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Bright Earth:  
The Invention of Colour

Philip Ball

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## About the Book

Colour in art – as in life – is both inspiring and uplifting, but where does it come from? How have artists found new hues, and how have these influenced their work? Beginning with the ancients – when just a handful of pigments made up the artist's palette – and charting the discoveries and developments that have led to the many splendoured rainbow of modern paints, *Bright Earth* brings the story of colour spectacularly alive. Packed with anecdotes about lucky accidents and hapless misfortunes in the quests for new colours, it provides an entertaining and fascinating new perspective on the science of art.

## About the Author

Philip Ball is a freelance writer and a consultant editor for the world's leading science journal *Nature*. He is a regular commentator on the interactions between science, art, history and culture. His previous books include *Bright Earth: The Invention of Colour*, *H<sub>2</sub>O: A Biography of Water* and *Critical Mass: How One Thing Leads To Another*, which won the 2005 Aventis Prize for Science Books. He lives in London with his wife and daughter.

ALSO BY PHILIP BALL

*The Devil's Doctor: Paracelus and the World of Renaissance  
Magic and Science*

*Elegant Solutions: Ten Beautiful Experiments in Chemistry*

*Critical Mass: How One Thing Leads to Another*

*The Elements: A Very Short Introduction*

*Molecules: A Very Short Introduction*

*H<sub>2</sub>O: A Biography of Water*

*The Self-made Tapestry: Pattern Formation in Nature*

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# Bright Earth

The Invention of Colour

Philip Ball

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## Preface

For The Past two years I have been learning to speak a new language. Or rather, not so much to speak it as to think it, for painterly colour is a language that words struggle to convey. Here, for example, is German art critic Lorenz Dittmann on Jean-François Millet's *The Gleaners* (1857):

The unusually restrained colours . . . follow a closely-stepped sequence: reddish tones in the central figure, based around copper-reddish, brownish and bright carmine; delicate nuances of colourful greys in the standing figure to the right: silvery bright blue-grey, dove-grey, blue and turquoise greys . . . the barely definable, shimmering brownish tone of the field in the middle distance takes on a slender pink-violet tone against the grey-scale of the figure at the back, which is echoed again in the slightly darkened foreground.

Do you see the image? Of course not, although the words begin to paint a picture of their own. Colour, like music, takes a short cut to our senses and our emotions. The Church understood this in the Middle Ages; so have the greatest painters, as well as propagandists, advertisers and designers. No wonder philosophers and linguists so love to debate colour – it tempts, teases and eludes them, at the same time as it promises wonders and deep secrets.

Well then, where does one start to learn this language? I am quite sure that there is no best answer. I have approached it through the *substance* of colour; and if that is partly because I have trained as a chemist, it is also because I relish paint and pigments as materials, with appearances, smells, textures and names that entice and intoxicate. Here is one language of colour that I can interpret already: phthalocyanine speaks to me of chlorophyll and blood, vermilion conjures up the sulphur and

mercury of the alchemists. Yet the painter's use of colour has not only its unique chemistry but also its historical traditions, its psychology, its prejudices, its religiosity and mysticism.

I imagine that, were I ever to acquire fluency in a foreign language, I would, on entering the country in which it is spoken, experience something of what I felt after revisiting the National Gallery several months into this project. Through the agency of colour I could begin to understand, or at least to catch fragments of, what was being said on the walls all around. Where before there were two-dimensional images in gilded frames, there was now a living world. Each picture seemed as though it had just left the artist's workshop or studio, the paint's transition from palette to panel or canvas visible in the brush-marks. Of course, time too has left its mark: paintings often need more decoding than the artist intended, as greens darken to black and reds fade to pink. In the end, the language of colour is really about learning to see.

I have been deeply fortunate to benefit, in this learning process, from the advice of people who have far greater fluency in the language of colour than I shall ever attain. My thanks go to Tom Learner at the Tate Gallery, Jo Kirby at the National Gallery, John Gage at the University of Cambridge, Martin Kemp at the University of Oxford, Helen Skelton and David Lewis at the University of Leeds, and most of all to Joyce Townsend at the Tate, who not only helped with materials and information but read the entire draft manuscript diligently. I am indebted to the Royal College of Art for the use of its splendid Colour Reference Library, and to my editors Andrew Kidd and John Glusman for helping the book find its shape. The sustaining interest and enthusiasm of many friends and colleagues are, of course, the nutrition that every writer needs, and can never adequately acknowledge.

Philip Ball  
London, 2001

*Note:* I have often used the masculine third person to denote a generic painter until the twentieth century. This is simply an attempt to be consistent with the historical record: female painters were usually such rare exceptions that 'his or her' would jar with the context. We can deplore the inequities of earlier ages without trying to deny them. But, as [Plate 4.2](#) shows, some women were able to become painters even in the most chauvinistic of times.

# 1. The Eye of the Beholder

## THE SCIENTIST IN THE STUDIO

*The starting point is the study of colour and its effects on men.*

*[Wassily Kandinsky](#), Concerning  
the Spiritual in Art (1912)*

*Then the man in the blue suit reaches into his pocket and takes out a large sheet of paper, which he carefully unfolds and hands to me. It is covered with Picasso's handwriting - less spasmodic, more studied than usual. At first sight, it resembles a poem. Twenty or so verses are assembled in a column, surrounded by broad white margins. Each verse is prolonged with a dash, occasionally a very long one. But it is not a poem; it is Picasso's most recent order for colours . . .*

*For once, all the anonymous heroes of Picasso's palette trooped forth from the shadows, with Permanent White at their head. Each had distinguished himself in some great battle - the Blue Period, the Rose Period, Cubism, 'Guernica' . . . Each could say: 'I too, I was there . . .' And Picasso, reviewing his old comrades-in-arms, gives to each of them a sweep of his pen, a long dash that seems a fraternal salute: 'Welcome Persian red! Welcome emerald green! Cerulean blue, ivory black, cobalt violet, clear and deep, welcome! Welcome!'*

*[Brassaï](#), Conversations avec  
Picasso (1964)*

'I BELIEVE THAT in future, people will start painting pictures in one single colour, and nothing else but colour.' The French artist Yves Klein said this in 1954, before embarking on a 'monochrome' period in which each work was composed from just a single glorious hue. This adventure culminated in Klein's collaboration with Paris paint retailer Edouard Adam in 1955 to make a new blue paint of unnerving vibrancy. In 1957 he launched his manifesto with an exhibition,

'Proclamation of the Blue Epoch', that contained eleven paintings in Klein's new blue.

By saying that Yves Klein's monochrome art was the offspring of chemical technology, I mean something more than that his paint was a modern chemical product. The very *concept* of this art was technologically inspired. Klein did not just want to show us pure colour; he wanted to display the glory of *new* colour, to revel in its materiality. His striking oranges and yellows are synthetic colours, inventions of the twentieth century. Klein's blue was ultramarine, but not the natural, mineral-based ultramarine of the Middle Ages: it was a product of the chemical industry, and Klein and Adam experimented for a year to turn it into a paint with the mesmerizing quality the artist was seeking. By patenting this new colour, Klein was not simply protecting his commercial interests but hallmarking the authenticity of a creative idea. One could say that the patent was a part of his art.

Yves Klein's use of colour became possible only when chemical technology had reached a certain level of maturity. But this was nothing new. For as long as painters have fashioned their visions and dreams into images, they have relied on technical knowledge and skill to supply their materials. With the blossoming of the chemical sciences in the early nineteenth century it became impossible to overlook this fact: chemistry was laid out there on the artist's palette. And the artist rejoiced in it: 'Praise be to the palette for the delights it offers . . . it is itself a "work", more beautiful, indeed, than many a work,' said Wassily Kandinsky in 1913. The Impressionist Camille Pissarro made the point forcefully in his *Palette with a Landscape* (1878), a pastoral scene constructed directly on his palette by pulling down the bright colours dotted around its edges.

The Impressionists and their descendants - van Gogh, Matisse, Gauguin, Kandinsky - explored the new chromatic dimensions opened up by chemistry with a vitality that has

arguably not been equalled since. Their audiences were shocked not only by the breaking of the rules – the deviation from ‘naturalistic’ colouration – but by the sight of colours never before seen on canvas: glowing orange, velvety purples, vibrant new greens. Van Gogh dispatched his brother to acquire some of the brightest and most striking of the new pigments available, and wrought them into disturbing compositions whose strident tones are almost painful to behold. Many were dumbfounded or outraged by this new visual language: the conservative French painter Jean-Georges Vibert rebuked the Impressionists for painting ‘only with intense colours’.

It was a complaint that echoes back through the ages, to be heard whenever chemistry (or foreign trade, which also broadens a culture’s repertoire of materials) has made new or superior colours available to painters. When Titian, Henry James’s ‘prince of colourists’, took advantage of having the first pick of the pigments brought to the thriving ports of Venice to cover his canvases with sumptuous reds, blues, pinks and violets, Michelangelo remarked sniffily that it was a pity the Venetians were not taught to draw better. Pliny bemoaned the influx of bright new pigments from the East that corrupted the austere colouring scheme Rome had inherited from Classical Greece: ‘Now India contributes the ooze of her rivers and the blood of dragons and of elephants.’

That the invention and availability of new chemical pigments influenced the use of colour in art is indisputable. As art historian Ernst Gombrich says, the artist ‘cannot transcribe what he sees; he can only translate it into the terms of his medium. He, too, is strictly tied to the range of tones which his medium will yield.’<sup>1</sup> So it is surprising that little attention has been given to the matter of how artists obtained their colours, as opposed to how they used them. This neglect of the material aspect of the artist’s craft is perhaps a consequence of a cultural tendency in the West to

separate inspiration from substance. Art historian John Gage confesses that 'One of the least studied aspects of the history of art is art's tools.' Anthea Callen, a specialist in the techniques of the Impressionists, makes a stronger criticism:

Ironically, people who write on art frequently overlook the practical side of their craft, often concentrating solely on stylistic, literary or formal qualities in their discussion of painting. As a result, unnecessary errors and misunderstandings have grown up in art history, only to be reiterated by succeeding generations of writers. Any work of art is determined first and foremost by the materials available to the artist, and by the artist's ability to manipulate those materials. Thus only when the limitations imposed by artists' materials and social conditions are taken fully into account can aesthetic preoccupations, and the place of art in history, be adequately understood.<sup>2</sup>

One might expect the 'craft' aspects of art to suffer less neglect when the use of colour is under discussion – for surely the nature of materials should then come naturally to the fore? But it is not always so. Faber Birren admits in his classic *History of Color in Painting* that 'the choice of colours for a palette or palettes is not in any way concerned with chemistry, or with permanence, transparency, opacity or any of the *material* aspects of art'. This extraordinary omission of the substantial dimension of colour is surely the precondition for such absurdities as Birren's assigning cobalt blue to the palette of Rubens and his contemporaries, almost two centuries before its invention.<sup>3</sup> In view of the attention that Birren gives to the hues required for a 'balanced palette', it is indeed odd how little concerned he is with whether artists of different eras had access to them.

### *Paint and the painter*

Every painter must confront the question: what is colour *for*? Bridget Riley, one of the modern artists most concerned with colour relationships, has expressed the dilemma very clearly:

For painters, colour is not only all those things which we all see but also, most extraordinarily, the pigments spread out on the palette, and there, quite uniquely, they are simply and solely colour. This is the first important fact of the painter's art to be grasped. These bright and shining pigments will not, however, continue to lie there on the palette as pristine colours in themselves but will be put to use – for the painter paints a picture, so the use of colour has to be conditioned by this function of picture making . . . The painter has two quite distinct systems of colour to deal with – one provided by nature, the other required by art – perceptual colour and pictorial colour. Both will be present and the painter's work depends upon the emphasis they place first upon the one and then upon the other.<sup>4</sup>

This is not a contemporary conundrum, but one that has confronted artists of all eras. And yet there is something missing from Riley's formulation of the artist's situation. Pigments are not 'simply and solely colour', but substances with specific properties and attributes, not least amongst them cost. How is your desire for blue affected if you have just paid more for it than for the equivalent weight in gold? That yellow looks glorious, but what if its traces on your fingertips could poison you at your supper table? This orange tempts like distilled sunlight, but how do you know that it will not have faded to dirty brown by next year? What, in short, is your relationship with the materials?

Raw colour supplies more than a physical medium from which artists can construct their images. 'Materials influence form,' said American artist Morris Louis in the 1950s; but 'influence' is too weak a word when we are faced with the explosive vibrancy of Titian's *Bacchus and Ariadne* (1523), Ingres's *Odalisque with a Slave* (1839–40) or Matisse's *Red Studio* (1911). This is art that follows directly from the impact of colour – from possibilities delimited by the prevailing chemical technology.

But although technology made Yves Klein's monochromes possible for the first time, it would be meaningless to suggest that Rubens did not paint them because those colours were not available to him. It is equally absurd to suppose that, but for a technical knowledge of anatomy and

perspective and the chemical prowess to extend the range of pigments, the ancient Egyptians would have painted in the style of Titian. Use of colour in art is determined at least as much by the artist's personal inclinations and cultural context as by the materials to hand.

So it would be a mistake to assume that the history of colour in art is an accumulation of possibilities proportional to the accumulation of pigments. Every choice an artist makes is an act of exclusion as well as inclusion. Before we can gain a clear understanding of where technological considerations enter the decision, we must appreciate the social and cultural factors at work on the artist's attitudes. In the end, each artist makes his or her own contract with the colours of the time.

### *Leonardo's quest*

Ernst Gombrich asserts that 'art is altogether different from science', but the reason he gives will bring a rueful smile to the lips of many a scientist: 'art itself can hardly be said to progress in the way in which science progresses. Each discovery in one direction creates a new difficulty somewhere else.' One can see that Gombrich never dabbled in science.

Exploring the link between art and science is back in fashion; but the debate is dominated by the supposition of cognate ideas and sources of inspiration. Artists of all persuasions today may be found mining the rich seam of association that crystallizes from our genetic inheritance, just as one can draw analogies between relativity and Cubism, between quantum mechanics and the works of Virginia Woolf.

This is all well and good in so far as it speaks of the much-needed cultural assimilation of scientific ideas (albeit commonly in a distorted or half-digested form). But it

appears that we are happier in the realm of the intellectual than that of the tangible.

Yet this Cartesian-like division of material and mind has not always reflected the attitude of the practising artist. It is only in the past half-century or so that every conceivable subdivision and admixture of the rainbow has been available in off-the-shelf tubes. Until the eighteenth century, most artists ground and mixed their own pigments, or at least had this process conducted in their studios. The almost sensual pleasure in the material component of colour evinced by medieval craftsmen like the Italian Cennino Cennini demonstrates that artists of his time were on intimate terms with their paints, and possessed some considerable skill as practical chemists.

Moreover, before the Age of Reason the distinction between 'art' and 'science' was not synonymous with that between intuition and rationality. In medieval times, men of science were chroniclers of antique knowledge and theory – a practice that did not necessarily require an inquiring mind. 'Art', on the other hand, implied technical or manual skill, and a chemist was as much an artist as was a painter. The artist was valued not for his imagination, passion or inventiveness, but for his ability to do a workmanlike job.

This was the world in which Leonardo da Vinci lived and worked. Vladimir Nabokov once said that he would be more interested in C. P. Snow's famous 'Two Cultures' debate if their disjunction did not seem to him more of a ditch than an abyss. Leonardo barely seemed to notice so much as a ditch. The ease with which he passed between his roles as artist, technologist and natural philosopher remains remarkable even when we remember that these distinctions were by no means as rigid during the Renaissance as they are today.

Scholarly circles in Leonardo's fifteenth-century Florence were alive with discussion about the role of reason, geometry and mathematics in art. Leonardo himself was a

firm advocate of the need for the artist to imitate nature as exactly as possible, which entailed learning the mathematical rules that governed nature: 'Those who devote themselves to [artistic] practice without science are like sailors who put to sea without a rudder or compass and who can never be certain where they are going.'<sup>5</sup> Yet how readily we see Leonardo's boundary-straddling through modern eyes. In stressing the importance of science in art, Leonardo had an agenda that was very much a product of its time. By emphasizing the role of mathematics, he attempted to elevate the status of painting to a Liberal Art, alongside geometry, music, rhetoric and astronomy. These Arts were those deemed worthy of serious intellectual study at the universities, whereas painting had been regarded since the Middle Ages as a craft, a lowly manual skill. Such activities in the classical past had often been performed by slaves, and painters of Leonardo's time were desperate to throw off this stigma. By arguing for the acceptance of painting as a Liberal Art, they sought to advance their own social standing.

Artists would plead their cause by pointing out that many great men of antiquity had shared their trade, and that kings and (more recently) popes had conferred favour upon them. In his book *Della Pittura (On Painting)* (1435), the Florentine architect and artist Leon Battista Alberti (1404-72) reminded his readers that

The number of painters and sculptors was enormous in those days, when princes and people, and learned and unlearned alike delighted in painting . . . Eventually Paulus Aemilius and many other Roman citizens taught their sons painting among the Liberal Arts in the pursuit of the good and happy life. The excellent custom was especially observed among the Greeks that free-born and liberally educated young people were also taught the art of painting together with letters, geometry and music.<sup>6</sup>

Leonardo, Alberti and their fellow painters questioned how poetry could be accepted as a Liberal Art while the creation of beautiful images in paint rather than in words was not.

‘Write up in one place the name of God,’ said Leonardo, ‘and put a figure representing him opposite, and see which will be the more revered.’<sup>7</sup>

The artist’s cause demanded that artists dissociated themselves from craftsmen, and allied their skills with mathematics and abstract thought. ‘Painting’, said Alberti, ‘was honoured by our ancestors with this special distinction that, whereas all other artists were called craftsmen, the painter alone was not counted among their number.’<sup>8</sup> This could not but have encouraged artists to downplay the material aspects of painting, such as the creation and grinding of pigments. In turn, this surely contributed to the desire of the Florentine painters to emphasize drawing and line (*disegno*) above the use of colour (*colore*), initiating a dispute that lasted for centuries. Dismissive comments such as those of Equicola in the sixteenth century could only have egged them on: ‘Painting has no other concern except with copying nature with various appropriately chosen colours.’

By the late fifteenth century Leonardo and his fellow painters had largely won their battle – but at the cost of simply reinforcing the bigotry that they inherited from Classical times. Nowhere does Leonardo challenge the underlying hierarchy that values the intellectual over the manual. Instead, he seeks to relocate the craft of the medieval painter on an abstract plane. Thus did art begin to fragment into the ‘pure’ and the ‘applied’, a distinction not seriously challenged until the nineteenth century. In *The Two Paths* (1859), John Ruskin deplored art’s own ‘two cultures’ and argued that decorative art and craft should not be regarded as ‘a degraded or separate kind of art’. With William Morris and others, Ruskin tried to reunite the craftsman with the fine artist in the Arts and Crafts movement. It is not clear that they enjoyed much success: Art Nouveau came and went, but artistic elitism remains.

## *Chemistry and art*

The relation of painting to the Liberal Arts in Leonardo's time was wholly analogous to the standing of chemistry in relation to natural philosophy, or what we would now call science. Those who pursued the chemical arts, who dwelt in smoky laboratories and wrought useful things, were excluded from the lofty halls of academic science. Science historian Lawrence Principe says of this pre-scientific chemistry or 'chymistry':

It has long been recognized that one of the 'problems' of chymistry before the eighteenth century was its status as a practical or technical art rather than as a branch of natural philosophy. The low status of chymistry as determined by its use amongst low technical appliers militated against its acceptance by many natural philosophers.<sup>9</sup>

Thus the Anglo-Irish chemist Robert Boyle, in his polemical *Sceptical Chymist* (1665), denounces the ignorance of the 'vulgar chymists', including not only the out-and-out cheats who sought to profit from faked alchemical transformations but also the 'laborants' such as the dyers, distillers and apothecaries who lacked theoretical knowledge. Leonardo had nothing at all to gain by aligning his cause with such a crowd, and so there is good reason for him to gloss over the chemical aspects of art.

That cannot, however, excuse the persistent perception of unseemliness in the idea that science provides art not only with concepts but with materials. The snobbery and ignorance apparent in the words of the Bauhaus architect Le Corbusier (Charles-Edouard Jeanneret) and his collaborator Amédée Ozenfant in 1920 are breathtaking:

. . . it is form which comes first, and everything else should be subordinated to it . . . Cézanne's imitators were quite right to see the error of their master, who accepted without examination the attractive offer of the colour-vendor, in a period marked by a fad for colour-chemistry, a science with no possible effect on great painting. Let us leave to the clothes-dyers the sensory jubilations of the paint tube.<sup>10</sup>

Let's not be too distracted by the absurdity of the suggestion that Cézanne - not the Impressionists or the Fauves, but Cézanne! - was an undiscerning dauber of raw colour. What is more telling is the way that Le Corbusier denigrates manual skills and delight in substance, in favour of 'form' and abstract space. This passage could almost have been written by the most bigoted of late-sixteenth-century Italian scholars praising *disegno* over *colore*. To deny that colour chemistry can have any possible effect on 'great painting' is, in the end, to claim that great art is all in the head, and cheapened by the sad necessity to reconstruct it from mere matter.

The connection to chemistry was perhaps deemed less distasteful in the nineteenth century, when chemists enjoyed unrivalled respectability (even Goethe used their metaphors). An anonymous writer on artistic technique in 1810 says cautiously: 'Chemistry is to painting what anatomy is to drawing. The artist should be acquainted with them, but not bestow too much time on either.' Yet even this much may be seen as a swan-song to the era when the painter was of necessity something of a chemist, when a training in art required at least as great an attention to the mechanical and practical aspects as to the aesthetic and intellectual. By the end of the nineteenth century, the artist was wholly reliant on scientifically adept professionals - 'colourmen' - to attend to the chemical aspects of their profession. One consequence of this rift is that the colours of some works of that period have weathered less well than the jewel-like fifteenth-century paintings of Jan van Eyck.

Chemistry is a topic that strikes fear into many a heart, and there seems little point in seeking to evade that fact. Unusually among artists, students of ceramics are one group who still have to learn some real chemistry - the whole package: balanced equations, the Periodic Table, atomic weights and so forth. In my experience, this does not make them feel any better about it. There appears to be

something intimidating about the dizzying varieties in which matter is composed from elemental blends; and if we are honest about it, something vaguely ominous and unsettling about the grey metallic minarets and pipelines within which these blends are industrially concocted today. It is a challenge to the imagination to connect these ugly factories and alien or unsettling names – cadmium, arsenic, antimony – with the stuff that, smeared over canvas, leaves us breathless in art galleries. Can such a villain (and the chemical industry's transgressions are not at all imaginary) be responsible for this beauty?

The truth – a dirty truth, if you will – is that new colours for artists have long been a by-product of industrial chemical processes that reach out to a much wider market. Without the engine of commerce to drive it, the manufacture of these new pigments would simply have not been viable. Artificial copper blues or 'verditer', the principal cheap alternatives to expensive blue pigments from the fifteenth to the eighteenth century, were a side-product of silver mining. They were largely replaced by Prussian blue, produced primarily for the massive textile dyeing industry rather than for the tiny market in artists' colours. The Mars colours (artificial iron oxides) could not have been made without the availability of cheap sulphuric acid, which was manufactured primarily as a textile bleach. The pigment known as patent yellow was an offshoot of the soda industry, while the manufacture of chrome yellow was stimulated by its use in cotton printing. Textile dyeing also led to a better understanding of the use of metals for the fixing (mordanting) of dyes, which then drove improvements in the preparation of 'lake' pigments in the early nineteenth century. The almost ubiquitous white pigment of the twentieth century, titanium dioxide, is produced almost entirely for commercial paints – the amount diverted to artists' materials is trivial.

Might it be exciting to see not only an art history but also an art that reflects these connections? The commercial aspects of colour manufacture have indeed influenced some twentieth-century artists. But aren't naked pigments already works of art - the products of skill and creativity, and substances of glorious elegance and splendour? The Anglo-Indian artist Anish Kapoor thinks so ([Plate 1.1](#)), and Yves Klein did too.

It is commonly asserted that the interaction between art and science is a one-way street; but the relationship between chemistry and art has been to their mutual benefit. The modern chemicals industry was spawned and nurtured largely by the demand for colour. Important advances in synthetic chemistry in the nineteenth century were stimulated by the quest for artificial colours. Many of the world's major chemicals companies - BASF, Bayer, Hoechst, Ciba-Geigy - began as manufacturers of synthetic dyes. And the reproduction of art and colour in photography and printing has given rise to major technological companies such as Xerox and Kodak.

There is, meanwhile, ample precedent for the collaboration between art and chemistry personified in Klein and Adam. Michael Faraday advised J. M. W. Turner on his pigments. The German chemistry Nobel Laureate Wilhelm Ostwald worked with the German paint industry in the 1920s, and his theory of colour was hotly debated at the Bauhaus where Klee and Kandinsky taught. In more distant times, painters consorted with alchemists to procure their colours. In this story about science, technology, culture and society, there are no chickens and no eggs. Chemical science and technology and the use of colour in art have always existed in a symbiotic relationship that has shaped both their courses throughout history. By tracing their co-evolution, we shall see both how art is more of a science, and science more of an art, than is commonly appreciated on either side of the fence.[11](#)

## *Fear and loathing of colour*

Yves Klein invites us to engage with the beauty of raw colour. This goes against our training. What is brightly coloured? Children's toys, the Land of Oz. And so colour threatens us with regression, with infantilism. Cultural theorist Julia Kristeva claims that 'the chromatic experience constitutes a menace to the "self" . . . Colour is the shattering of unity.'<sup>12</sup> What else is coloured? Vulgar things, vulgar people. Colour speaks of heightened emotions, even linguistically, and of eroticism. Pliny is not alone in xenophobically attributing strong colour to a kind of decadent Orientalism. Le Corbusier asserted that colour was 'suited to simple races, peasants, and savages'. Needless to say, he found it in abundance in his 'journey to the East', and was repelled: 'What shimmering silks, what fancy, glittering marbles, what opulent bronzes and golds . . . Let's have done with it . . . It is time to crusade for whitewash and Diogenes'<sup>13</sup> - which is to say, for cool reason over all this unseemly passion.

The nineteenth-century art theorist Charles Blanc (what's in a name?) insisted that 'design must maintain its preponderance over colour. Otherwise painting speeds to its ruin: it will fall through colour just as mankind fell through Eve.'<sup>14</sup> Here, then, is another reason to distrust colour: it is feminine. Contemporary artist David Batchelor argues that a fear of colour - chromophobia - pervades Western culture.<sup>15</sup> 'Man', said Yves Klein, 'is exiled far from his coloured soul.'<sup>16</sup>

But perhaps chemists, who are on intimate terms with the materiality of colour, who have seen the majestic rainbow progression of manganese through its different states of oxidation, who have watched the royal, clear blue of ammoniacal copper sulphate emerge from the pale, opaque blue of its alkaline precipitate - perhaps they are especially

attuned to and appreciative of unadulterated colour. Oliver Sacks recalls the allure of chemistry's liquid colours in his childhood:

My father had his surgery in the house, with all sorts of medicines, lotions, and elixirs in the dispensary - it looked like an old-fashioned chemist's shop in miniature - and a small lab with a spirit lamp, test tubes, and reagents for testing patients' urine, like the bright-blue Fehling's solution, which turned yellow when there was sugar in the urine. There were potions and cordials in cherry red and golden yellow and colourful liniments like gentian violet and malachite green.[17](#)

To the chemist, colour is a bountiful clue to composition and, if measured carefully enough, can reveal delicate truths about molecular structure. It takes a particular turn of mind to see chromatic beauty lurking in the molecular structures of alizarin and indigo, to sense the rich hues within the stark, schematic depictions of these dye molecules. The Italian chemist and writer Primo Levi intimates how this relation between colour and constitution broadens the chemist's sensitivity to colour:

I find myself richer than other writers because for me words like 'bright', 'dark', 'heavy', 'light', and 'blue' have a more extensive and more concrete gamut of meanings. For me 'blue' is not only the blue of the sky. I have five or six blues at my disposal.[18](#)

### *Naming colours*

Before we can adequately explore what colour means to the artist, we must ask what we mean by colour itself. This might seem uncontentious enough. In spite of the old solipsism that I can never know if my experience of 'red' is the same as yours, we both agree when the term is appropriate and when it is not. Yet there are hordes of 'lower-level' colour terms in most modern languages over which the scope for dispute is limitless: when does puce become russet, burgundy, rust-red? This is partly a matter for perceptual psychology; but the language of colour