FOUR

Mysterious Reds

With ingenuity and effort, hidden reds can be brought out into the open – mined from the earth or extracted from plants or animals. Yet other red things can be made from things that are not themselves red. These reds are born in fire and are known as 'synthetic' or 'artificial', terms which today carry with them a certain suspicion. Here I try to look at them in a more positive light, exploring the fact that 'synthesis' involves bringing things together and is the polar opposite of analysis, which involves pulling things apart. I also aim to acknowledge the art in 'artifice', recognizing that while the word has recently come to mean 'shallow, contrived and almost worthless', for over 2,000 years, it meant 'full of deep skill and art'.[1]

We generally assume that artificial reds are modern, but they are as old as humankind. In fact, the valuing and making of these reds is one of the key features that archaeologists and anthropologists have used to define human beings, since the decorative use and making of colour provides physical evidence of shared symbolic activity.[2] Red earths were collected in prehistory and they were valued for their colour thousands of years before they became valued as sources of iron. However, yellow ochres were also collected because – almost magically – they could be turned red. The very first artificial red to attain widespread cultural value was an earth that changed colour beneath the campfire.

The initial transformation of a yellow into a red may have been fortuitous but it took observation and skill to turn it into a repeatable operation. Pioneering cavemen and women had to recognize which particular rocks would change colour, since most did not, and then the once-yellow-now-red rock was buried under ash and cinders so it had to be separated from the remains of the fire. This is because the best colours and the most dramatic colour changes happened with very soft and crumbly rocks that broke easily. Red fragments and powder could have been retrieved from cinders and ash using breath or the wind, like 'separating the wheat from the chaff', or by using water, with cinders floating, ash dissolving and red rock settling. All this was reliably worked out tens of thousands of years ago and technical details were recorded nearly 4,000 years ago.[3]

Hints about the significance of changing yellow into red can be found in the Greek name for yellow, *ochros*, which meant, among other things, 'lifeless'.[4] Red, on the other hand, has always been associated with life. Burning ochre appeared to awaken or revive a mineral life force. Making reds from earths has continued ever since, with blocks of yellow ochre burned in kilns custom-built for the purpose. Today, analysis of changes in crystal structure can show whether prehistoric red stones are natural or artificial in origin.[5]

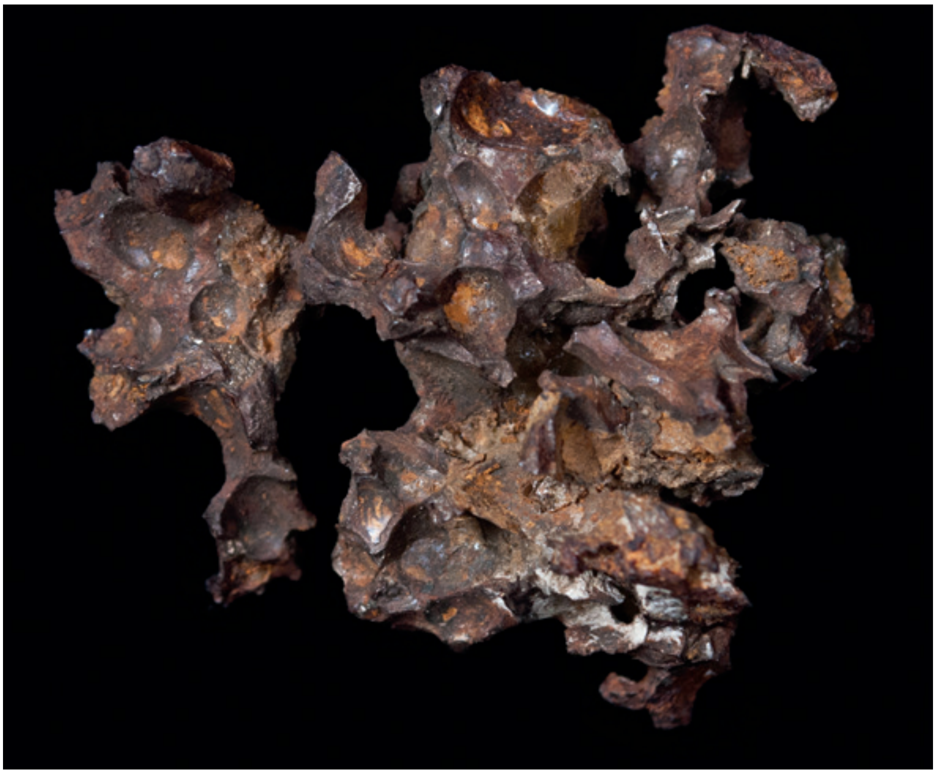
23 Yellow ochre together with a piece of the same rock transformed after an hour or so in a campfire. The once-yellow-now-red piece split once pulled from the fire and shows a rich red through the whole stone.

We can easily imagine that the ability to take yellow earth and, at will, turn it red may have been discovered accidentally in the course of everyday life. However, unwavering exploration was required to discover the other synthetic or artificial reds. They were the result of enormously complicated activities which purposefully transformed raw matter, and they were not at all related to anything required for subsistence living. These activities were not the preserve of full-time specialists, nor were they necessarily the preserve of males – they were a magical form of play. Until quite recently, all the synthetic reds that people managed to make came from a rather special type of material – an ore, or a stone that could be processed to make metal.[6]

Iron ores

The origin of iron smelting is lost in the mists of time and the standard story is that it was discovered accidentally while firing pottery. This is highly unlikely. The first pottery was decorative and ornamental, not utilitarian, which suggests that firing started as part of ritual or symbolic play with a culturally significant material – sculpted clay. Clay utensils came later. The utility of fired clay was a happy side effect of experiments in decoration and ornamentation. It is therefore possible that iron smelting arose because the metal's raw materials – yellow ochre, haematite or red earth – were already valued rocks and were therefore the focus of cultural attentions. These attentions must have included, at some point, the explorations that eventually produced iron. In other words, the later utility of haematite or red earth – as the source of iron – is most probably due to their earlier significance as stones prized for their redness. Nearly 500 years ago, the author of a German textbook on mineralogy said that colour was the single most important quality when it came to judging stones. Yet the significance of colour is only just beginning to be appreciated in modern archaeology.[7]

Palaeolithic playing with mineral reds could be compared with mankind's engagement with another type of stone. It has



24 Fragment of the Krasnojarsk pallasite meterorite that fell on Mount Bolshoi, Russia, in 1749. This particular type of stone-and-iron meteorite is rare but, since the 18th century, several metric tonnes of iron meteorites have been collected.

been suggested that, at the same time that people shaped stones, stones shaped people's ways of thinking. Flints 'told' people where to hit them in order to make sharp flakes and the modified shapes 'told' people about the possibility of tools that could cut. Similarly, the colour change in burnt ochres 'told' people that they contained something active and worth pursuing. Human intelligence is not located inside the skull, or even only within the skin – it is distributed across the mind, the body and the environment, and it emerges through our conscious interaction with matter.[8] It is most probable that the ultimately world-changing technology of iron smelting emerged from symbolic play with, and valuing of, redness. If flint stones were co-creators of the Stone Age, then red stones were co-creators of the Iron Age.[9]

The oldest red stones to be valued culturally – as well as the yellow ones that were converted into reds – were ores of iron. These natural and synthetic reds had magical associations, and similarly magical powers were associated with the extraction of their iron.[10] The prehistoric discovery of how to make iron revolutionized agriculture and warfare and brought with it powers which had to be controlled, socially and politically. The powers derived from a red rock conferred special significance upon the smith in many cultures and, throughout the world, smelting ores and forging metals became surrounded by webs of taboo, ritual and myth.[11]

In the British tradition, faint echoes of the ancient powers associated with the smith's ability to extract metal from stone can be found in Arthurian legend. There, the 'true king' was identified as the one who was able to 'draw the sword from the stone'.[12] Now, extracting a steel weapon from a rock was a skill that only a smith possessed because – although gold, silver and copper can occur as metals – iron is never found as a metal on earth.

Actually, to be strictly accurate, iron did not occur as a metal *in* the earth but was, very occasionally, found *on* the earth's surface in the form of meteorites. Metallic iron meteorites fell to earth and the places where they fell were often turned into cult centres, while the metal was usually turned into tools with ritual uses. When Cortés asked the Aztecs where they got their iron, they pointed to the sky. The Sumerian for 'iron' is a combination of the pictograms for 'sky' and 'fire' while the ancient Egyptians called it 'metal from heaven'. Meteorites, or 'thunder stones', were generally seen as weapons of the gods.[13]

Yet meteorites fall much too rarely to feed an iron industry. Heavenly iron originally had spiritual value and iron attained its now familiar military value only after people learned how to deliver the metal from red earth. The fact that smiths usurped the heavenly source and exploited an earthly source – together with the value of their output – added to the mystery of their craft. Their extraction of iron from ores involved ochres, plus chalk, limestone or ground-up shells and breath blown through pipes or, later, air forced by bellows.[14] In the thirteenth century, Albertus Magnus said that iron was 'purified by many strong fires, which force it to distil out of the substance of the earth or stone, with the very bowels of which it seems to be united'.[15]

The power to manipulate nature – to sidestep heaven, to identify the appropriate earthly stone, roast and smelt the ore then forge the metal – was embodied in the craftsperson, in their raw materials and processes, and in the objects they crafted.[16] In Arthurian legend, that power was reflected in Excalibur (drawn from the stone by fire and breath) and in the king as well as in his kingdom, which he 'forged' by harnessing his people's true 'mettle'. In wider culture, that power was embodied in red.

In prehistory, something like Excalibur's powers resided in synthetic or artificial red ochres that were made and collected by Palaeolithic cave dwellers. In more recent history, similar powers resided in the other sinopia or *miltos*, and cinnabar, as well as in the artists, apothecaries and alchemists who knew its secrets. Those powers might also be transferred to things painted with cinnabar, like the statue of Jupiter and his celebrants that Pliny was 'at a loss to explain'. They were certainly associated with the mercury that was extracted from cinnabar and the vermilion that could be made from that mercury.

Vermilion

The reds that the ancient Greeks traded through Sinope included cinnabar (the similarity of the words 'cinnabar' or *cinabro* and 'sinopia' hints at the distant historic connection). Although cinnabar was not valued as a red pigment it was highly valued as an ore. Just as red ochres were smelted for their iron, cinnabar was smelted for its mercury. Cinnabar was full of mercury and getting it out of the stone was much easier than getting iron out of red earths. Even buried underground, the red cinnabar could actually 'sweat' little silvery beads of the liquid metal. The fact that cinnabar was constantly releasing mercury explains Theophrastus' reports of deadly suffocating air in the 'Sinopic *miltos*' mines.[17]

The earliest evidence of cinnabar mining is late Neolithic, around 4,000 years ago,[18] but, by the time of recorded history, it is clear from Theophrastus that everyone knew the risks of playing with cinnabar and mercury. Around the time of Christ, bladder-skin masks were recommended to prevent inhaling dust when working with cinnabar. At the Spanish Almadén cinnabar mines, where security was 'second to none', local processing was

25 Piece of cinnabar from Hungary acquired by Sir Isaac Newton in 1669, probably intended as raw material for his numerous alchemical experiments. The grey colour is due to the red rock's surface coating of mercury droplets.

forbidden and 900 kg of the ore were sent annually to Rome. A thousand years later, artists and scholars warned of the threats to health that vermilion posed to those who worked with it.[19]

Stones were usually described in lapidaries, a type of book that was for minerals what herbals were for vegetables and bestiaries were for animals. Albertus Magnus wrote such a lapidary – *Book of Stones* – but it doesn't mention cinnabar. Nor, except in passing, does he mention it in his *Book of Intermediates*, or ores. Yet in his *Book of Metals* he calls it 'the stone in which [quicksilver or mercury] is produced'.[20] Albertus Magnus was not alone in writing about cinnabar in the context of metals. Pliny wrote about it in his *Book of Silver and Gold*, saying that it was 'found in silver mines'.[21] The main interest in cinnabar seemed to be its connection with metals since it was the ore for mercury, which was used in the purification of silver and gold.

When cinnabar was heated to extract its liquid mercury, vast clouds of noxious sulphur fumes were released, so it was crystal clear to the ancients that cinnabar was a natural mixture of mercury and sulphur. Since all the metals were related – they were seen as various stages of perfection, from lead, the basest, to gold, the most noble – mercury and sulphur were thought to coexist within each of the metals, and differences between them were due to the purities and ratios of mercury and sulphur. In the words of Albertus Magnus, 'in the constitution of metals, Sulphur is like the substance of the male semen and Quicksilver [also known as Mercury] like the menstrual fluid that is coagulated into the substance of the embryo.' This idea was enduring, and a seventeenth-century alchemical treatise claimed that both Nature and Art made metal from Sulphur and Mercury.[22]

Red earths and red cinnabar were early stages in Nature's slow subterranean ripening of metals. It was widely believed that the smith's arts of smelting were simply speeded-up versions of natural processes. In addition to the art of making metals from ores, the related alchemist's arts could also help the metals on their way to perfection, from lead through to gold. (So, by the Middle Ages, burning yellow ochre to make a red ochre would be seen as helping Nature on her first step towards iron and, ultimately, gold.) The alchemist's art was colour-coded and, in that code, red was very significant indeed.

Albertus Magnus said that 'alchemists wishing to make gold seek for the red elixir', which was also called 'the red of the Sun' and 'the medicine of the Sun'. Albertus also described the synthesis of 'a shining red powder'. That red powder was the 'red elixir' or the Philosopher's Stone, which the alchemist Roger Bacon claimed was made of sulphur and mercury.[23] So, alchemists sought the red powder made of sulphur and mercury in their quest to make gold. And while ordinary painters used the red powder made of sulphur and mercury as a pigment, they also used it in an elixir-like way to make a range of synthetic gold-coloured pigments.[24]

In his painting manual, Cennino Cennini said that his best red pigment, vermilion, was 'made by alchemy'. He also knew how to make it, but did not include details, simply saying 'you will find plenty of [recipes] for it, and especially by asking of the friars'.[25] He implied that making vermilion was common knowledge and suggested that you bought it from the apothecary instead of making it. However, in another painting manual written a few centuries earlier, details of red vermilion's synthesis were included. Theophilus said,

> take sulphur . . . break it up on a dry stone, and add to it two equal parts of mercury, weighed out on the scales. When you have mixed them carefully, put them into a glass jar. Cover it all over with clay, block up the mouth so that no fumes can escape, and put it near the fire to dry. Then bury it in blazing coals and as soon as it begins to get hot, you will hear a crashing inside, as the mercury unites with the blazing sulphur. When the noise stops, immediately remove the jar, open it and take out the pigment.[26]

In practice, the process is more difficult than Theophilus' recipe suggests and many aspects of it were extremely dangerous. In brief, it involved finding a red vein of crystalline mercury sulphide and mining it at great risk, then burning it to drive off the choking sulphur and leave pure toxic mercury. That mercury was recombined with more sulphur – collected from a volcano – then placed in a fire to make red crystals. A modern chemist (as opposed to a medieval alchemist) would ask, why bother? As far as modern science is concerned, the red thing you ended up with was exactly the same as the red thing you started out with – you broke something down then stuck it back together again. But to the alchemist and to the painter, the initial red, cinnabar, and the final red, vermilion, were very different. The added value embodied in crystals of vermilion was an immeasurably greater level of personal engagement with the colour. The experience could offer insights into the nature of red, into their own nature and into the nature of all things. The alchemist respectfully took the opportunity to choreograph an elemental dance in which the leading couple parted, each taking the limelight for a solo

performance, before eventually rejoining with a fuller appreciation of their other half's individual qualities. The alchemist was a participant in, and witness to, an inorganic love story.

The synthesis of vermilion from cinnabar gave artists, apothecaries and alchemists the opportunity to engage profoundly with the basic structure of the material world. The process involved taking a solid and simultaneously creating from it a liquid and a vapour, then taking the liquid and mixing it with a solid to make another solid. The process went through various colours, from a red (cinnabar), into a silver (mercury), mixed with a golden red-yellow (sulphur), going through black (meta-cinnabar, a stage that Theophilus discreetly missed out of his recipe) and finally back to a red (vermilion).

This was a colour-coded journey through different states of being upon which the intrepid experimenter could meditate. The key stages in that journey were white, black and red, which artists recognized as being the same sequence of colours that charted the alchemical quest.[27] The final red physically embodied the mysteries alluded to in the mythical creation of dragonsblood from hylomorphic 'form' and 'matter' in the guise of elephants and dragons.

Nobody had to make this particular red but, at considerable risk to their health, many did and making vermilion was the most commonly repeated recipe in all medieval manuscripts.[28] Alchemists, apothecaries and artists all made it, but its synthesis is also found in collections of household recipes, along with how to make soap and even soup. The desire to make red vermilion spanned the whole of the Old World. For example, on his journey east, Marco Polo reported 200-year-old yogis in India who made and regularly took a potion – reminiscent of the kermes cordial – which was made from (presumably homeopathic quantities of) mercury and sulphur.[29] On his journey to the west, the Monkey King met Taoists who refined cinnabar, called *dan*, a key component in *waidan* and *neidan*, respectively outer, or material, and inner, or spiritual, alchemy. It is therefore no surprise that red cinnabar was an ingredient in 21 of the 27 elixir recipes in Ko Hung's fourth-century *Pao Phu Tzu*.[30]

26 Jar of synthetic vermilion made in the 19th century. Natural cinnabar's mercury and sulphur, split and reunited.

Alchemical elixirs were red the world over and in the European tradition many other reds, in addition to vermilion, were explored as possible sources for the elusive elixir, life force or Philosopher's Stone. One example is recorded in a painting that Joseph Wright of Derby worked on for over twenty years. It was inspired by an event that took place a century earlier, it was out of tune with his Enlightenment times and it was only sold after his death. The painting's full title is *The Alchymist, in Search of the Philosophers' Stone, Discovers Phosphorous, and Prays for the Successful Conclusion of his Operation, as was the Custom of the Ancient Chymical Astrologers*. It shows the alchemist and his workshop illuminated by a powerful light emanating from the reaction vessel. The glowing phosphorus – sign of a mineral life force – was made from an oil distilled out of concentrated human urine, which was, of course, red.

European alchemists, apothecaries and artists all knew and used that other red, dragonsblood, yet they could only imagine its dramatic genesis somewhere in the legendary East. By contrast, they could see, smell, hear and feel vermilion's genesis first-hand, and this is what made it so intriguing. If you were to make vermilion from cinnabar, you could see the whole world reflected in mercury's shifting silvery surface. If unlucky, an invisible cloud of sulphur could grab you by the throat and choke you. If successful, you could hear crashing as sulphur united with mercury under blazing coals. Finally, you could smash the vessel into which you put a coagulated black mass and be greeted by the glittering facets of countless red crystals. Vermilion's mercury and sulphur were the real mineral counterparts of dragonsblood's mythical dragon and elephant.

The philosophically inclined artist, apothecary or alchemist could experience Aristotle's hylomorphism in action in vermilion's synthesis. In Lao-Tzu's terms, this red displayed the *yin* and *yang* of *wanwu*, the 'ten thousand things'.[31] It was appropriate that the cosmic battle of dragons and elephants resulted in a red, and it is equally appropriate that the union of mercury and sulphur is red. Red is the centre of the Aristotelian colour scale, midway between black (the colour of *yin* or matter) and white (the colour of *yang* or form).[32]

Great power was available to the person who understood the nature of the two principles, mercury and sulphur, and of their role in all transformations – of synthesis and analysis, of gathering and scattering or of marriage and divorce. Such power was harnessed by the smith and underlay the story of Arthur and his sword in the stone. The same power was explored by the alchemist and was evident in their apparent ability to make gold. However, power – whether derived from the sword or from gold – is open to abuse, so the artists who wrote about the synthesis of this particular red either simply referred their readers to 'the friars' or left out vital details. They also used obscure names for their materials and processes in order to hide the truth from the unqualified and to protect Nature from those who might exploit her powers.

The multitude of names for these culturally charged reds also served to reinforce connections between them – just as 'cinnabar' related to sinopia, so also 'vermilion' was related to *vermis*, the 'little worm', a generic name for the extraordinarily expensive insect reds. To further confuse the unwary, vermilion could also be called 'minium', the name of yet another artificial red.

Minium

The non-vermilion version of minium was made from another metal, produced from a different ore. (Vitruvius and Pliny called it *minium secondum* in order to distinguish it from minium-as-vermilion.) In traditional metallurgy, each of the metals was connected to a planet or a god. The metal mercury was associated with the planet and god Mercury, also known as Hermes. Iron was associated with Mars, or Ares, and the metal that gave this third synthetic red was lead, which was associated with Saturn or Kronos, the father of all the gods.

In the first century AD, Britain was described as an island where Kronos was imprisoned by sleep, surrounded by 'many demigods as attendants and servants'.[33] The god Kronos (manifest in the heavens as the planet Saturn and on earth as the metal lead) slumbered in Britain with a retinue of 'demigods' that included the goddess Diana (associated with the moon and silver). Legends of these imprisoned gods and goddesses encouraged Britain's colonization – the Roman Empire wanted to awaken Kronos (Saturn) and Diana, who slept together in a mineral that we now call galena. Upon invading the British Isles, they mined and roasted the hard shiny stone, driving off the noxious sulphur to leave *calx*, the source of metals.

There were several ways of getting the red powder minium from the metal and one of them was directly related to the reason why the Romans wanted Britain's lead in the first place. The small amount of silver dissolved in the molten lead was extracted by a long process that finished with cupellation. This involved blowing air across silver-enriched molten lead to make a fine powder of litharge. The name of this powder – from 'lith' for stone and 'arge' for silver – hints at its significance because, when all of the molten lead had been consumed into the litharge, droplets of pure molten silver nestled in a bed of dry powder.

Litharge is a dull yellow and is not particularly stable. It can be turned into the more stable minium, or red lead, and there is evidence that this red by-product of silver mining was traded as a pigment across the Roman Empire. Chemical trace element analysis and lead isotope analysis of the red pigment in a group of second-century AD Roman-Egyptian red-shroud mummies determined that it was made from litharge, which was in turn made from lead mined for its silver content in Rio Tinto (literally, red river), Spain.[34] Minium's production was as toxic as vermilion's, but rather than being the central focus of a small-scale contemplative exercise for a few friars, painters, alchemists, yogis or Taoists, minium was the tiny, almost insignificant by-product of a massive empire-wide precious metals industry.

Once all the silver had been extracted from lead, the metal had a wide variety of uses such as providing pipe work, securing stained-glass windows and keeping the roof watertight. When it was exposed to acid fumes – usually by being sprinkled with

27 Roman-Egyptian red-shroud mummy, *c.* AD 100–150, human remains, polychromed cartonnage and wood. The casing was painted with minium manufactured from lead mined in the Sierra Morena mountains of Andalusia and exported to the opposite end of the Mediterranean.

vinegar and urine and buried under horse manure for a month – it slowly grew a white surface coating of rust. This white powder was collected as an artists' pigment and a medicine, but it could also be placed in a fire, whereupon it turned into minium.[35] This red powder also had medicinal uses, along with vermilion, and – as was evident in the brief history of rouge – both reds also had extremely long careers as cosmetics.

The synthetic reds were either ores for metals or they were made from metals. They might even be both. Iron, for example, which came from powdery red ochre and eventually turned into a pile of powdery red rust, was usually obtained from those natural ores that themselves looked most like rust.[36] In the cases we have considered so far, the metals themselves were not red – mercury is a silver colour, iron can be various shades of grey and lead is black. But according to the mercury-sulphur theory of metals, the metal itself might also be red if the metal's inner balance was particularly tipped towards sulphur. Gold was often described as a red metal and so was copper, and both were used to spectacular effect to make yet more synthetic reds.

Red glass

Copper metal will rust just like iron and lead, and copper was purposefully rusted – sprinkled with vinegar and urine and buried under horse manure for a month – just like lead. But its rust is green.[37] The red colour that came from copper was made when staining glass, and it was very different from the red that dragonsblood resin created in recipes for imitation ruby. Dragonsblood reds fade, but copper reds can be as lustrous today as they were when newly made, nearly a thousand years ago.

Glass could be made with sand and plant ash; Theophilus recommended the ash of beech trees in particular. If you wanted red glass, you would add copper filings to molten glass, which was warmed gently before being worked up into goblets or windowpanes. The process sounds simple; the recipe is once again deceptive. Great skill was required to make stained glass

28 Gold Anglo-Saxon bracteate from the 6th century with red glass inlay emulating garnet.

and if it was heated too strongly the copper could turn the glass green, instead of red. Red glass was the second most expensive colour (after blue) and it was the second most popular colour (again, after blue) in many Gothic cathedrals.[38]

The great panes of medieval red stained glass that survive today owe their existence to much older artificial rubies since the techniques of window making developed out of the ancient techniques for imitating gems. In the first century AD, Pliny observed that rubies were counterfeited with 'great exactness' in red glass but, with care, he could distinguish between the real gem and the glass by differences in colour, hardness and weight and by the presence of bubbles.[39] In the twelfth century, Theophilus wrote of 'setting gems in painted [window] glass', but he was fully aware that the 'gems' and the 'glass' on to which they were fixed were one and the same material.[40]

29 Michael Faraday's ruby-red glass microscope slide with a deposit of nano-scale colloidal gold that he referred to as a 'sol'. It was prepared for a Royal Institution lecture of 1858 and is inscribed 'Faradays Gold given to Me himself after his Lecture at the RI'.

Medieval imitation rubies were cut with a dome-shaped top, just like real ruby cabochons, and they are found decorating the most extraordinarily prestigious works of art, such as the fabulous thirteenth-century altarpiece that stood on the high altar of London's Westminster Abbey. For centuries, Britain's monarchs were crowned in front of an altar decorated with over 2,000 imitation gems, including many hundreds of red-glass rubies.[41] The presence of imitation rubies on such an important object could not possibly indicate corner-cutting as the money ran out. Instead, the imitation gems were valued because of the skill, time and effort dedicated to making them. According to a twelfth-century inscription on an enamel plaque, 'Art is above gold and gems; the Creator is above all things.'[42]

For the craftspeople in medieval Westminster, the transformation of dry sand, plant ash and copper filings into something that looked just like a ruby was an opportunity for meditation, in exactly the same way that vermilion's synthesis was an opportunity for meditation. The meditative potential of red glass was reinforced by the fact that gold in glass also gave a ruby red, which became known as the Purple of Cassius or Kunkel after two seventeenth-century alchemists who experimented with and developed ruby-red glass. In the nineteenth century, Prince Albert and other worthies were treated to spectacular projections of ruby-red light from glass microscope slides of nanometre-sized gold particles in Michael Faraday's public scientific lectures.[43]

Whether stained with copper or with gold, red glass and imitation rubies participated fully in the quality of redness. They had an aspect of real ruby and, as the products of labour, they also had an honourable aspect of artifice (in the original sense of 'full of deep skill and art'). The artifice of these traditional synthetic reds was quite unlike that of modern synthetic reds, the subject of the next chapter. Today, artificial reds are made behind high razor-wire fences in vast industrial complexes where very few really know what goes on. The mystery of medieval glass-making, on the other hand, was, paradoxically, common knowledge. As Chaucer's squire said in 'The Squire's Tale', in the enduringly popular *Canterbury Tales*:

> . . . others said how strange it was to learn
> That glass is made out of the ash of fern,
> Though bearing no resemblances to glass;
> But being used to this, they let it pass.[44]

People accepted that, with cunning, a ruby could come from a serpent's head and they knew that something very much like ruby could be made, with a different kind of cunning, from ash, sand and a pinch of copper or gold. Such beliefs and knowledge informed the ways in which people engaged with the world, with each other and with the colour red. As St Bruno, the eleventh-century bishop of Segni, said, red stained glass and imitation rubies 'preach not by speaking out loud but by signifying'.[45] These synthetic reds provide tantalizing glimpses of an ever-present but often-hidden red thread.