From Chapter 3: Just How Much a New Colour Was Worth

In the first months of 1856, Gustave Flaubert began Madame Bovary, Karl Bechstein opened his piano factory, the plans for the bell Big Ben were drawn up at a foundry in Whitechapel and Queen Victoria instituted the Victoria Cross. During the Easter holidays of that year, August Hofmann returned briefly to Germany, and William Perkin retired to his laboratory on the top floor of his home in the East End of London. Perkin's domestic workplace contained a small table and a few shelves for bottles. He had constructed a furnace in the fireplace. There was no running water or gas supply, and the room was lit by old glass spirit lamps. It was an amateur's laboratory, an enthusiast's collection of stained beakers and testubes and rudimentary chemicals. The room smelled of ammonia. The table on which he worked was stained with spillage from previous efforts, and probably from ink. He was surrounded by landscape paintings and early photographs, and by jugs and mugs and other domestic trinkets that were as alien to a laboratory as delicate soda crystals were to any other house in this smoky residential neighbourhood. It was an unexpected setting for one of chemistry's most romantic and significant moments.

Looking back, Perkin adopted a rather nonchalent tone to describe his actions. "I was endeavouring to convert an artificial base into the natural alcoloid quinine, but my experiment, instead of yielding the colourless quinine, gave a reddish powder. With a desire to understand this particular result, a different base of more simple construction was selected, viz. aniline, and in this case obtained a perfectly black product. This was purified and dried, and when digested with spirits of wine gave the mauve dye."

In effect, the discovery at that time of one apparently simple molecule could rarely claim such a far-reaching impact on the development of science and industry. The room in his father's house afforded views of the ships in the London docks, and of the London and Blackwall Railway, an inspiring vision of travel and progress. But Perkin's view of the distance held no glimpse of the future, no vision of the Lancashire factories 200 miles away which soon would reverberate with the sound of his invention.

The chemistry was simple, involving the then popular "additive and subractive" method: find a compound that looks similar to the one you are trying to create - in this case, Perkin chose allytoluidine - and used two regular processes, distillation and oxidisation, to alter its formula by adding oxygen and removing hydrogen (in the form of water). It was a naive manoeuvre.

Most chemists, particularly those trained by Hofmann at the Royal College, would have thrown the reddish powder into a rubbish bin, and begun again. It was Perkin's intuitive talent - an enquiring mind in an unsupervised laboratory - that he chose to experiment further, and test the effect of this procedure on aniline. And it was a mark of his skill that, in analysing the crude black product that resulted, he was able to separate out the five per cent that contained his colour.

By the time Perkin found mauve, aniline had been linked with various colours for thirty years. The liquid had first been discovered by the Prussian chemist Otto Unverdorben in 1826, one of several products isolated from the distillation of natural vegetable indigo. Some years later the chemist Friedlieb Runge obtained it from the distillation of coal-tar, and found it gave a blue colour when combined with chloride of lime. But such colours were considered to have no practical use. In the unlikely event that a scientist would have believed that a particular tint might be useful in the dyeing of a woman's dress, they would most certainly believe their calling to be unworthy of such fripperies.

But Perkin was excited about his unexpected find. Chemists blundered every day; partly, that was the nature of their job. But only occasionally did their errors lead them in interesting directions. Perkin stained a silk cloth with his discovery, and did little more than admire the new shade. It was, he realized, a brilliant and lustrous colour, and he found that it did not fade with washing or prolonged exposure to light. The problem he faced was what to do with it next. "After showing this colouring matter to several friends, I was advised to consider the possibility of manufacturing it upon the large scale."

One of these friends was Arthur Church, with whom Perkin discussed the seemingly insurmountable problem of making more than a small beaker of his colour. Liquid aniline was hard to obtain in quantity, and expensive; Perkin had never stepped foot inside a factory, and knew nothing of manufacturing chemicals outside the laboratory; and he knew no one in the textile or dyeing trades to whom he could turn for advice.

Both Perkin and Church knew that their mentor would disapprove of any schemes not directly connected with research. They resolved not to tell Hofmann about mauve when he returned from Germany, certainly not until Perkin had established its exact properties and had conducted further experiments.

For this, Perkin moved to slightly larger premises - a hut in his garden. He enlisted the help of his brother Thomas, and together they made several blocks of mauve, each purer and more concentrated than the last. Through a friend of his brother, Perkin learnt the name of a highly-regarded dye works in Scotland, and decided to send the owner some samples of cloth. He received a lengthy reply from a man called Robert Pullar in the middle of June, and his tone was encouraging.

"If your discovery does not make the goods too expensive it is decidely one of the most valuable that has come out for a very long time. This colour is one which has been very much wanted in all classes of goods and could not be had fast on silk and only at great expense on cotton yarns. I inclose you patterns of the best lilac we have on cotton. It is done by only one house in the United Kingdom, Andrews of Manchester, and they get any price they wish for it, but even it is not quite fast, it does not stand the tests that yours does and fades by exposure to air."

Pullar was 28, and was later described by a general manager of his company as possessing "a mind always looking forward for something new and better". His large dyeworks in Mill Street, Perth, had recently received a royal warrant, and now advertised itself proudly as silk dyemakers to the Queen. Robert Pullar liked to quote Faraday: "Without experiment I am nothing; still try, for who knows what is possible." Perkin had been lucky in his choice of adviser; he was to discover later that not all dyers or printers were as progressive or encouraging.

Pullar explained to Perkin that he could not put a price on the colour, not until he had tested it himself in a dyeing vat. “If the quantity of yarn or cloth that could be soaked in one gallon of your liquor would take up all the colouring matter in that gallon, then I would say that the price would be much too great...” If this happened, the dyestuff required to colour one pound of silk or cotton would cost about five shillings - far too much for a manufacturer to pay.”

Pullar offered to help Perkin in any way he could, and regretted that he did not live nearer London to meet him in person. “We are always very desirous here to have every thing new, as we do a large trade in manufacturing and a new colour in the goods is of great importance.”

Perkin showed this letter to Arthur Church, who encouraged him to take out a patent immediately. But there was a problem with Perkin’s age, as patents were usually only granted to those over 21. He sought counsel’s opinion, and was advised that since a patent was a gift from the Crown, the matter of age should be immaterial. Perkin filed his application at the end of August 1856, when he was 18. But then he began to wonder: what good would it do him? Just how much was a new colour worth?

New colours had been discovered by chance since ancient times, and some magnificent myths had evolved. A sheep dog belonging to Hercules, while walking along a beach in Tyre, bit into a mollusc and turned his mouth the colour of coagulated blood. This became known as Royal or Tyrian purple. It brought prosperity to Tyre around 1500 BC, and for centuries remained the most exclusive animal dye money could buy. It was the colour of high achievement and ostentatious wealth, and came to symbolize sovereignty and the highest offices of the legal system. Within Jewish practice, the dye was used on the fringes of prayer shawls; in the army, the wearing of purple woollen strips was used to denote rank. Purple was also the colour of Cleopatra’s barge, and Julius Caesar decreed that the colour could be worn only by the emperor and his household.

It was prohibitively expensive. The molluscs - be they *murex brandaris* from the Italian coast or *murex trunculous* located first on the Phoenician coast - were drained of their glandular mucous in their hundreds of thousands to make a single robe. Pliny described how, during autumn and winter, the shellfish were crushed, salted for three days and then boiled for ten. The resultant colour resembled “the sea, the air and a clear sky,” suggesting that Tyrian purple defined not one particular shade but a rich spectrum from blue to black. The dying process varied from port to port, and might be mixed with water or honey to achieve different hues, but the end product shared one truth: even the deepest colours were fugitive. Although Tyrian purple was one of the fastest colours in the Roman Empire, a tunic that drew gasps on its first outing might last only weeks in the salty air before resembling marine wrack.

Of the other animal dyes the most popular was cochineal, the crimson dye from cactus insects. Introduced into Europe by the Spanish from Mexico (then New Spain) in the 16th century, it was widely used as cloth dye, artists’ pigment, and much later a food colourant, but again required a huge seasonal harvest - about 17,000 dried insects for a single ounce of dye. What may have been the first English dye house was established for cochineal in Bow, east London, in 1643, and the scarlet became known as Bow-Dye and was described in terms of bruised flesh.

Vegetable dyes tended to be cheaper, and in greater supply. In Perkin's day the most common were madder and indigo, the ancient red and blue dyes used for cloth and cosmetics. Madder, the root of some 35 species of plant found in Europe and Asia, has been found in the cloth of mummies and is mentioned by Herodotus, and is probably the first dye to be used as camouflage - Alexander the Great spattering his army with red to convince the Persians they had been critically wounded in earlier battle. In The Former Age, circa 1374, Chaucer depicts the idea of man's early innocence when

No mader, welde, or wood [woad] no litestere [dyer]
Ne Knew; the flees [fleece] was of his former hewe.

Indigo, used not only as dye and pigment but also an astringent lotion, derived from the leaf of Indigofera tinctoria, a shrub-like plant that was soaked in water and then beaten with bamboo to hasten oxidation. During this process the liquid changes colour from dark green to blue, when it is then heated, filtered and formed into a paste. Before the colonisation of America, it came predominantly from India in the form of dye-cakes, and this ancient derivation held firm to the time when Perkin could observe the colour in women's fashions in the West End. There were several other important plant dyes - carthamus, woad, saffron, brazilwood and turmeric - but even these represented an extremely narrow range of colours confined variously to red, blue, yellow, brown and black. Woad, again known to Pliny and used commonly by ancient Britons as a facial and body dye, contained a similar colouring matter to indigo, although derived from a different plant and containing about one-tenth the tinctorial power.

Throughout much of the 18th century the greatest advances in dyeing technique were made in France, but between 1794 and 1818 an American working in London called Edward Bancroft claimed many significant improvements. Bancroft patented three new natural dyes, including the yellow quercitron, and wrote the first scientific treatise on dyeing in English. His Experimental Researches Concerning the Philosophy of Permanent Colours combined exact chemical observations with personal anecdotes: he noted, for example, how his favourite purple coat hardly faded though he wore it for several weeks. Bancroft had a further claim on posterity, as he was later exposed as a double-agent during the American Revolution, working both for the British government and Benjamin Franklin.

The process of dyeing cloth hadn't changed much in centuries, and the most skilled practitioners had passed complex and guarded procedures through generations. But in New York in 1823, William Partridge published "A Practical Treatise on Dyeing of Woollen, Cotton and Skein Silk, with the Manufacture of Broadcloths and Cassimeres Including the Most Improved Methods in the West of England", for thirty years the standard text, in which all the most popular dyes were disclosed like magicians' secrets and presented like cookery recipes. To prepare the fastest blue, for example, you would need an English vat containing "five times one hundred and twelve pounds of the best woad, five pounds of umbro madder, one peck of cornell and bran, the refuse of wheat, four pounds of copperas, and a quarter of a peck of dry slacked lime."

There were detailed descriptions of how to prepare the lime, followed by directions to chop the woad into small lumps with a spade, and gradually add other ingredients to water set at 195 degrees. The instructions ran on for several pages. "The vat should be set about four or five o'clock in the afternoon, and be attended and stirred again at nine o'clock the same evening," before being cooled. By this stage the result should be bottle-green. The dyer was then directed up again at five in the morning, and told to add more lime or indigo to lighten the colour. Bubbles and skin and increasing thickness would denote a good fermentation, which should then be bolied again and cooled, and boiled and cooled, and more lime added, and then it was time for the wool dipping. This was where matters became complicated. You really needed two vats of woad, one two months old, the other new, and the wool should be dipped in each in turn. The temperatures of the dye should be finely held at 125F -130F, then cooled overnight, then heated to 155F-165F, and then more woad added, with more lime, bran, madder and indigo. If the vats were skilfully managed it should colour 220 pounds of wool every week; within six weeks, the dyer should have four hundred pounds of dark blue wool, two hundred of half-blue, and two of very light. But this was only attainable if the very best woad and indigo were used, and here there were problems: "There is probably no article more uncertain in its strength and quality than woad," Partridge concluded. He advised buying only the very strongest, as "any considerable variation in this particular will prove very disastrous to the operator, however skilful he may be in his profession, and will be altogether ruinous to a young beginner."

As with cinchona bark, the supply of plant dyes was often limited to specific regions and hampered by a nation's attempts to monopolise production. Clothes manufacturers were forced to use the colours available in the dyers' vats; trends in colour were fashioned less by taste than by the vagaries of war and efficiencies of foreign ports. It stood to reason that a colour you could make on demand in a laboratory somewhere, with a constant strength and purity, would surely be worth an awful lot of money.

Initially, Perkin called his discovery Tyrian purple, the better to elevate its worth. His detractors, those who believed his discovery insignificant, preferred to call it aniline purple. Chief amongst these was August Hofmann, who learnt of Perkin's new colour after the summer holidays, along with some distressing news of his protege's future. The two arranged a meeting, during which Perkin told Hofmann that he was considering manufacturing mauve commercially. He also said that this would require him to leave the Royal College of Chemistry. "At this he appeared much annoyed," Perkin recalled at a memorial meeting to mark Hofmann's death in 1892. "[He] spoke in a very discouraging manner, making me feel that perhaps I might be taking a false step which might ruin my future prospects."

The objection caused a serious rift between them - probably the first cross words they had shared. "Hofmann perhaps anticipated that the undertaking would be a failure, and was very sorry to think that I should be so foolish as to leave my scientific work for such an object, especially as I was then but a lad of 18 years of age. I must confess that one of my great fears on entering into technical work was that it might prevent my continuing research...”

Footnote: While Hofmann objected to Perkin’s new obsession, it was not solely due to his pursuit of a practical application of his learning. Hofmann himself was involved in several such projects: In 1854 he analysed the spa waters of Harrogate for the Harrogate Water Committee; he sat on the chemical sub-committee assigned to examine the decay of the limestone and dolomite structure of the Houses of Parliament (no solution agreed upon); and in 1859 the Metropolitan Board of Works asked Hofmann to consider the possibilities for deodorisation.

Hofmann and his colleagues would have found it hard to imagine how one of the most promising scientific careers could be summarily abandoned in pursuit of a colour. Chemists came across new colours at random almost every week, and just as easily dismissed them as being an undesirable or irrelevant side-effect of their missions. Besides, some chemists had deliberately produced artificial dyes before mauve, and had observed how well they had coloured silk or wool, but had not attempted to manufacture them in commercial quantities. The first had been the picric acid made by Woulfe in 1771 from indigo and nitric acid (it dyed silk bright yellow), and in 1834 Runge had used carbolic acid to make aurin (a red colour), and pittacal (a deep blue) was obtained from beechwood tar. Other colours encouraged the development of implausible histories, not least murexide, a derivative of alloxan, which surfaced in small quantities in Manchester dye works in the 1850s and was said to come from the excrement of serpents. But the quantities of synthetic dyes in use at the time of the Great Exhibition of 1851 was so small as to not merit any mention in the huge accompanying Reports.

Then there was the bright crimson produced by Perkin and Church some months before, again considered unworthy of further exploitation. Perkin’s purple may have been cast aside in a similar manner were it not for the further encouragement he received from Robert Pullar in Perth towards the end of 1856.

The scale of Pullar’s dye works must have seemed an impressive place to a young man unfamiliar with industrial practices. The presence of scientists, however, was nothing new to printworks, and some had employed their own textile chemists from 1815. In fact, Perkin’s discovery came at a time when the state of technical advance in Britain’s dye and printing works was ideally poised to exploit it. Production levels in the textile industry were increasing at unprecedented rates. Exports in the calico business, for example, increased fourfold between 1851 and 1857, from about 6,500,000 items to 27 million. Employment in the silk industry doubled to 150,000 people between 1846 and 1857. At one of the many jubilee celebrations of Perkin’s discovery, the chemist CJT Cronshaw told a gathering of the Society of Chemical Industry: “If a fairy godmother had given Perkin the chance of choosing the precise moment for his discovery, he could not have selected a more appropriate or more auspicious time.”

This was not only true of the position of Britain’s dyeworks. Perkin could only have discovered mauve when he did because of the particular state of chemical knowledge. He was born not long after the Cumbrian chemist John Dalton had theorised that atoms combine with each other in definite numbers, thus leading to the establishment of chemical formulae. But Perkin conducted his early experiments at a time when so much was yet unknown, thus allowing for his productive error over the synthesis of quinine. If Perkin had been born 20 years later, he would have known how fruitless his search would have been, and thus would not have blundered into mauve. John Dalton, incidentally, died 12 years before Perkin's discovery, but the beauty would have been lost on him anyway: in 1794 he had been the first person to describe colour blindness - his own.

The principal reason that August Hofmann would have failed to share Perkin's enthusiasm for his new colour was because he would not have been unduly surprised by it. Even before he came to London he had heard Liebig predict that artificial dyes would someday be made from a substance such as aniline. But the roots of his disapproval lay in the current relationship between pure and applied science, which really meant the relationship between science and industry, two worlds set against each other by deficiencies in education.

In 1853, Lord Lyon Playfair had travelled through Germany and France at the request of the Prince Consort, specifically to report back on the state of foreign scientific and technical education. His analysis was damning: the great universities of Europe had already forged a strong connection between laboratory work and industry, whereas in industrial Britain he found only an "overweening respect for practice and contempt for science". He found the greatest culprit to be the severe shortcomings in basic teaching. Playfair feared the impact on Britain in the event of free trade, suggesting that when "the raw materials confined to one country become readily available to all at a slight difference in cost, then the competition in industry must become a competition in intellect."

The Great Exhibition of 1851 inspired many lectures sponsored by the Society of Arts, and some of them singled out a peculiar irony: while Britain shook the world with its industrial clout, it was virtually alone in Europe in lacking a well-defined system of technical education.

The same year saw the opening of Owens College in Manchester, and at its inaugural gala the college's professor of chemistry Edward Frankland suggested that Britain's textile industry was ill-prepared for the future. Its pre-eminence in manufacture would only be maintained by far stronger links with men of science. "The advantages of chemistry to the chemical manufacturer, the dyer and calico printer are almost too obvious to require comment," he said. "These processes cannot be carried out without some knowledge of our science, yet with the exception of some few firms...this knowledge is too often only superficial, sufficient to prevent egregious blunders and ruinous losses, but inadequate to seize upon and turn to advantage the numerous hints which are almost sure to be constantly furnished in all manufacturing processes."

The Chemical Society, founded in 1841, drew its few hundred members from manufacturing and academic backgrounds, and prided itself on the links between the two. In 1853, the president of the society, Frank Daubeny, seemed to express relief when he informed his members that Professor Robert Bunsen's work on volcanic eruptions could be used as "undeniable evidence of the extensive utility of our pursuits." Four years later, the new president WA Miller spoke of the invention of mauve as further proof of the burgeoning usefulness of their skills. "One of our Fellows, Mr Perkin, has afforded me the opportunity of bringing before you the results of a successful application of abstract science to an immediate practical purpose." At the time, he could hardly of known of the immense implications of this observation.

In fact, the successful application was still some months away, but when it came it did little to placate those who believed that Perkin's intellect could be better employed elsewhere. Even in 1862, it appeared that Hofmann accepted Perkin's breakthrough only very grudgingly. After visiting the International Exhibition that year in London, he still wished that "the care and time involved in an undertaking of such magnitude may not divert [Perkin] from the path of scientific enquiry, for which he has proved himself eminently qualified." Such a pure attitude ran counter to the dominant industrial ambition of the age: the pursuit of wealth.

In retrospect, it appears that Perkin shared some doubts about his commercial ambitions, though not for fear of being thought greedy. He resolved to regard his foray into industry as a means to an end. Writing to his friend Heinrich Caro, he stated that at the time of his discovery, "for a scientific man to be connected with manufacturing was looked upon as infra dig." Scientists who crossed the line were treated as pariahs, betrayers of their calling. Perkin was worried that, should he fail, there would be no way back. "Even poor Mansfield, as soon as he started to be a manufacturer, sold his scientific instruments (I have his balance which I purchased from him) evidently with the idea that his research days were over," Perkin wrote. "This public opinion and example made me dread becoming a manufacturer, because research was the principal ambition of my life, and I determined so far as in me lay that I would not give this up, whatever I did."

At the time, however, he kept this desire very much to himself, and was treated by some with disdain. "It was said that by my example I had done harm to science and diverted the minds of young men from pure to applied science, and it is possible that for a short time some were attracted to the study of chemistry from other than truly scientific motives." In other words, Perkin's discovery affected the whole nature of scientific investigation: for the first time, people realized that the study of chemistry could make them rich.

Taken from Mauve (Faber, 2000)