Curiosity:
How Science Became Interested in Everything

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Introduction

Europe has paid the equivalent of at least $6 bn for the Large Hadron Collider at the particle-physics centre CERN in Geneva. Despite efforts to suggest that there will be useful practical spinoffs from this investment, I think it is clear that the main, and the proper, justification for it is pure curiosity about the profound questions that the LHC will explore. According to CERN's former Director General Robert Aymar, the LHC is "continuing a tradition of human curiosity that's as old as mankind itself." At a time when scientists are being told to justify their work in economic terms, this defence of science motivated by nothing more than inquisitiveness is essential.

But Aymar's image of a long-standing "tradition of curiosity", although widely shared by scientists, is too simplistic. There's evidently an evolutionary benefit in wanting to explore our environment – we're not the only animals to do that. But curiosity is a much more subtle notion, and our relationship to it has changed over the ages. We are unlikely to do justice to what curiosity in science could and should mean today unless we understand this history.

For a start, the word itself has had many meanings – too many, in fact, to identify any core concept at all. In earlier times, a "curious" person could indeed be an inquisitive one, but could equally be one who simply took care in what they did: both curiosity and care have their root in the Latin word *cura*. And it's not just people but objects too that may be described as "curious". This might mean that the object was rare, exotic, elegant, collectable, valuable, small, hidden, useless, expensive – but conversely, in certain contexts, common, useful or cheap.

And while in some sense the story of curiosity is indeed as old as humankind itself, its most significant phase occurs in the seventeenth century. During that period, the concept of being curious experienced a profound transformation – we can say that this is when curiosity went from being a vice to being a virtue. Some indication of that can be seen simply by counting the appearances of the words 'curiosity' and 'curious' in the books of that period (Figure 1). So what happened to enable this transition?

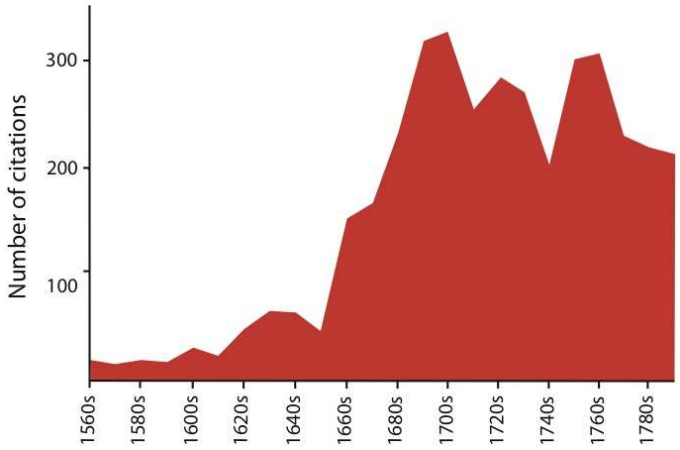

Figure 1 How the number of citations of the word 'curiosity' and its cognate terms in English-language books changed from the sixteenth to the eighteenth centuries. (After Neil Kenny, Univ. Oxford.)

Curiosity condemned

Until the late Renaissance, curiosity in the sense that is normally implied today – investigation driven purely by the wish to know – was condemned. But surely, you might say, the ancient Greeks were curious? Well, they were undoubtedly interested in how nature works; but they certainly wouldn't have described this as curiosity. For one thing, there was a clear sense of what was and what wasn't an appropriate focus of interest for natural philosophers – a hierarchy of relevance. What mattered were general rules, not minute particulars. And curiosity itself was considered to be not a desire for knowledge but an unwelcome distraction from attaining it. For Aristotle, curiosity had little role to play in philosophy: it was a kind of aimless, witless tendency to pry into things that didn't concern us.

In early Christianity it was worse than that. Now curiosity wasn't merely frowned upon, but was deemed sinful. The Bible told us all we needed – and should expect – to know, and made it clear that there were some things we were *not* supposed to know. God was said to have created Adam last so that he would not see how the rest of the job was done. And of course desire for forbidden knowledge led to the Fall of Man.

The transgressive aspect of curiosity is an insistent theme in Christian theology, which time and again demanded that one respect the limits of inquiry and be wary of too much learning. Deuteronomy says that 'The secret things belong to the Lord our God', and in Ecclesiastes Solomon declares that we should "be not curious in unnecessary matters, for more things are shewed unto thee than men understand." For Saint Augustine in the fifth century, curiosity became a "disease", one of the vices or lusts at the root of all sin. He wrote that "It is in divine language called the lust of the eyes.

So in the Middles Ages and the early Renaissance, curiosity was viewed with a great deal of suspicion, and often outright condemnation. It was a vice. So there was a lot of work to be done before the early modern scientists of the seventeenth century – men like Galileo, Johannes Kepler, Robert Boyle, Robert

Hooke and Isaac Newton – could express their curiosity freely. Popular accounts of the so-called Scientific Revolution in that period often seem to imply that these men began to ask questions merely because of their great genius. Needless to say, it wasn't as simple as that. Undoubtedly these people did have exceptional minds, but exceptional minds did not in themselves suddenly start to appear in the seventeenth century. So what was it that enabled curiosity to flourish at this time?

There isn't a simple or single answer to that, but I believe it's possible to identify some of the key factors. One was the influence of the Renaissance itself, and in particular the emergence of humanism, which reformed culture and education by challenging the medieval tradition of scholasticism. This had tended to pursue learning by rote and by the pedantic inspection of a narrow body of classical texts. Humanism made it acceptable to challenge this ancient knowledge, and it emphasized the benefits of writing and speaking clearly and eloquently.

In the sciences, most thinking had long been dominated by the ideas of Aristotle on physics, and of Hippocrates and Galen in medicine. But in the Renaissance some scholars, often at the fringes or outside of the academic world, began to suggest that perhaps these ancients didn't know everything after all. They also suggested that the best way to find out about the world was not to read old books but to rely on experience – to try things out for themselves, or in other words – and we have to be careful about the way we use this word – to experiment.

Many of these iconoclasts were in one way or another interested in the tradition known as natural magic. This form of magic didn't mean superstition and spells, but more or less the exact opposite. It was a belief that nature was governed by occult forces, meaning literally that they were hidden and invisible. Such forces did and do exist: magnetism is one, and so is gravity, and it was precisely because Isaac Newton was an heir to the natural-magic tradition that he was prepared to invoke this occult force to explain the movements of the planets. These hidden forces provided the framework for understanding a wide range of phenomena according to strictly mechanistic and rational principles, and they helped to erode and replace the teleologies of Aristotle. After all, which explanation would *you* rather believe for why bodies fall to earth: because it is in their nature to do so, as Aristotle said, or because some occult force pulls them down?

Academies of secrets

Perhaps the definitive work on this view of the world was one simply called *Natural Magic*, published in 1558 by perhaps the most under-rated of predecessors to the scientists of the following century. His name was Giambattista Della Porta, and in the late sixteenth century he was one of the most celebrated natural philosophers in Italy. Della Porta's *Natural Magic* portrays nature as a treasure trove of secrets that can and should be pried open. That image more or less characterizes the scientist's view of the world for at least the next hundred years, and arguably still applies today. And Della Porta didn't pursue this mission alone: instead, he convened at his home in Naples one of the first proto-scientific societies, called the Accademia dei Secreti, the Academy of

Secrets, who came together to tease out nature's secrets by careful observation – at least, until it was closed down in the 1570s by the Inquisition.

Societies dedicated to studying nature sprung up all over Italy in the late sixteenth century, and one of the most significant was begun in 1603 by Federico Cesi, an 18-year-old young duke of Umbria. It had just four members, all idealistic young men, and because they liked to imagine themselves as being keen-eyed observers, a legendary attribute of the lynx, they called themselves the Accademia dei Lincei, the Academy of Lynxes. Cesi's father disapproved of these modern ideas and ordered his son to disband the group; but when he died in 1610, Cesi lost no time in resurrecting his plans. He wrote to the now elderly Della Porta in Naples and asked him to become the academy's fifth member, which Della Porta did. A year later, the academy acquired its sixth member when Cesi went to a banquet and met an astronomer who had just astounded all of Europe with a booklet describing new discoveries made with the telescope. And that was how Della Porta found himself in an exclusive little club with Galileo.

The book that brought Galileo to Cesi's attention illustrates another key aspect of the emancipation of curiosity. This book was called *Siderius Nuncius*, *The Celestial Messenger*, and in it Galileo announced that using the newly invented telescope he had seen four new 'stars', - actually moons – orbiting the planet Jupiter. He also reported that our own moon was not the perfectly smooth sphere assumed by Aristotelians, but was rugged, with mountains and valleys. Galileo explained that these were revealed by the highlights and shadows visible in the telescope as light glanced across the moon's surface at the border of the sunlit and shadowed regions (Fig. 2). In other words, the moon was a world rather like ours.

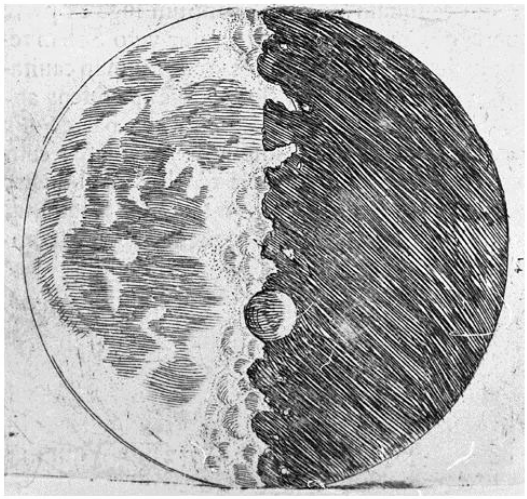

Figure 2 Galileo's sketch of the moon as a world with rugged terrain, picked out in light and shadow at the boundary of the sunlit and dark sides.

This revelation of new worlds is a recurring theme during the liberation of curiosity. Galileo's discoveries impressed writers and poets such as John Donne and John Milton. Galileo's observation that the Milky Way is not some cloudy vapour but millions of stars left them astonished at the scale of the universe and the multiplicity of worlds it contained, making our home planet seem even more

puny and incidental. This awesome, infinite void is precisely the view we get in Milton's epic poem *Paradise Lost*. Milton visited Galileo under house arrest, and probably looked through his telescopes. He described what he saw more memorably than Galileo ever could:

> A broad and ample road, whose dust is gold,
> And pavement stars, as stars to thee appear
> Seen in the galaxy, that milky way
> Which nightly as a circling zone thou seest
> Powdered with stars.

These visions of new worlds in the cosmos spawned a literature of space travel in the seventeenth century. One of the founders of the Royal Society, John Wilkins, gave the first factual picture of the moon as another world in his 1638 book *Discovery of a New World in the Moon*, but he'd already been anticipated in a work of early science fiction written around 1628 by Francis Godwin, the bishop of Hereford, called *The Man in the Moone*. Godwin's hero reached the moon by tethering a craft to giant geese which migrated there annually – a possibility that Wilkins took seriously. Other cosmic-voyage books followed, most notably two novels by Cyrano de Bergerac called *The States and Empires of the Moon* and *The States and Empires of the Sun*.

As all of these works testify, there was another influence on this interest in new worlds, which was naturally enough the discovery of the New World itself – the voyages to America. Ever since the return of Columbus, Europeans had been coming to terms with the realisation that there was more in the world – more peoples, customs, plants, animals, medicines and minerals – than could be found in the works of Aristotle or the compendia of Pliny and other classical writers (Fig. 3). This supplied a spur to fresh curiosity, sharpened by the possibility of exploiting these new-found riches for commercial gain.

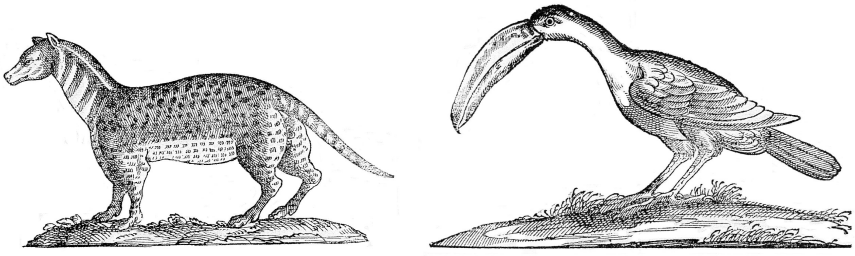

Figure 3 A Mexican civet and a toucan from Frnacisco Hernández's *Mexican Treasury* (1651).

These explorers, voyaging both east and west, brought back many specimens which were avidly bought by collectors in Europe. Collecting rare and precious natural objects had been an obsession among European nobles ever since the late sixteenth century, which they displayed in so-called cabinets of curiosities. To many of the earliest collectors these treasure troves were symbols of power: not just, or even primarily, because of their financial value but because they were supposed to represent a kind of world in microcosm. The Flemish physician Samuel Quiccheberg, who looked after the collection of the Duke of Bavaria, called the cabinet a "theatre of knowledge". It was a sort of a stylized

representation of all that could be thought or seen in the world. A cabinet was not literally a single piece of furniture but any enclosed space – the larger ones, like that of the Holy Roman Emperor Rudolf II here in Prague, might occupy several rooms, usually crammed with objects from floor to ceiling. By possessing this microcosm the noble collector wasn't just symbolizing but also in a sense *exercising* his mastery of the world. The cabinet acted as a kind of mental laboratory within which the relationships between things could be contemplated. This was a pre-scientific mode of finding or asserting order in the world.

By the mid seventeenth century, these collections were becoming something in between a cabinet of curiosities and a repository of samples of natural history. One of the finest collections in England was that of the botanist John Tradescant, the gardener of the English king Charles I, who allowed any visitor into his house in London to see it for a modest fee. In other words, it became essentially a museum. After the death of Tradescant's son in 1662, this collection was acquired by the English antiquarian Elias Ashmole, who bequeathed it to Oxford University on condition that it be housed in a grand building named after him – the first genuine museum in the country, called the Ashmolean. Meanwhile, the collection of the Irish physician Hans Sloane, who succeeded Isaac Newton as president of the Royal Society in 1727, was donated on his death to the king George II, and formed the basis of the British Museum, created in 1753.

So by the middle of the seventeenth century, all elements were in place for an institutionalized programme of curiosity. The notion of a scientific society was well established, especially in Italy. There was a tradition of finding out about the world by experimentation and observation, and a precedent for knowledge acquired by experience rather than by classical authority. The telescope had shown the advantages of using instruments to enhance human perception, and by the 1620s the microscope had been invented too. And in the 1620s the English philosopher Francis Bacon argued the case for why a systematic programme of knowledge collection based on these principles and instituted by a kind of scientific brotherhood would be valuable to the state. It was in the context of all these developments that a group of natural philosophers gathered around John Wilkins while he was warden of Wadham College in Oxford to form what they called an experimental club for pursuing and popularizing the new experimental philosophy. This group moved back to London after the restoration of Charles II in 1660 and took to meeting in Gresham College, and in November of that year they decided to formalize their meetings and applied for a royal charter to create what became known as the Royal Society.

But in its early days the society went about its business very differently from what we normally expect of science today. It accumulated supposed facts, many of them strange and fantastical, in much the same way and the same spirit as collectors of curiosities amassed objects. And these lists of facts, recorded for example in the society's journal the *Philosophical Transactions*, show us just what had changed about the nature of curiosity. In earlier ages, questions about nature had tended to be limited to what was obviously useful, or important, or universal: why plants grow, why winds blow, why we get sick, how the stars and planets progress across the sky. But now nothing was out of bounds: any

question was permissible, however odd or seemingly inconsequential. At the Royal Society, the slightest blemish seen on the surface of a distant planet might spark earnest and learned debate, or why fleas can jump so high, or why concentric coloured rings could be seen in flakes of mineral under the microscope. This was all interesting; arguably it was progress – but it wasn't yet true science.

A preference for gathering facts and observations rather than making interpretations and theories is particularly clear in Robert Boyle's famous studies using the air-pump, a hand-pumped instrument for producing a near-vacuum (Fig. 4). The question of whether or not a vacuum could exist in nature was highly contentious at that time. Boyle seemed to be one of the people best placed to address that issue, but he wouldn't do it. He simply recorded what he saw in his experiments as accurately as he could, without commenting on the question of whether his instrument's glass dome contained a vacuum.

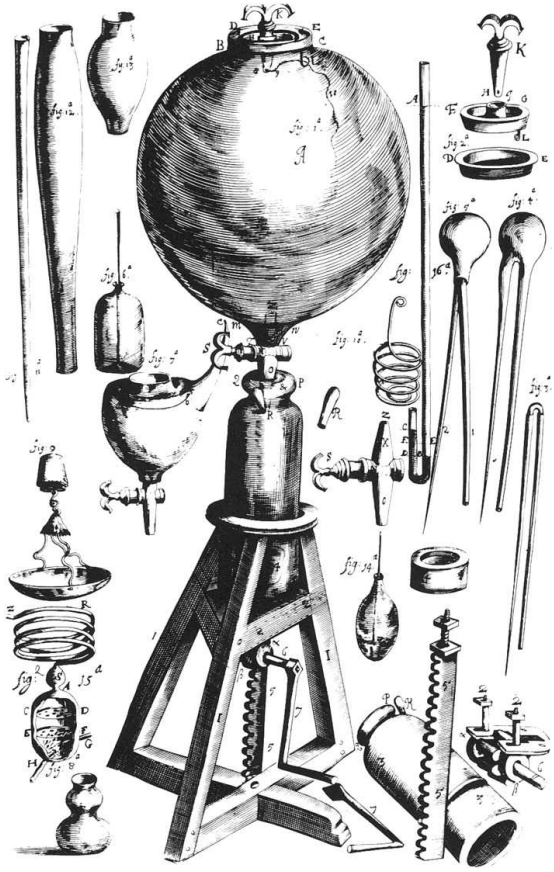

Figure 4 Robert Boyle's air pump.

To some of the people who were opposed to the experimental philosophy, such as Thomas Hobbes, Boyle's air-pump studies epitomise the problems with the whole experimental approach. Hobbes objected to the idea that you could find out about nature by using complicated instruments and devices that create non-natural states, such as globes emptied of air, or lenses that magnify and perhaps distort light. Today the use of scientific instruments is relatively uncontroversial – no one seems to worry that the Large Hadron Collider is claiming to pronounce on the beginnings of creation by creating conditions that don't exist today in

nature, not least a vacuum more extreme than that in interstellar space. But the validity of doing this wasn't at all obvious when modern science was beginning.

If Boyle was renowned for his air-pump, what made his assistant Robert Hooke famous was his experiments with the microscope. These gained authority and impact from the way they were presented, most memorably from Hooke's spectacular drawings of his observations printed at large scale in his 1665 book *Micrographia.* This begins with the mundane peculiarities of human art, describing what printed letters or the texture of cloth look like when magnified. Then it moves through minerals like sand and charcoal to the vegetable world of mould, sponges and seeds, including the first description of biological cells, seen in a slice of cork. It culminates with the amazing spectacle of the insect world, using specimens mostly drugged with brandy – they tended to shrivel up if they were killed. The masterpiece is the head of a fly, decapitated and glued onto the sample stage with multi-faceted eyes staring opaquely into the lens [Fig. 5).

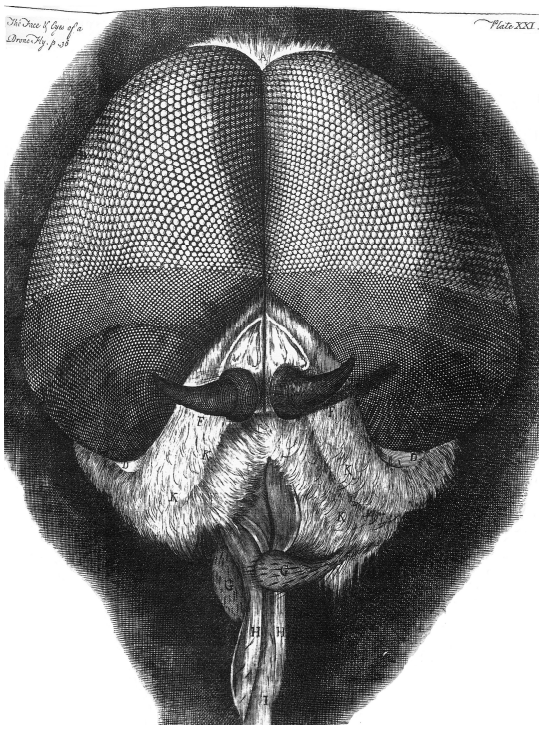

Figure 5 A fly's head, as seen through the microscope and drawn by Robert Hooke in *Micrographia* (1665).

If instruments like the microscope presented the natural philosopher with the happy prospect of finding riches wherever he looked, it also eroded any distinctions about where one *should* look – in the dust on the shelf and the mould in the ill-tended larder, there was more than enough to occupy the curious mind for days and weeks, perhaps a lifetime. You could almost be forgiven for suspecting that the early microscopists were unduly drawn towards the lowliest forms of matter, to cinders and decay, urine and faeces, spit and sperm. To find such things worthy of 'serious examination' could seem not merely perverse but perverted.

And that was a real problem for the Royal Society: what they were up to often looked very odd to the world outside. Although some people continued to

disapprove of these activities on the grounds that they were impious, far more harmful now was the risk of ridicule.

Hooke was reminded of that in 1676 when he went to see a new play by the well-known playwright Thomas Shadwell called *The Virtuoso*. It turned out to be a satire on the activities of the Royal Society, personified by the bumptious clown Sir Nicholas Gimcrack, who first appears in his study lying face down on a table and imitating the motions of a frog. He explains to his visitors that he's learning to swim, but only by focusing on the theory. By implication, this was all the Fellows of the Royal Society were doing: wasting their days in absurd activities that had no practical benefit, or making hypothetical claims that are never actually realized.

Worst of all, Hooke realised that *he* was the model for Gimcrack. Shadwell's ridiculous virtuoso experiments with an air pump and, according to his niece, has "spent two thousand pounds in microscopes to find out the nature of eels in vinegar, mites in a cheese, and the blue of plums" – all of these being things Hooke had described in *Micrographia*. And audiences loved it, including the Royal Society's patron Charles II, who never seemed to take their efforts very seriously. Several of the Royal Society's members admitted that this mockery was more damaging than were the philosophical criticisms of serious-minded people like Hobbes.

Well, curiosity and science seem nevertheless to have survived the satirists, although of course you don't have to look too far to find the same caricatures of unworldly boffins today. In fact, scientists are now apparently confident enough to flirt with these stereotypes themselves, as for example in the Ig Nobel prizes, awarded annually for research that is either spectacularly silly or, more often, just looks like it. Past winners include the real physics Nobel laureate Andre Geim, who won it for the magnetic levitation of a frog.

And yet science still has a tricky relationship with curiosity. There are very well motivated complaints from many scientists that research driven purely by curiosity is not supported or valued enough. But they don't quite trust this argument, and so they yoke it to a utilitarian defence: that you never know where curiosity will lead, and that important innovations and discoveries have often come from it. This is true enough, but it becomes increasingly tenuous and unlikely when applied to a project like the LHC. Curiosity still can't quite be trusted to be its own justification.

Perhaps it never has been. The history of curiosity suggests that it has always been accompanied by an agenda. For the academies of secrets it was a desire for quasi-magical power to manipulate nature. For Francis Bacon, curiosity was an engine of state power. For Robert Boyle it was a religious duty to understand all the corners of God's creation. Robert Hooke's voracious curiosity was accompanied by a desire for recognition. None of this is by any means to condemn curiosity, but it does suggest that we might be more thoughtful about what is really driving curiosity today.

Both wonder and curiosity are often used to justify Big Science projects like the LHC, or NASA's new Mars rover, which of course is actually called *Curiosity*, or

the Hubble Space Telescope, which gives us images coloured and framed to look like nineteenth century paintings of nature (Fig. 6).

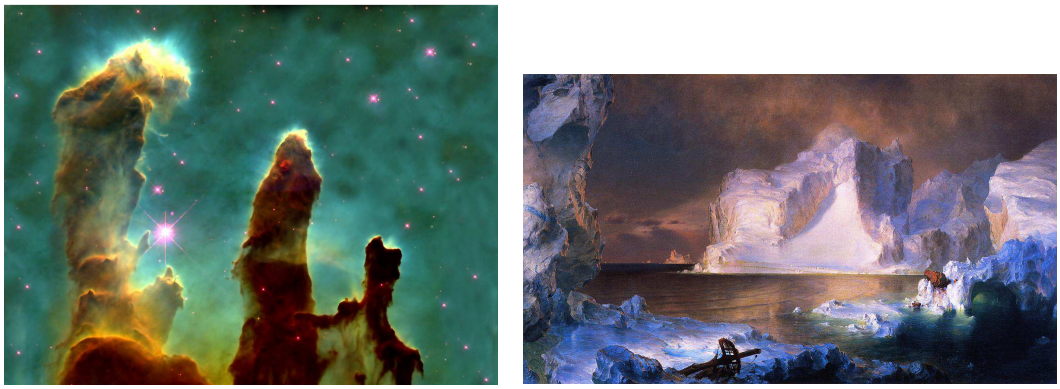

Figure 6 Astronomical sublime: the images from the Hubble Space Telescope evoke nineteenth-century paintings of awesome nature.

But however well motivated they are, one has to ask how much room is left in huge, costly international collaborations like this for the sort of spontaneous curiosity that would allow Hooke and Boyle to follow their noses. Can we really have "curiosity by committee", a consensus about where curiosity should direct us? That's why we shouldn't let Big Science blind us to the virtues of Small Science, of the benchtop experiment, the real heritage of della Porta and Boyle and Hooke, which often makes do with cheap, improvised equipment and leaves space for trying out hunches and wild ideas, revelling in little surprises, and indulging in science as a craft. Experiments like this may turn out to be fantastically useful or spectacularly useless; they are the result of nothing more than the questions "can we do this?" and "what if we do that?". They are each little acts of homage to curiosity, and in consequence, to our humanity.

This talk was based on Philip Ball's book Curiosity: How Science Became Interested in Everything *(Bodley Head, 2012).*
