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## INTRODUCTION

# Changing Colour: Yellow Dyes from Antiquity to Early Modernity

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## Yellow is the new gold

There are some who make excessive use of gold, because they think it lends a certain majesty to painting. I would not praise them at all ... I would try to represent with colours rather than with gold.<sup>1</sup>

Gold has many properties, but one of the most generally recognised is its yellow colour: sometimes bright and sun-like, sometimes deepening almost to red. Yet, as Leon Battista Alberti famously recognised in his treatise on painting, the best way of representing gold's magnificence is not necessarily to use gold itself, but rather a fusion of pigment and technique. Since ancient times, a host of yellowing techniques were indeed used to imitate gold, appearing in crafts as diverse as textile dyeing, skin painting, manuscript illumination, and the alchemical "citrination" of white metals.

As Michel Pastoureau has observed, writing the history of yellow also involves writing the history of gold.<sup>2</sup> But when we subtract gold from the meanings of yellow, what remains? Histories of art typically give less exposure to plain yellow than to other colours, such as red and blue. In cultural studies of colour, yellow emerges as ambivalent, even unpopular; used to signify such negative emotions as jealousy or cowardice, or to single out marginalised groups as a marker of effeminacy, heterodoxy, or Jewishness.<sup>3</sup> To quote Pastoureau (who himself turned to

<sup>1</sup> Leon Battista Alberti, *On Painting*, trans. Cecil Grayson (London: Penguin, 2004), 85.

<sup>2</sup> Michel Pastoureau, *Yellow: The History of a Color*, trans. Jody Gladding (Princeton, NJ: Princeton University Press, 2019), 9; first published as *Jaune: Histoire d'une Couleur* (Paris: Éditions du Seuil, 2019).

<sup>3</sup> On yellow in pre-modern culture, see also Herman Pleij, *Van karmijn, purper en blauw: over kleuren van de Middeleeuwen en daarna* (Amsterdam: Prometheus, 2002), translated as *Colors Demonic and Divine: Shades of Meaning in the Middle Ages and After*, trans. Diane Webb (New York: Columbia University Press, 2004). For the modern period, see Sabine Doran, *The Culture of Yellow: The Visual Politics of Late Modernity* (London: Bloomsbury, 2013); John Gage, *Colour and Culture: Practice and Meaning from Antiquity to Abstraction* (London: Thames and Hudson, 1993).

yellow only after completing studies of blue, black, green, and red), the history of yellow is a turbulent one: “in any given period ... less conspicuous than red, black, blue, or even green.”<sup>4</sup> The colour’s most positive associations – costliness, lustre, impermeability – tend to be absorbed by gold, leaving yellow with less attractive connotations. Even in material terms, the impermanence of many widely-used organic yellow dyes compares unfavourably to the durable shine of gold.

Yet this same unstable materiality also makes yellow an object of interest. This special issue examines the meanings of yellow as an end in its own right, one pursued by dyers, pigment-makers, and experimenting chemists. Rather than offering cultural histories, our contributions are grounded in the materiality of yellow products and yellowing effects. Each paper also draws on the methodology of experimental reconstruction, an approach that allows historians to experience the material peculiarities of yellow firsthand, while permitting deeper insight into the ambivalence of both textual sources and the colour itself.

Our case studies range across Graeco-Roman Egypt, the medieval Islamic lands, and late medieval, early modern, and nineteenth-century Europe. In general, we have elected not to linger on abstract colour theories, including ancient and medieval speculations over the nature of light and perception that already provide the basis for extensive scholarship.<sup>5</sup> We instead follow the lead suggested by ancient and medieval handbooks that engage directly with the technical aspects of making things yellow – whether those things are garments, inks, stolen horses, or transmuted metal. As our sources show, the break between theoretical discussions of colour based on light, and artisanal applications of colour using pigments, was already well understood by the Middle Ages.<sup>6</sup> Although Aristotelian debates tended to conflate all instances of colour into one, generic “yellow,” the practical environment of making and dyeing was highly attuned to gradations of tone and shade – certainly, no one used to working with orpiment or sulphur would ever have confused the bright, citron yellow of these minerals with the tawny shine of precious metal. Approaching yellow through material substances, rather than in the abstract, paradoxically makes it easier to explore the history of yellow separately from that of gold.

## The materiality of yellow

To speak of colours, regardless of the language in which it is done, is to impose distinct boundaries on a continuous spectrum. The semantic area of colours is a privileged field in which to observe the competing claims of nature and culture over

<sup>4</sup> Pastoureau, *Yellow*, 9.

<sup>5</sup> John Gage, *Color and Meaning: Art, Science and Symbolism* (Berkeley: University of California Press, 1999); Robert A. Crone, *A History of Color: The Evolution of Theories of Lights and Color* (Dordrecht: Kluwer, 1999); A. Mark Smith, *From Sight to Light: The Passage from Ancient to Modern Optics* (Chicago, IL: University of Chicago Press, 2014).

<sup>6</sup> See also Samuel Y. Edgerton, Jr., “Alberti’s Colour Theory: A Medieval Bottle without Renaissance Wine,” *Journal of the Warburg and Courtauld Institutes* 32 (1969): 109–34.

language, reflected in the discrepancy between what the eye can see and what language can describe.<sup>7</sup> Homer's notion of colours was the spark that ignited the linguistic debate, as "yellow" (*xanthos*) is rarely used in the Homeric poems, yet seems to encompass a wide range of hues: from the shining blond of the gods' hair to amber and the blaze of fire, blending into red at one extreme, and green at the other.<sup>8</sup> Something similar happens with the naming of yellow in other languages. Whether in lexica, in poetry, or anything in between, the name of a colour and its hues are often associated with particular material similes – egg yolk, turmeric, corn, ochre – that give *body* to the colour even beyond its linguistic expression. On the other hand, some colour expressions derive from abstract *realia*. For example, in Latin the adjective *flavus* may indicate a variety of different shades of yellow (including that of the River Tiber), but when yellow is defined as *citrinus*, it refers to the specific colour of the fruit. In Arabic, the adjective *asfar* may refer to the reddish colour of metals such as copper and bronze, but also to the hue of egg yolk, or the characteristic gleam on the coat of a black horse.

The connection between the pure semantics of colour and the materiality of its similes is crucial to our inquiry. It allows us to deal with yellow in different linguistic traditions, and to appreciate their idiosyncratic aspects and their cultural values without letting them become an insurmountable obstacle to researching the materiality of yellow. Although languages employ different semantic spectra, it is nonetheless possible to identify areas of shared use, especially when we can point to certain objects as referents over long periods of time. In Greek, for instance, the Aristotelian corpus associates the colour of the sun with yellow (*xanthos*), a simile that can be helpful even for modern readers.<sup>9</sup> To invoke a deeper orange-yellow, medieval sources might refer to saffron or minium, substances that have remained consistent in colour over centuries.

Rather than proceeding from abstract terms, our solution to the semantic problem is therefore to approach colour through materials and practices – from the "world up." This approach starts with the yellow things described in historical sources, which encompass all the kingdoms of nature: animal, vegetable, and mineral. In the vegetal world yellow is ubiquitous, appearing in a profusion of flowers, leaves, roots, fruits, and oils, many of which were well known in antiquity for their medical and commercial value. These plant-based yellows are commonly encountered in pre-modern literature, in part due to the dominance of plants in materia medica and textile dyeing. However, the mineral kingdom is also rich in yellows, from the bright sunshine yellow of sulphur and orpiment to shades closer to red, including litharge and minium, or the earthier tones of ochre. Nor

<sup>7</sup> Guy Deutscher, *Through the Language Glass: Why the World Looks Different in Other Languages* (New York: Metropolitan Books, 2010).

<sup>8</sup> Maria Michela Sassi, "Una percezione imperfetta? I Greci e la definizione dei colori," *L'immagine riflessa* 2 (1994): 281–302.

<sup>9</sup> Peter Struyken, "Colour Mixtures According to Democritus and Plato," *Mnemosyne* 56, no. 3 (2003): 273–305 (on 281–82).

does the animal kingdom lack for yellow, from wasps and brimstone butterflies to bile and beeswax. Even in antiquity, yellow was recognised as a bodily product and resource, giving rise to the close study of yellow materials, such as urine, or to their imitation, such as the blond of human hair.

As people interacted with these substances, they recounted and stockpiled their experiences, generating new meanings from the interaction between human beings and natural things. At the beginning of the fifteenth century, Cennino Cennini, compiler of the famous *Libro dell'arte* on painterly techniques, showed a keen awareness of the material properties of different yellows, including important variations in brightness and durability, when surveying yellow pigments.<sup>10</sup> Ochre, for instance, is made from earth and offers a good “all-round” colour, suitable for frescoes, although rather coarse. Saffron, of vegetable origin, is suitable for dyeing linen or painting on parchment, but soon fades on exposure to air. The mineral pigment orpiment, made using alchemical techniques, offers “a more beautiful-yellow colour, resembling gold, than any pigment that there is,” with the drawback that it will blacken over time, besides being extremely toxic. The search for the ideal combination of properties led Cennini to praise a colour of uncertain provenance, “a pigment called giallorino” that was brighter and longer-lasting than saffron but less dangerous than the arsenical compounds orpiment and realgar. “And I am given to understand,” Cennini notes, “that this pigment is actually a stone, created in the vicinity of great fires in the mountains. However, I tell you that it is a pigment manufactured, but not by alchemy.”<sup>11</sup> Artificial intervention rather than natural occurrence would eventually yield bright, durable colours like lead-tin yellow (one candidate for Cennini’s *giallorino*): new products that contributed directly to the increased use of yellow in crafts such as manuscript illumination – and with it, a new range of meanings.

Materials therefore provide the foundation for exploring how yellow colours were used, how their properties were evaluated, and how these properties and uses in turn generated new conceptual and cultural contexts. In this issue, for instance, Caterina Manco and Matteo Martelli’s paper identifies the importance of qualities like brilliance and brightness in ancient yellow dyes. Lucia Raggetti explores the synaesthetic quality of yellow and gold, often associated in Arabic sources with perfume or the touch of skin – associations that also rendered the colour susceptible to moral and religious critique. Papers by Jennifer Rampling and by Marjolijn Bol and Giacomo Montanari explore yellow’s evanescence and durability: whether fading in sunlight as a paint or textile, chemically changing

<sup>10</sup> Lara Broecke, ed., *Cennino Cennini’s Il Libro Dell’Arte: A New English Translation and Commentary With Italian Transcription* (London: Archetype, 2015), 70–76.

<sup>11</sup> Cennini, *Il Libro Dell’Arte*, 72–73. The identity of *giallorino* was discussed extensively by Mary Philadelphia Merrifield, *Original Treatises, Dating From the XIIth To the XVIIIth Centuries, On the Arts of Painting*, 2 vols. (London: John Murray, 1849), vol. 1, clvi–clxiii; see also Ashok Roy and Barbara H. Berrie, “A New Lead-Based Yellow in the Seventeenth Century,” *Studies in Conservation* 43, suppl. 1 (1998): 160–65.

fibres into a more permanent colour, or, as an alchemical sign, prefiguring a deeper transformation into red.

## Ways of yellowing

While yellow substances provide the starting point for these studies, equally important are the role of yellowing processes: the complex and often mysterious interactions between a colouring agent and the thing being coloured (or, to use Aristotelian terminology, the “patient” receiving colour from the “agent”). The relationship between agent and patient is itself characterised by different material features, including the porosity and starting colour of the patient. Sometimes, yellowing may require the patient to be relatively impermeable, as in the case of oil painting, where more porous surfaces such as canvas or wood are treated with several layers of animal glue or thin layers of drying oil to prevent absorption of the oil paint into the support. In other instances, a porous surface is necessary to allow the yellowing agent to penetrate the substance and make it yellow from within, as happens when dyeing wool or other fibres. Yellowing processes do not require that the colouring agent itself be yellow, or even have material form – in fact, both sunlight and fire might qualify as yellowing agents, depending on their proximity to specific materials. Nitric acid, although clear, produces yellowing in some organic substances, from silk and wool to bones and wood, even as it causes their structure to degrade: a process examined by Bol and Montanari.

Agents could be organic or inorganic, with the plant kingdom offering the widest variety of yellowing substances, as charted by the extensive catalogue of yellow-dyeing plants appended to Manco and Martelli’s paper. Animals also supplied their fair share of yellowing agents, although more often they served as the patient to be yellowed: their hides, fur, and fleeces providing the fibres for yellowed cloth, and their skins the parchment for illuminated manuscript pages; while their bones, horn, and ivory were yellowed for use in furniture and weaponry. Living animals, such as horses, might also be yellowed for purposes of decoration or deceit. Here, as Raggetti notes in her paper, the starting colour of the patient made a difference – to yellow a horse, using organic dyes such as alkanet, henna, and saffron, required that the animal start out white. Other transformations involved the dramatic lightening of a dark substance. Rampling shows how alchemical colouring techniques, such as the oxidation of black powdered lead into litharge, might conjure yellow even from materials of a completely different colour, seemingly through the application of fire alone.

Such yellowing could be durable or transient. A range of artisanal contexts, including dyeing and metallurgy, also supply evidence of continuous colour change. For instance, indigo is a substantive dye: accordingly, material is doused in the dye without a mordant, emerging with a brilliant yellow colour that swiftly darkens into green and then the distinctive dark blue of indigo. The colour

change in the process of making indigo, in fact, stimulated theories about the role of oxygen in the production of colour, as shown in Bol and Montanari's paper.

The many ways in which materials were made yellow in the past have yielded a rich vocabulary of terms for describing these methods. For the purposes of this issue, we use "yellowing" to describe the general act of conveying a yellow colour to a material, while situating more specific terms – painting, tinting, dyeing, varnishing, citrining – in the specific historical circumstances in which they were employed. This multiplicity of colouring techniques can be broken down into three broad categories: coating, dyeing, and transmutation.

**Coating** adds a layer to a surface, without necessarily altering the substance of the patient. This broad category includes a range of paints, inks, cosmetics, and varnishes, typically made from particles suspended in a binder. Paints, for instance, are usually made by binding pigment particles with another substance, such as a glue or oil. Many cosmetics are formulated like paint, although others are better classed as dyes (for instance, a red organic plant dye like madder, that is applied to the face as a liquid rather than as grains). In the pursuit of making imitations of gold, oil-resin varnishes, on the other hand, were often coloured yellow with dyes rather than pigments. Unlike pigments, dyes dissolve in their medium, making these coatings perfectly light-transmitting. Applied to silver and tin, such varnishes were used to substitute for gold; while yellow varnishes, applied to gilded surfaces, served to protect the fragile gold leaves.<sup>12</sup>

**Dyeing** penetrates the body of a substance, relying on the porosity of the material (or a mordant) to introduce the colouring agent into the patient. Dyeing is most often associated with colouring fabric, although in practice it was used for a host of materials. For instance, in Greek and Byzantine handbooks on medicine, specific dyes were employed to penetrate blond hair, imparting the colour of gold. As Manco and Martelli show, the same dyes were also tested on metals in the hope that they could soak into the hard surface. The value of a good dye was economic as well as aesthetic – even if not always licit. Drawing on medieval Arabic sources, Raggetti identifies the practice of smuggling horses and trafficking people by dyeing hides and hair in false colours, including yellow: temporary changes intended to deceive. But as Bol and Montanari show, in other cases it was the durability of yellow colourations that dyers sought. Compared to various other plant or insect-derived colourants, organic yellow dyes are not particularly lasting. As a result, other ways of yellowing, such as using acids to stain bone, wood, and horn, were closely investigated as more permanent alternatives to dyeing with plant-derived yellows.

**Transmutation** brings about structural change – or the appearance of it. Chemical reactions make durable changes to the surface of metals, as when sulphur reacts with silver through the application of "water of sulphur."<sup>13</sup> They can also go

<sup>12</sup> Marjolijn Bol, *The Varnish and the Glaze: Painting Splendor with Oil, 1100–1500* (Chicago, IL: University of Chicago Press, 2023), esp. chap. 2.

<sup>13</sup> On the water of sulphur, see Matteo Martelli, "Transmuting Tinctures: Water of Sulphur, Quicklime and 'Washes' in Graeco-Egyptian Alchemy," *Technai: An International Journal for Ancient Science and Technology* 13 (2002): 115–42; Lawrence M. Principe, *The Secrets of Alchemy* (Chicago, IL: University of Chicago Press, 2013), 10–11.

beyond superficial alteration, transforming not just the surface but the very substance of a patient. When these reactions result in yellow products, we may therefore consider them to be yellowing processes. Both durable and transient yellowing effects are features of transmutational alchemy, an art supposed to culminate with the manufacture of lasting, authentic gold. Metallic transmutation, if it were ever achieved, would therefore qualify as an extreme example of yellowing. In practice, temporary yellowing was likely to occur at multiple points in an alchemical work – appearances that might be favourably viewed, as Rampling argues in her paper, as “tokens” that alchemists interpreted as evidence of good progress.<sup>14</sup> Such yellowing effects might also become ends in themselves. Alchemical recipe collections often include “citrinations”: processes that aim to yellow the surface of white metals without any expectation that transmutation is occurring. It is likely that some of the yellowing techniques that pepper early modern craft handbooks began life as by-products of the alchemical quest for gold.

## Reproducing yellow

In keeping with our emphasis on materiality, the contributions to this *Ambix* special issue all draw on a common methodology: the attempted reconstruction of past practices in the present day. Historical reconstruction has, of course, received considerable scholarly attention over the past two decades. In the premodern sphere, historians of alchemy have used experimental reconstruction to shed light on enigmatic texts and obscure chemical practices.<sup>15</sup> The tacit knowledge embodied in artisanal practices, revealed through the replication of craft procedures from metalworking to healing poultices, offers an important source of insight for historians of science and medicine.<sup>16</sup> Art historians, too, have found that knowledge of technique offers new perspectives on the premodern visual and decorative arts.<sup>17</sup>

Our own essential partners in this enterprise are Giacomo Montanari, Marianna Marchini, and Lucia Maini, colleagues in the Department of Chemistry at the University of Bologna who shared laboratory space, apparatus, specialist chemical knowledge, and their own sensitivity to the properties and colourful transformations of materials. This collaboration was vital to solving the problems raised by yellow dyes, puzzles that require an interplay of knowledge between scientists

<sup>14</sup> See also Jennifer M. Rampling, *The Experimental Fire: English Alchemy, 1300–1700* (Chicago, IL: The University of Chicago Press, 2020), 296–99 and 311–12.

<sup>15</sup> See the articles collected in Hjalmar Fors, Lawrence M. Principe, and Otto Sibum, eds., “From the Library to the Laboratory and Back Again: Experiment as a Tool for the History of Science,” *Ambix* 63, no. 2 (2016); Lawrence M. Principe, “‘Chemical Translation’ and the Role of Impurities in Alchemy: Examples from Basil Valentine’s *Triump-Wagen*,” *Ambix* 34 (1987): 21–30; William R. Newman, *Newton the Alchemist: Science, Enigma, and the Quest for Nature’s “Secret Fire”* (Princeton, NJ: Princeton University Press, 2018).

<sup>16</sup> See especially Pamela H. Smith, ed., *The Making and Knowing Project*: <https://edition640.makingandknowing.org/#/> (accessed 19 July 2023); Pamela H. Smith, *From Lived Experience to the Written Word: Reconstructing Practical Knowledge in the Early Modern World* (Chicago, IL: University of Chicago Press, 2022).

<sup>17</sup> Sven Dupré, Anna Harris, Julia Kursell, Patricia Lulof, and Maartje Stols-Witlox, eds., *Reconstruction, Replication and Re-enactment in the Humanities and Social Sciences* (Amsterdam: Amsterdam University Press, 2020); Bol, *Varnish and the Glaze*.



and historians, calling for creativity, patience, and understanding on all sides. This collaboration offered further benefits, by requiring all parties to step outside their own disciplinary “comfort zones” in order to reach a deeper understanding of one another’s fields – and also of their own. Appropriately, the chemists have the last word in this volume, by providing an epilogue that sets out their own experience of working with historians on reconstructing yellow: both its cultural manifestations, and the colour itself.

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## Disclosure statement

No potential conflict of interest was reported by the author(s).

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