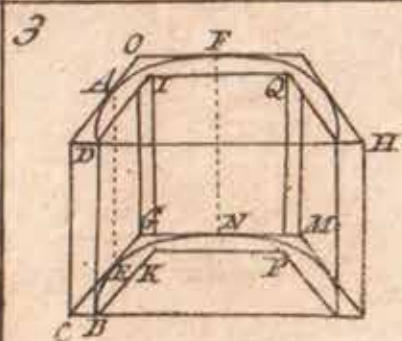
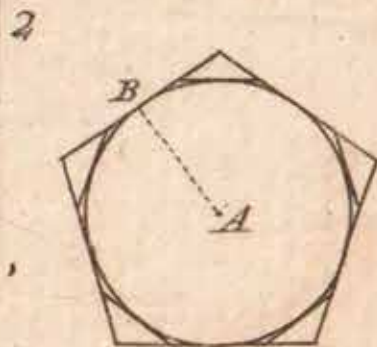
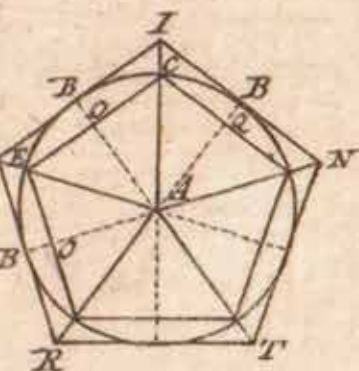
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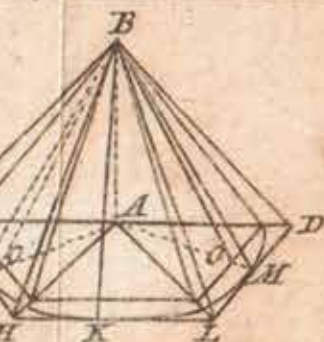
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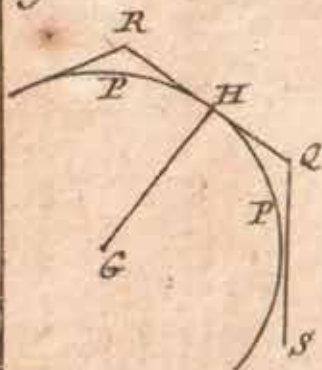
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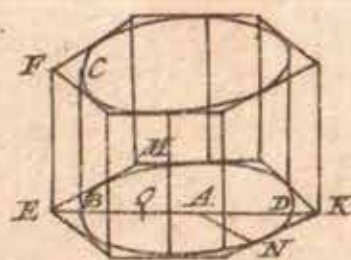
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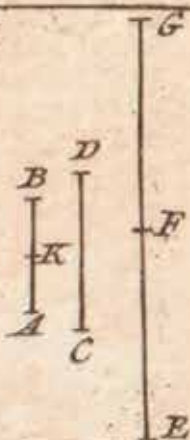
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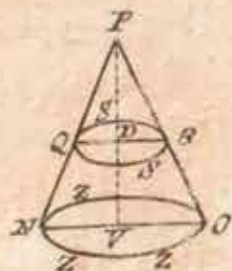
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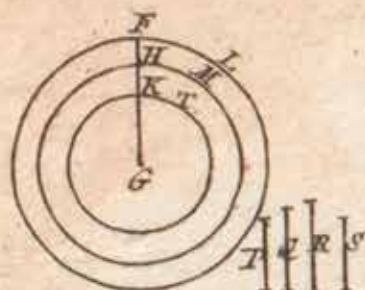
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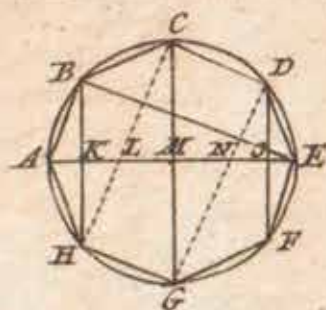
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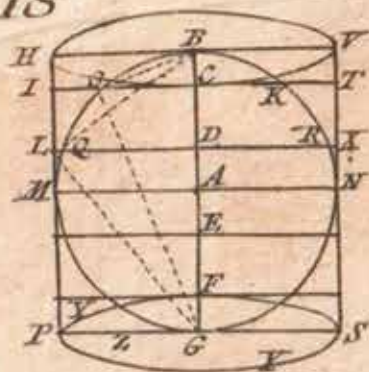
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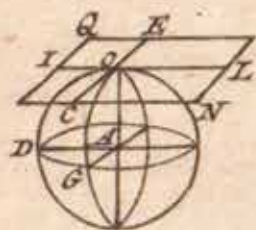
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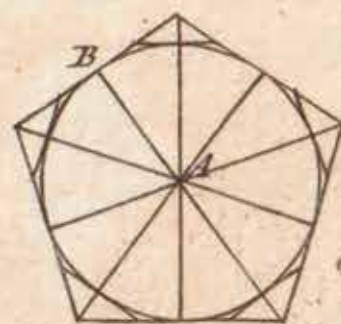
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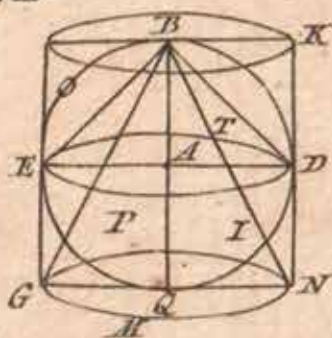
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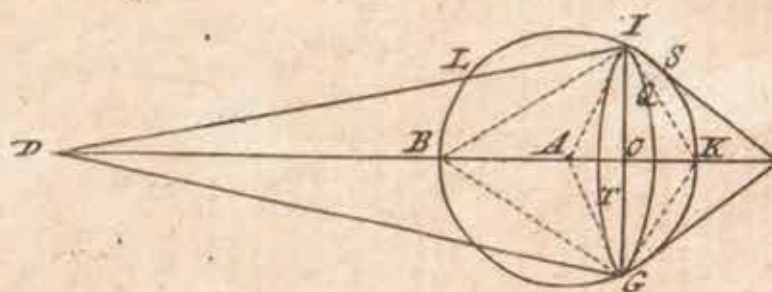
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# IS MATHEMATICS DISCOVERED OR CREATED?

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Mathematics evokes a range of opinions and experiences.

For mathematicians, and those who love learning about it, mathematics is a rich, beautiful field, full of surprises. It is a way of understanding the world and discussing it with others in an abstract language that they often see as a type of poetry. In practising mathematics, its disciples encounter the beauty inherent in its very nature. And they will always aim to produce ever more beautiful works of mathematical art. “Beauty is the first test: there is no permanent place in the world for ugly mathematics,” exclaimed the English mathematician G. H. Hardy (1877–1947) in 1940.

If you have other views of this ancient discipline, you might be thinking of its utility in everyday life, such as its association with accounting or the use of numbers and statistics in public communications. Or the use of geometry in architecture.

Put that aside for now. Hear Hardy’s cry that mathematics must be beautiful, first and foremost. This is an enduring view that shapes how *mathematicians* think about mathematics: whatever pattern and rule they notice and study, they will attempt to formulate it in an abstract, yet remarkably elegant, and beautiful, way.

The moment we mention the word ‘abstract’, however, the method through which mathematicians, using their own tools, create their art, we immediately run into difficulty. You don’t require specialised knowledge to be moved by a visual work of art; the forms, colours and composition speak directly to us in some way. The only problem is, people don’t usually notice this in mathematics, as most non-mathematicians can’t speak its language well enough.

<

*Geometry, from a series depicting the Seven Liberal Arts,  
Frans Floris the Elder, 1557.*

Nevertheless, you are invited here to be brave, and approach mathematics as if it were an art form. Throw yourself boldly into reading and looking at the images presented in this book, so you can learn a bit about this art. Depending on what kind of reader you are, you may want to start from the beginning or explore chapters in order of your interest. Or you might prefer to look at the images, enjoy them, and go from there. Before you is a journey that will introduce you to mathematics. All you need to do is let yourself enjoy illustrations related to mathematical discoveries and concepts. Above all, the snippets of the thrilling ideas behind these illustrations should have you basking in the beauty of mathematics as it slowly reveals itself to you. You will glimpse a reason for mathematicians wanting to engage with their discipline in the first place.

As with other arts, you might expect this book to be organised into chapters according to a central theme. And so it is here too - an overarching abstract idea is used instead of shapes, colours or words, so mathematical concepts and processes are grouped in chapters on ratio, patterns and symmetry, dimensionality, and so on. An essential aspect of experiencing mathematical beauty is to be able to focus on something and then 'zoom out'. This can be achieved by spotting a theme, that becomes a thread, that in turn runs through history, intertwining the different stories of people and cultures with the original abstract idea from which we started. Each chapter then follows a chronological order of developments.

But before we begin this journey, let's clarify a few things. We regard art as something created by humans. However beautiful natural patterns like snowflakes might be, we rarely consider them as art in their own right, except, perhaps, metaphorically. In such a case, we speak of nature as an artist crafting its own works. Art, on the other hand, would be a human interpretation of snowflakes in some form. With mathematics, it's much the same: the recognition of rules and patterns by humans, and the recording of what has been observed, is what makes mathematics what it is. This raises a peculiar question: are these laws and patterns mathematicians notice somehow part of a larger package, a piece fallen from a monolithic block of knowledge, handed down to us by some divine providence, like the image of a monolith at the end of this book? Or do mathematicians *invent* the order and meaning that result in mathematics? In other words, is mathematics discovered or created?

## GOD THE GEOMETER

To delve deeper into this question, we can ask whether this wondrous world of ours was created by a divine being and, if so, is that divine being not also a mathematician? Otherwise, how could things be so perfectly aligned and lead us to understand the order and beauty of the creation that results in mathematical rules? This type of thinking was prevalent in the Middle Ages, leading to God often being presented as a Divine Mathematician or, more precisely, a Divine Geometer. Although now considered to be more of an allegory, this image is a powerful reminder that there is an order that we uncover gradually through mathematics, as if mathematics itself were created by a divine being using divine instruments.

>  
*God the Geometer, illumination on parchment from  
a 13<sup>th</sup> century Bible, Codex Vindobonensis 2554, f.1  
verso. Austrian National Library.*





## A PRIEST OF DIVINE MATHEMATICS

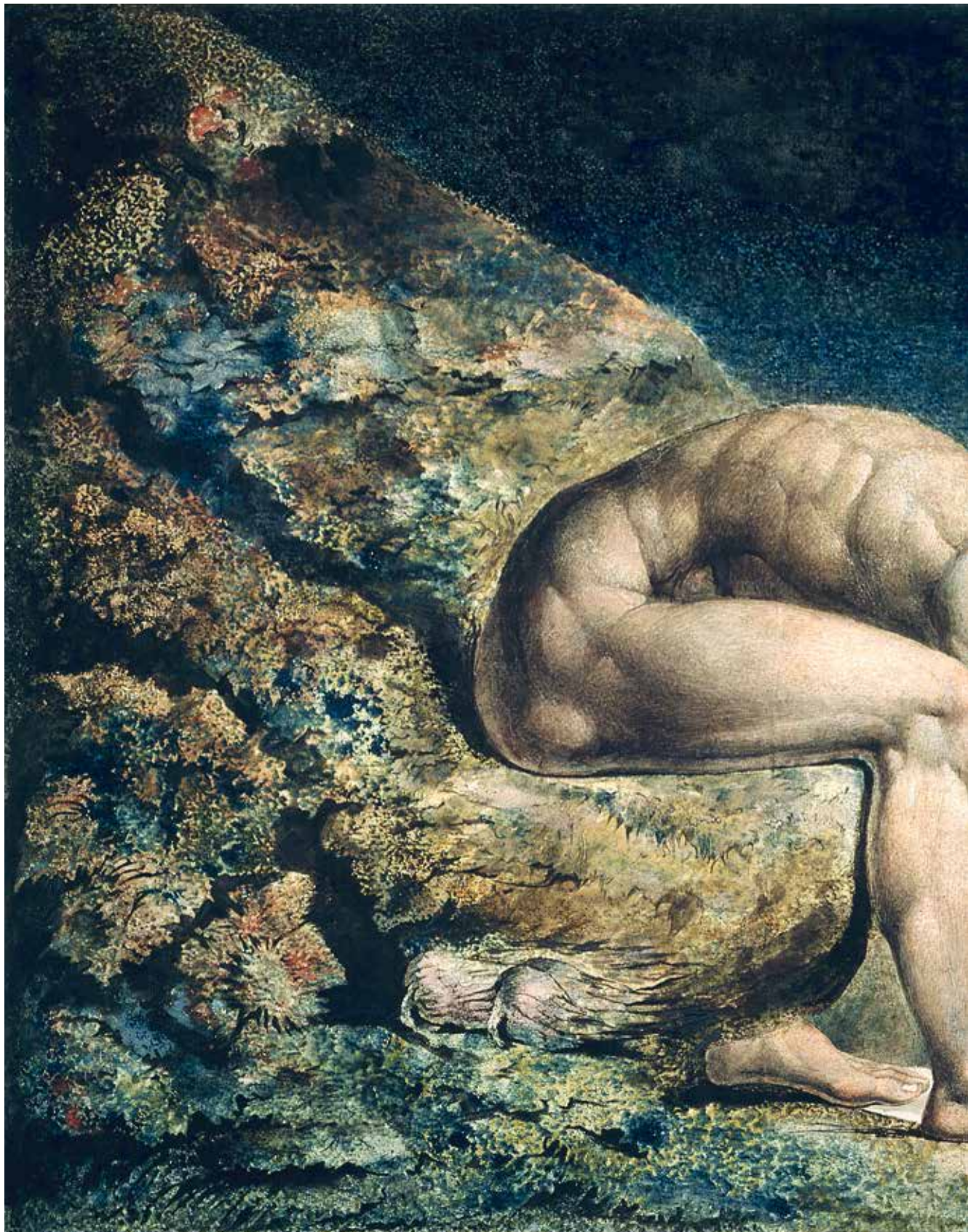
Once we humans think of something connected to mathematics, it's hard to stop thinking about it, even if, at that moment, we disregard it as inaccurate or imprecise. We'll see this motif repeated throughout the history of mathematics and revisited in chapters 6 and 7 of this book.

So, the story about God as Divine Geometer had a similar outcome. If God were indeed a mathematician, it was thought that his work would be better understood by those closest to her or him. This train of thought led to the question: who would such persons be? Well, those who learnt how to speak to God would certainly understand most clearly what God had in mind. Invariably this is the group of people (in each society, regardless of the god's name and nature) who comprise the priestly class.

A logical extension of that position is that, if a Divine Geometer created mathematics, a priestly class that understands and can interpret mathematics for the rest of us would inevitably claim a special authority over mathematical knowledge. But, unlike theories that don't require proving, mathematics does, otherwise it doesn't function. Therefore, revelatory mathematics would descend upon such priests not through thunder or flame, but through patient learning and daily practice. The moment of revelation would be no less sudden and beautiful. This type of thinking may certainly have contributed to most mathematicians also being trained as priests from the early 11<sup>th</sup> century when the modern university system originated, to the dawn of modern times. But then something else took place.

<

*Priest of Mathematics, Christopher Clavius, line engraving, 1606. Clavius was a Jesuit and German mathematician, physicist and astronomer, who was a member of the Vatican commission that accepted the calendar change from Julian to Gregorian.*



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Albrecht Dürer, *Melencolia I*, 1514. Collection of Städel Museum

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