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ARISTOTLE AS A SOURCE FOR LEONARDO’S THEORY OF COLOUR PERSPECTIVE AFTER 1500*
Janis Bell

Leonardo’s theory of colour perspective has generally been regarded as a collection of first-hand observations of nature, quoted to support a particular interpretation of his art or to demonstrate his unusual sensitivity to the appearance of nature. Ernst Gombrich, however, has recently emphasised that a priori theories tinged Leonardo’s observations on the colours of mountains. Although he did not try to identify their sources outside the workshop tradition, he recognised the need for an extensive critical analysis of Leonardo’s ideas. My own investigation of Leonardo’s writings on colour perspective around 1492 revealed that his ideas were based predominantly upon the optical tradition of the late middle ages and upon Aristotle’s Meteorology. I found that many of his so-called ‘observations’ were not records of what he saw on outings in the mountains outside Florence or Milan, but rather the product of reasoning, as Leonardo attempted to formulate pictorial precepts from the science of optics which he regarded as the foundation of the pictorial arts. Much of Leonardo’s theory of colour perspective after 1500 is similarly based upon reasoning, but his sources shifted from medieval optics to texts by or attributed to Aristotle. His principal source was the Pseudo-Aristotelian On Colours, but Sense and Sensibilia seems to have captured his interest as well. The information in these texts led Leonardo to discard the conclusion previously put forward in Manuscripts Ashburnham (‘A’) and Trivulzius (about 1490–92) that air

* The following abbreviations are used throughout for the citation of Leonardo’s writings:
CU = folios in the Vatican Codex Urbinas 1270.


is blue, to expand his description of ‘the way that colours vary as they get distant from the eye’, and to reformulate precepts for pictorial practice.

On Colours presented the idea that the blue colour of the air was only an appearance resulting from the mixture of light and dark, for air itself was said to be colourless. It also presented the argument that all colours are apparent and that the ‘true colour’ of objects is an ideal which can rarely if ever be perceived. This argument followed from the premise that the coloured appearance of every object depends upon its illumination as well as the colour and illumination of the medium through which it is seen. In picking up these ideas, Leonardo began to regard distance as another causal factor in the variation of colour appearance. Thus, the focus of his research on colour perspective broadened to include the effects of the colour of light sources and of adjacent coloured surfaces upon the colour of opaque bodies situated at varying distances.

LEONARDO’S KNOWLEDGE OF DE COLORIBUS

The evidence for Leonardo’s knowledge of On Colours comes from two passages in the Treatise on Painting (Vatican Codex Urbinas 1240) that paraphrase part of the third chapter: CU 193r, and CU 140v. The first folio, CU 193r, dates from around 1508–10, since it derives from Libro A, a lost notebook which Pedretti has reconstructed on the basis of marginal notes in the Codex Urbinas. The original text of the passage on CU 140v is lost. It probably dates earlier, however, for it is closer to a paraphrase.

4 MS A, fol. 98v (Ri 298–99, CU 53v–54, Mc 230, 227, LU 149–150); MS Triv, fol. 59 (CU 77, Mc 221). All references to the last 24 folios of MS A which have been bound separately as Florence, Biblioteca Nazionale, MS Ashburnham II, are cited as MS A, following the editions of A. Corbeau and N. De Toni, Nuovissimi. 

5 MS A, fol. 98r (Ri 14).

6 For the basis of the reconstruction see Pedretti, Libro A, pp. 24–27. Pedretti there suggested a date for Libro A of c. 1508–10, because of its connection to the Codex Hammer (ex-Leicester), which he then believed was compiled c. 1506–08; he now dates the Codex Hammer later, for which see n. 21 below. The dating of Leonardo’s surviving manuscripts is still somewhat conjectural, but less so than for lost books and compilations like the Treatise on Painting. The fundamental study of Gerolamo Calvi, I manoscritti di Leonardo da Vinci dal papiro da vista cronologico storico e biografico, Bologna 1923, is still useful, but an updated summary can be found in Pedretti, Commentarii: Art Bulletin, I, 1979, pp. 642–50.

7 The dating of passages from lost manuscripts is somewhat conjectural. Most are placed by Pedretti within a five-year time span, c. 1505–10, with some dated to a two-year span (1508–10), and a few considered as late as 1515 (Libro A, pp. 177–221, which updates his earlier ‘Note sulla cronologia del “Trattato della Pittura” di Leonardo’, L’arte, xxiv, 1959, pp. 25–39 and xxv, 1960, pp. 16–89). See also the earlier, more general dating of A. M. Brizio, ‘Il Trattato della Pittura di Leonardo’, Scritti in onore di Lionello Venturi, Rome 1956, pp. 309–20, and her positive review of Pedretti in Raccolta Vinciana, xix, 1962, pp. 347–49. A computerized text of all Leonardo’s writings would make it possible to do sophisticated textual analyses of Leonardo’s language which, together with an analysis of content, could make the dating more specific and more accurate. Passages subsequently found in Madrid MS II, dated 1505–10 before the discovery of the manuscripts, are now assigned to 1503–04 on the basis of dated sheets. See also C. Farago, A Critical Interpretation of Leonardo da Vinci’s ‘Paragone’, with a New Edition of the Text in the Codex Urbinas’, Leiden 1991, for a revised dating of the Paragone. A concordance of passages in CU which have been traced to original manuscripts was published by McMahon, and updated by Pedretti in his Libro A. To this should be added those passages recently identified in the Madrid Codices, for which see C. Pedretti, ‘Le note di pittura di Leonardo da Vinci nei manoscritti inediti a Madrid’, Lettura Vinciana VIII, 1968 (repr. Leonardo da Vinci: Letture Vinciane I–XII, [1960–72], Florence 1974, pp. 200–48), and Leonardo da Vinci, The Madrid Codices, ed. L. Reti, 5 vols, New York 1974, iii, pp. 89–90.
Both CU 140v and On Colours proceed from a statement of the basic principle of reflected colour to note how light and shade and then reflected colour affect the appearance of any given colour, including the colour of the air.

Leonardo: But simple colour is never seen; this is proved by the ninth [proposition] which says that the surface of every body participates in the colour of the object opposite it, even if it is the surface of a transparent body such as air, water, and the like.8

Leonardo then develops the idea of sky colour as an example of reflected colour, in which the air is seen picking up the colour of the light and the darkness which surrounds it, just as a solid body might pick up the colours of illuminated or shadowed surfaces adjacent to it. Here On Colours continues to provide a model, suggesting that all colours by the time they reach the eye are a blend of the many colours reflected from all those objects around it.

Leonardo: ...because the air takes the light from the sun and the darkness from the privation of the sun. Therefore, it is tinged with as many various colours as interposed between them and the eye.10

Finally, Leonardo goes on to explain that air itself has no colour but takes its colour from the humidity mixed within it, which, when it is dense, becomes illuminated. Again, this parallels the text of On Colours, which next discusses the colour of air when rare and dense. Pseudo-Aristotle argues that the density of air determines its susceptibility to the passage of solar rays, which, in turn, determines whether it looks more or less blue. Leonardo reaches the same conclusion.

Leonardo: Because air in itself has no more colour than does water, but it is the humidity mixed into it from the middle region down which thickens it; and when it is thickened, the solar rays which strike it illuminate it. And the air which is above this middle region remains totally dark, and because light and darkness make the colour

Pseudo-Aristotle: We never see a colour in absolute purity; it is always blended, if not with another colour, then with rays of light or with shadows, and so it assumes a tint other than its own... For if light falls on a given object and is coloured by it crimson or herb-green, and then the light reflected from that object falls on another colour, it is again modified by this second colour, and so it gets a new chromatic blend.9

Pseudo-Aristotle: This happening to it continuously, though imperceptibly, light when it reaches the eye may be a blend of many colours, though the sensation produced is not of a blend but of some colour predominant in the blend...

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Pseudo-Aristotle: A translucent white medium, when of a very rare consistency, looks hazy in colour; but if it is dense, like water or glass, or air when thick, a sort of mist covers its surface... Air seen close at hand appears to have no colour, for it is so rare that it yields and gives passage to the denser rays of light which thus shine through it; but when

8 ‘Ma il colore non si vederà mai semplice; provasi per la nona che dice la superficie d’ogni corpo parte-cipa del colore del suo ombretto, ancora ch’ella sia superficie di corpo trasparente com’è aria acqua e simili...’


10 ‘...perche l’aria piglia la luce dal sole et le tenebre dalla privatione d’esso sole adonque si tinge in tanti vari colori quanto son quelli infra li quali ella s’infra-metete infra l’occhio e loro...’ Mc translates the last phrase ‘so that it [the air] is tinted with as many different colors as occur between it and the eye’. However, the plural ‘loro’ refers to the sun and the darkness at the boundary of the air.
blue, this blue colour is what tints the air to a greater or lesser extent depending upon whether the air is mixed with more or less humidity.\(^{11}\)

This is a rare example of Leonardo’s close dependence upon a Latin source.\(^{12}\) When he wrote this passage, he clearly had chapter three of *On Colours* in mind and followed the sequence of ideas.\(^{13}\) How Leonardo got to know *On Colours* is unclear. His library list in Madrid Codex II, dated about 1504, does not include it.\(^{14}\) However, we do know that the text had survived in two medieval translations, one of which was included in the edition of Aristotle’s works published in Venice in 1482 and again in 1496.\(^{15}\) Furthermore, interest in the Greek text was germinating in the early sixteenth century, resulting in the publication of new translations and commentaries by Caelius Calcagnini of Ferrara (1538) and Simone Portius of Naples (1548); also, a large part of the first three chapters were quoted in Sophonias’s commentary on Aristotle’s *On the Soul*.\(^{16}\)

**THE APPARENT BLUE OF THE SKY: THE CODEX HAMMER**

Several years before he wrote the passage on folio 140v of the Codex Urbina, Leonardo seems to have become familiar with the idea that the blue of the sky is an apparent colour due to darkness seen through light. In Institut de France manuscript H\(^2\), folio 77v, dated January and February 1494, he wrote: ‘The air is blue by reason of the darkness above it, because it is black and white make blue’.\(^{17}\) His source at this time was probably Ristoro d’Arezzo, whose *Composizione del mondo* of about 1282 was a popular text.\(^{18}\) Ristoro also follows the explanation of the colour of the air in a deep mass it looks practically dark blue. This again is the result of its rarity, for where light fails the air lets darkness through and looks dark blue. When densified, air is, like water, the whitest of things.

\(^{11}\) ‘...perche l’aria in se non a colore piu che s’habia l’acqua ma l’umido che si mista con essa dalla meza regione in giu e quello che la ingrossa et in grossando li razi solari che vi percottano v’aluminano e’ l’aria che da detta meza regione in su resta tenebrosa, e perche lucre e tenebre comporte colore azuro e questo e l’azuro in che s’tinge l’aria con tanta magiore o minore oscurita quanto l’aria è mista con minore o maggiore umidita.’

\(^{12}\) As G. Perini explained in ‘Biographical Anecdotes and Historical Truth: an Example from Malvasia’s *Life of Guido Reni*,’ *Studi Setcenteschi*, xxxi, 1990, pp. 149–60, esp. 157, when one author follows another with regard to (1) general concept, (2) order of arrangement of elements, and (3) often a keyword, we can identify what literary theorists call ‘intertextuality’, as distinguished from general thematic affinity. I am indebted to her for general references on this subject, among which one of the most useful is C. Segre, *Avviamento all’analisi del testo letterario*, Turin 1985.


\(^{15}\) Gottschalk (as in n. 3), p. 59. Kristeller and Crazz, eds (as in n. 3), pp. 318–22, do not cite the Sophonias commentary.

\(^{16}\) ‘L’aria è azzurra per le tenebre che è di sopra, perché nero e bianco fa azzurro’ (Ri 304).

\(^{17}\) Ristoro has been identified as a source for Leonardo in the Codex Hammer by C. Pedretti, *The Codex Hammer of Leonardo da Vinci*, Florence 1987, p. 31; by M. Baratta, *Leonardo da Vinci e i problemi della terra*, Turin 1903, and in my article cited in n. 2 above. The first
with a brief general statement about mixing. However, Leonardo did not go deeper into this question until he discovered the passage in *On Colours*. Another stimulus was the opportunity to ascend Mount Monboso (now called Monte Rosa) in the Alps. This experience is recorded in the Codex Hammer (before 1508–10).

On Codex Hammer folio 4r (4A), Leonardo records his observation that the colour of the sky appeared darker from the summit than it normally did at sea level. This he regards as a confirmation of the Pseudo-Aristotelian explanation for the blue colour of the sky:

I say that the blue colour that the air appears to be is not its true colour, but is caused by the hot moisture having evaporated into very minute, imperceptible atoms. This moisture attracts the percussion of solar rays and becomes luminous against the obscurity of the immense darkness of the region of fire which forms a covering above it. And this may be seen, as I myself saw, by anyone going up Monboso, a peak of the Alps that divide France from Italy... I saw the air dark overhead and the sun striking the mountain appeared to be more luminous than in the plains below, because less density of air is interposed between the summit of that mountain and the sun.

But Leonardo was not content to stop at the mere confirmation of another’s ideas. In the spirit of scientific inquiry, he devised experiments to establish this

published edition of Ristoro by E. Narducci, Rome 1859, has been superseded by the critical, philological edition, *La composizione del mondo colle sue causioni*, ed. A. Moroni (Accademia della Crusca), Florence 1976, from which all quotations and citations are taken.

Leonardo’s source may alternatively have been the meteorological study listed in his library as ‘De mutatione aeris’, which has been identified with the popular *De mutatione aeris* of Firman de Beauval (Venice 1485). Reti (as in n. 14) suggested the possibility that this title referred to a treatise of this name by Japhar (1507), while Pedretti, *Commentary*, ii, p. 363, following Maccagni, suggested that it refers to a collection of astronomical treatises by Leopoldus Ducatus (Augsburg 1489), one of which had the same title. The great notoriety and circulation of the treatise of Firman de Beauval (Firminus de Bellavalle) makes this a more likely candidate in my opinion. A full study of these meteorological treatises in relation to Leonardo’s ideas would be necessary to establish the identification of this citation. On Firman see L. Thorndike, *A History of Magic and Experimental Science*, 6 vols, New York 1923–41, iii, pp. 268–80.


In his most recent publication of the Codex, *The Codex Hammer of Leonardo da Vinci*, Florence 1987, Pedretti puts the date back even further: 1504–06 had been proposed in the first publication by Calvi (1900); at an exhibition in Bologna at the Palazzo del Podestà (for which see Pedretti, as in n. 20), 1506–08 was proposed. The later dating puts it entirely in a Milanese ambient; the reasons for pushing back the date are not entirely convincing, and are typical of Pedretti’s approach to the artist, for which see A. M. Brizio, *Art Bulletin*, lii, 1971, pp. 528–32 (review of Clark and Pedretti, op. cit.).

22 The number in brackets refers to the number of the sheet when the binding was removed for study, and then presented at the exhibition in Bologna (see Pedretti, as in n. 20, pp. 22–23). Leonardo wrote on large sheets, folded in half, stuffing each subsequent one inside the others. The new numeration reflects the order in which the notes were written.

23 ‘Minor grosseza’ has to be interpreted as ‘less density’, not as a measure of quantity as Richter has it, for it would otherwise conflict with the argument presented below that a greater quantity of air looks lighter, not darker.

24 (Ri 300) ‘Del colore dell’aria: Dico l’azzurro in che si mostra l’aria non essere suo proprio colore, ma è causato da umidità calda vaporata in minutissimi e insensibili atomi, la quale piglia dopo se la percussione de’ razzi solari e fassi luminosa sotto la oscurità delle immense tenebre della regione del fuoco che di sopra le fa coperchio; e questo vedrà, come vid’ io, chi andrà sopra Monboso, giogo dell’alpi che dividono la Francia dalla Italia, ...vidi l’aria sopra di me tenebrosa e ’l sole che percorrea la montagna essere più luminoso quivi assai che nelle basse pianure, perché minor grossezza d’aria s’interponea infra la cima d’esso monte e ’l sole.’
theory. It is not certain whether these experiments were actually carried out, or whether they remained notional, the kind of “thought experiments” typical of much Renaissance and medieval science, particularly in the field of optics.

For another example of the [generation of the] colour of the air, we will take the case of smoke produced by old and dry wood which, as it comes out of a chimney, appears to turn very blue when seen between the eye and a dark place. But as it rises and comes between the eye and the illuminated air, it suddenly looks an ash-grey colour. And this happens because it no longer has darkness behind it, but in its place the luminous air. And if this smoke comes from young, green wood, then it will not assume a blue colour, because not being transparent and yet full of abundant humidity, it will act like a condensed cloud that terminates lights and shadows as if it were a solid body. The same thing happens with the air that is rendered white from excessive moisture, and when little infused with heat is rendered dark, the colour of dark blue, and this suffices regarding the definition of the colour of the air.25

This last passage can only be understood with reference to Pseudo-Aristotelian chemistry, as for example in On Colours, folio 794b30, which says that as moisture cools, it turns black.

At this point, Leonardo launches into a rebuttal of the theory that the air itself is blue, possibly remembering Ristoro d’Arezzo’s own rebuttal of the same theory. Ristoro said that there are people who believe that the blue colour of the air is due to vapours, but this is contradicted by our experience in looking at the stars. The stars, which are seen through the air, do not take on a blue colour as they do when seen through blue glass.26 Leonardo writes:

Though one could also say that if the air had a transparent blue for its natural colour, it would follow that wherever a greater quantity of air came between the eye and the element of fire, it would appear a much darker blue, as we see with blue glass and with sapphires, which are darker in proportion as they are larger. But the air in this case is the direct opposite, in so far as wherever a greater quantity is interposed between the eye and the sphere of fire, it appears much whiter; and this happens towards the horizon; And the smaller the extent of air interposed between the eye and the sphere of fire, so much darker will be the blue colour...27

25 ‘Ancora per esempio del colore dell’aria alleggeremo il fumo nato di legne secche e vecchie il quale uscendo de’ camini pare forte azzurreggiare quando si trova infra l’occhio e il loco oscurò, ma quando monta in alto e s’interpone infra l’occhio e l’aria aluninata, intermedie si dimostra di colore cenerognolo, e questo accade perché non à più oscurità dopo se, ma in loco di quella à aria luminosa; e se tal fumo sarà di legne verdi e giovani allora non penderà in azzurro, perché non sendo trasparente e pien di superbia umidità, esso fa ufficio di condensata nuvola che piglia in se lumi e ombre terminate, come se solido corpo fusse; El simile fa l’aria che la trappa umidità rende bianca e la poca infusa col caldo la rende oscura, di color di scuro azzurro, e questo ci basta in quanto alla definitione del colore dell’aria.’

26 Morino, ed. (as in n. 18), p. 221 (i,8,16): ‘E erano aiquanti che diceano che quello colore era e-l’aere fatto da vapori, e per quella casione parea a l’occhio vedere lo cielo de colore d’azzurro: e la verità contra-

dice a loro, emperciò che se questo fosse, che entra l’occhio e lo cielo fosse l’aere de colore d’agiarro, tutte le stelle se vedereano de colore d’azzurro, la quale cosa non se vede. E segno di questo si è che s’elli sarà denanti a l’occhio uno vetro transparente de colore d’azzurro, o verde, o rosso o d’altro colore, cioè che se vedearà da l’altra parte se vederà de quello colore; e magiuremente s’elli se vedearà da l’altra parte cose ch’abiano colore chiaro. E vedendose lo cielo de colore d’azzurro colla stelle chiare entro per esso, lo per lo mello, emperciò che se vedessero mello le stelle entro per esso; e pare a l’occhio più nobele e delettevele a vedere che nullo altro colore: secondo che fosse lo campo azzurro e li fiori bianchi entro per esso, lo quale sarea più nobele e delettevele a vedere. E cum ciò sia cosa che lo cielo non debia avere colore...’

27 ‘Benchè si potrebbe ancora dire che se l’aria avesse per suo naturale colore esso azzurro transparente, se-guirebbe che dove s’interponesse maggio quantità d’aria infra l’occhio e l’elemento del foco, che quivi si
He then returns to an explanation of the blue colour of the sky based upon the presence of particles which pick up the light of the sun, suggesting that the reader observe various situations in nature where this apparent blue occurs, including illuminated smoke in a dark place, and the distant shadows of mountains. His final argument builds upon his experience as a painter, tempered, however, by his desire to validate Aristotelian theory.

but whoever wishes for a final proof should paint a board various colours including a beautiful pure black, and a glaze of thin transparent white should be laid over them all, with the result that the lightness of this white will create a more beautiful blue over the black than over any other colour—but it should be applied very thinly and finely ground.28

Ristoro had used the same reference to painting practice in his chapter on the blue of the sky, suggesting that we may have here another, less obvious example of intertextuality.29 However, Ristoro and On Colours were not the only sources for this passage. Leonardo also relied upon ideas in Aristotle’s Meteorology, Sense and Sensibilia, and upon the subsequent medieval tradition of optics which was indebted to these texts.

Both the idea that humidity gives colourless, transparent air its density and candour, and the definition of this humidity as imperceptibly small particles of vaporised moisture which pick up the light from the solar rays,30 depend upon notions in book three of Aristotle’s Meteorology, a work which was in Leonardo’s book collection from as early as 1490.31 In chapter two, Aristotle presented the argument that the air reflects colours, but not form, because of imperceptibly small mirrors in it, and that the colours of the rainbow arise from the reflection of light on the moisture in the air.32 In Leonardo’s argument, the particles of moisture act like mirrors, picking up the percussion of solar rays and making the air look luminous. This luminosity is, of course, less intense than that of the solar rays. The idea that this process of reflection could be the cause of apparent colours is implied again in chapter four, where the rainbow is said to be due to reflection of mirrors in clouds ‘so small as to be invisible’.33

The idea that the light of the air was due to particles of moisture contained within it was further tested by Leonardo in an earlier passage in Codex Hammer folio 36r (1B), in which he described the experimental production of apparent blue with a fine spray of water that was illuminated and viewed against a dark ground:

28 For the notion of intertextuality see n. 13 above.
29 These ideas have been unjustifiably hailed by Ricci (as in n. 20), pp. 45–46, and Pedretti (as in n. 18), p. 31, as a prefiguration of the modern scientific explanation for the phenomenon, first proposed by Lord Raleigh, which is based upon the idea of atmospheric particles selectively scattering light according to its wavelength.
30 See Bell (as in n. 2), and Ri 1448.
32 Meteorology iii.4.373b25.

...
When water blown out in a fine spray in a dark place is exposed to the passing sun it makes a blue ray, and this blue effect is greater with distilled water and thin smoke.\textsuperscript{34}

Here Leonardo is responding even more directly to the discussion of the rainbow in \textit{Meteorology}, where a few lines later, Aristotle wrote:

We get a rainbow, too, if a man sprinkles fine drops in a room turned to the sun so that the sun is shining in part of the room and throwing a shadow in the rest. Then if one man sprinkles in the room, another, standing outside, sees a rainbow where the sun’s rays cease and make the shadow.\textsuperscript{35}

Thus, Leonardo’s argument for the blue colour of the air in Codex Hammer folio 4\textsuperscript{r} (4A) is a straightforward application of Aristotle’s theory of the rainbow, especially since blue was one of the three primary colours of the rainbow. It should not be surprising, therefore, to learn that Leonardo explored the causes of the rainbow at this same time on a sheet now at Windsor Castle.\textsuperscript{36}

Another important idea in Codex Hammer folio 4\textsuperscript{r} (4A) is that conditions for apparent blue can be simulated with smoke and observed experimentally. Like mist or vapours, smoke was said to reduce the transparency of the medium. Medieval optical treatises in the tradition of Ibn al-Haytham (Alhazen) suggested that the effect of smoke on the visibility of things seen through it was similar to fog.\textsuperscript{37} Aristotle had also compared the effects of smoke and vapours, in \textit{Sense and Sensibilia}.\textsuperscript{38} Both provided a precedent for Leonardo’s research on the effects of smoke in the medium.

Leonardo distinguished two variables: the rarity or density of the smoke, and the colour of the background behind it. He argued that a blue tint would only arise if the smoke were rarefied, for otherwise it would not be transparent enough to see through: this is what happened when young, green wood was burned, for it had too

\textsuperscript{34} (Ri 301) ‘...come l’acqua soffiata a uso d’attomi in loco scuro dove passi la spera del sole fa esso razzo azurro e massime essendo tale acqua destillata e ’l fumo sottile fa azzurro.’ Leonardo’s use of the term \textit{attomi} is not particularly revealing as it derives from Epicurean philosophy and was widely used in the Renaissance to describe infinitesimally small, indivisible particles. See the early definitions in \textit{Grande dizionario della lingua italiana}, ed. S. Battaglia, i, p. 799. Galileo later used the term specifically to describe the particles of moisture diffused in the atmosphere.

\textsuperscript{35} \textit{Meteorology} iii.4.374a33–374b5.

\textsuperscript{36} Windsor MS C, fol. 19150r (Ri 288), and see the related passages in Pedretti, \textit{Commentary}, i, pp. 215–20. Pedretti recognises (p. 219) that ‘Leonardo’s observations based on experiment are also inspired by the reading of some text, or maybe simply affected by the recollection of such reading’.


\textsuperscript{38} 3.440v7–12: ‘Another is that the black and white appear the one through the medium of the other, giving an effect like...that produced by the sun, which in itself appears white, but takes on a crimson hue when beheld through a fog or a cloud of smoke.’
much moisture. Leonardo saw a parallel between this dense smoke and clouds in the sky, where the moisture was so dense that transparency was lost. Background colour could be easily tested by observing smoke against the light sky, in which case it would look grey instead of blue, confirming the necessity of the dark background for the appearance of blue. But Leonardo also seems to have devised laboratory experiments involving pieces of coloured cloth, as we learn from the passage on Codex Hammer folio 36r (1B):

It is experience that shows why the air appears blue although it has darkness behind it; let smoke be made from dry wood in a small quantity, and let the rays of the sun fall on this smoke, and place behind this smoke a piece of black velvet on which the sun does not shine, and you will see all the smoke which comes between the eye and the darkness of the velvet take on a very beautiful blue colour. And if in place of the velvet you put a white cloth, the smoke will look ashy-grey. Too much smoke impedes [the effect]; and a little is insufficient to form a perfect blue. Hence it is a moderate amount of smoke which will form a beautiful blue… I say this in order to show that the blue of the air is caused by the darkness above it, and give the preceding examples to those who cannot confirm my experience on Monboso.39

Coloured cloths occurred frequently as backgrounds for studies of secondary light and colour in the Optics of Ibn al-Haytham, which may have suggested this experiment to Leonardo. Such examples demonstrate that Leonardo, like many others at the time, readily combined Aristotelian and medieval optical ideas.40

Finally, Leonardo’s last argument in Codex Hammer folio 4r (4A) depends upon Aristotle’s premise in Sense and Sensibilia that all colours arise from a mixture of light (white) and dark (black). Aristotle proposed three ways in which a variety of colours are generated from the primary colours, light/white and dark/black. The first is what we would call optical mixing: the juxtaposition of small spots of colour side by side that cannot be distinguished individually by the eye. The next is superposition of one colour over another. The third is total blending. The blue colour of the sky would logically fall into the second category, with the blackness of outer space being seen through a translucent vellum of white. However, Aristotle never stated that sky blue was due to mixture, although he compared translucent layers of pigment to translucency in air and water. Rather, he stated in Meteorology that ‘white colour on a black surface or seen through a black medium gives red’,41 and in Sense

39 ‘E esperienza che mostra, come l’aria à dopo sé tenebre e però pare azzurra; sia fatto fumo di legnie secche in poca quantità sopra il quale fumo percolano li razi solari, e dopo questo fumo poni una pezza di velluto nero che non sia visto dal sole, e vedrai tutto quel fumo che s’oppone infra l’occhio e la oscurità del velluto mostrarsi in color di bellissimo azzurro, e se in loco del velluto metti panno bianco, el fumo, è cene- rognolo; el tropo fumo, impedisce e ‘t poco non forma la perfezione d’esso azzurro, onde la mediocre isposizione di fumo forma bello azzurro; …’quest’è detto per mostrare che l’azzurro dell’aria è causato di oscurità che è sopra di lei, e darsi li predetti esempi a chi non confermassero la sperimenta di Monboso.’


Leonardo was to return to these Aristotelian ideas in his Book on Colours (now lost), as evidenced by CU 67f. In this passage he elaborates upon the concept of veiling colours, juxtaposing thoughts on colour mixing to observations of smoke. The ideas expressed in CU 67f follow logically from Codex Hammer folio 4v (4A), and would date from 1508–10, contemporaneous with the reconstructed Libro A, to which it also closely relates. In another passage, CU 70v, Leonardo clarifies the natural source of the dark background, presenting a schema of the constitution of the upper atmosphere. He conceived of the atmosphere surrounding the earth as consisting of concentric spherical strata, in accordance with Aristotelian tradition. He called the outermost sphere darkness, a region beyond the strata of air; this region is so rarefied that fire (that is, sunlight) cannot illuminate it. However, Leonardo explains that the species from this outer sphere of darkness are able to pass through to the eye, since the air is still somewhat rare and thin. Inside the darkness is the sphere of fire, the species of which also pass through the air because they are less dense than the air, but, as he had demonstrated in the Codex Hammer, they are reflected in the atoms of moisture in the air, making it appear whitish. Leonardo writes on CU 70v:

...the third proposition of the ninth book which shows that that body will be least illuminated by the sun that is more rare in quality. Therefore, the element of fire which clothes the air, being in itself more rare and more thin than the air, does not even occupy the darkness there above it which is not part of the air. And consequently the air, a body less rare
than fire, is more illuminated by the solar rays which pass through it, illuminating the infinity of atoms which infuse the air, rendering it bright to our eyes...  

Leonardo then concludes that the *species* of darkness seen through the bright air creates the blue colour of the sky in accordance with the third proposition of his tenth book.

However, the main focus of the passage on folio 70v of the Codex Urbinas is to demonstrate another proposition of great importance to the practice of colour perspective: ‘the air will assume less of a blue colour the nearer it is to the horizon, and will appear darker the more remote it is from that horizon’. Leonardo sets about doing this by proving that the distance from the observer to the horizon is greater than the distance seen overhead. This argument is an absurdity by modern standards, but Leonardo constructs a neat diagram to prove his point, based upon the schema of concentric spheres and basic Euclidian geometry (Figure).

And the blue will seem lighter the more the thickness of air lying between the darkness and our eyes. Such as, if the eye which beholds it were at P, and looked above it at the thickness of the air PR, then, lowering the eye somewhat, it would see the air along the line PS, which would seem brighter because there is a greater thickness of air along the line PS than along the line PR. And if the eye were directed toward the horizon, it would see the air almost totally devoid of blue, which comes about because the line of vision penetrates a much greater extent of air by the straight line PD than by the oblique line PS. Thus our proposition is proved.  

This explanation supplements his earlier argument in Manuscript A folio 98rv, in which the whiteness of the horizon was attributed to a greater density of vapours. Several undated passages in the Codex Urbinas reveal that Leonardo was able to accept both explanations concurrently. This synthetic approach was typical of Renaissance Aristotelian thought, as Edward Grant has argued. Indeed, both ex-

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48 ‘Questo si prova per la terza del nono che mostra quel corpo manco sara aluminato dal sole il quale sia di qualità più rara, adunque il foco ellemento che veste l’aria per essere lui piu raro e più sotile che l’aria manco manco ci occupa la tenebre che son sopra di lui che non fa essa aria e per consequenza l’aria corpo men raro che el fochi piu s’aluma dalli razi solari che la penetrano aluminando la infinita degli attomi per che essa s’infontdano si rende chiara alli nostri occhi....

49 ‘L’aria siara tanto men participante del colore azuro quanto essa è piu vicina all’orizzonte e tanto piu oscura quanto ella e esso orizzonte è piu remota.’

50 ‘e tanto ci parà d’azzro piu chiaro quanto infra esse tenebre et li occhi nostri s’interporà magior grosseza d’aria, come se l’occhio de chi la considera fussi in p. e riguardassi sopra di se la grossezza dell’aria p.r. poi declinando alquanto l’occhio vedessi l’aria per la linea p.s. la quale lì parrá piu chiara per essere magior grosseza d’aria per la linea p.s. che per la linea p.r. e se tale occhio si inclina all’orizzonte vedera l’aria quasi al tutto privata d’azzro la qual cosa seguita perche la linea del vedere penetra molto magior sointa d’aria per la rettiudine p.d. che per la obliqua p.s e così s’ar prussuo il nostro intento.’

51 For further discussion see Bell (as in n. 2).

planations for the light colour near the horizon are valid to the extent that a greater total quantity of illuminated moisture intervenes between the object and the eye: a denser stratum near the earth, and a longer distance to the horizon.

**The Colour of the Luminous Source**

Codex Urbinas folio 193rv also begins as a paraphrase of *On Colours*, chapter three, but soon launches into a discussion of the effects of coloured light on colour appearance. In CU 193rv (from Libro A, carta 21, dated about 1508–10), Leonardo opens with the statement ‘No object is ever seen entirely in its natural colour’—which is a repetition of a phrase from *On Colours*: ‘We never see any colours absolutely pure’. Pseudo-Aristotle then goes on to explain that colours are always blended with either another colour, or with light and shadow, and lists several effects of illumination on colour appearance:

That is why objects assume different tints when seen in shade and in light and sunshine, and according as the rays of light are strong or weak, and the objects themselves slope this way or that, and under other differential conditions. Again, they vary when seen in firelight or moonlight or torchlight, because the colours of those lights differ somewhat.

In the preceding chapter of the same text, Pseudo-Aristotle had already presented this idea, giving examples of the sea looking purplish when one side of the waves are in shadow, and birds’ wings appearing a different colour when extended against the light than when seen in shadow. *On Colours* then goes on, as we saw earlier (p. 102), to treat coloured reflections as another reason why colours are never seen in their purity, and finally to discuss the impurity of the medium.

Leonardo’s argument proceeds along the same lines. He specifies two causes for the apparent colours of an object: the intervening medium, and the colour of the light rays.

What is proposed above may happen from two different causes, of which the first occurs through interposition of the existing medium between the object and the eye. The second happens when things that illuminate the above-mentioned object have some colour of their own. That part of the object would appear in its true colour if it were illuminated by a colourless light, provided that in this illumination no other object were visible than the aforesaid light.

Leonardo regards both direct illumination and reflected light as having an effect on colour appearance. That is why the light has to be ‘colourless’ and no other objects should be visible. He then launches into a discussion of this hypothetical situation, examining whether or not it is really an impossibility in nature.

It so happens that this can never be seen except in the case of the colour blue placed with its plane facing the sky on top of a very high mountain, such that no other object faces it, the

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54 Mc 793, Lu 654.  
57 ‘Nisun corpo non si dimostrerà mai integralmente del suo naturale colore. Qualche si propone può accadere per due diverse cause delle quali la prima accade per interposizione del mezo che s’incluce infra l’obbietto e l’occhio. Seconda è quando le cose che allumina el predetto corpo e ritengano in se qualità d’alcun colore. Quella parte del corpo si dimostrerebbe del suo naturale colore, il quale fusse aluminato da luminoso senza colore e ch’inf tale aluminamento non vegga altro obbietto ch’el predetto lume.’
setting sun is covered with low clouds, and the cloth\textsuperscript{58} is the colour of the air. But here I retract because even rose grows more beautiful when the sun in a reddish sunset illuminates it together with the intervening clouds; although in this case it might still be accepted as true. Because if rose, illuminated by a reddish light, is more beautiful than otherwise, that is a sign that lights of colours other than red take away some of its natural beauty.\textsuperscript{59}

It is interesting to observe the thought process in which Leonardo challenges his own arguments. First, he questions whether it is really necessary that only the light be visible, noting that rose colours are enhanced at sunset despite the presence of clouds. Then, he questions whether colourless light is really the ideal illumination for a given colour, noting that light of the same colour as the object enhances the beauty of that coloured object. What Leonardo means by ‘bellezza’, as Shearman, Ackerman and Barasch have noted, is a quality of appearance associated with the most saturated tones of a colour. The reason that rose or blue is enhanced by reddish or blue illumination is that the saturation of the coloured object is increased, and if measured with a spectrophotometer, a sharper concentration at the wavelength for red or blue respectively would be evident. Finally he concludes that most lighting conditions reduce the optimum beauty of colour.

Leonardo’s interest in the conditions for the maximum beauty of colour connects this passage with his studies of the effects of lustre, shadow, and medium illumination on colour appearance.\textsuperscript{60} The results of these studies have been directly connected to his pictorial practice by Shearman and subsequent writers. His study of colour perspective is not unrelated to such concerns. Leonardo’s search for a solution to the problem of representing the saturated colours of nature without sacrificing pictorial relief was complicated not only by the fact that the illusion of a unified pictorial light seemed to require relatively equivalent tonal values for all hues, but also by the requirements for a convincing pictorial space. As Leonardo had realised as early as around 1492, when he wrote Manuscript A, folio 98\textsuperscript{r}, linear perspective was inappropriate in certain situations necessitating the use of colour gradations to clarify the relative distances of objects.\textsuperscript{61} To the extent that Leonardo could discover the natural conditions in which ‘bellezza dei colori’ occurred—despite the fact that it would have to be toned down to create pictorial relief and recession—Leonardo was hopeful of finding a solution to the representation of the natural beauty of colour.

\textsuperscript{58} Pedretti, \textit{Libro A}, p. 44, suggests the reading ‘piano’, proposing a mis-transcription on the part of the scribe. Since completing this essay, I have proposed in ‘Leonardo and Alhazen: the Cloth on the Mountain Top’, \textit{Achademia Leonardo Vinci}, vi, 1993, pp. 108–11, that Leonardo wrote ‘panno’, thinking of the experiments with reflected colour in the optical tradition of Alhazen, where a cloth was often used as the surface receiving secondary light, as in his own experiments with cloths and the colour of smoke in the Codex Hammer.

\textsuperscript{59} ‘Questo non accade mai potersi vedere se no nel color turchino posto per piano in verso il cielo sopra un altissimo monte accio che in tal locho no possa vedere altro obbietto et ch’i’ sole sia occupato nel suo morire da bassi nuvole, e ch’el panno sia del colore de l’aria. Ma in questo caso i’ mi ridicio: perche il rossato anch’egli cresce di bellezza quando il sole ce l’alumina nel occidente, rosseggia e’ insieme col’i nucioli che se gli interpongono, benché in questo caso si potrebbe ancora accettare per vero per che s’el rossato aluminato dal lume rosseggiante mostra più ch’altrove bellezza gli segno che i lumi d’altri colori che rossi gli togliero la sua bellezza naturale.’


\textsuperscript{61} See also CU 298\textsuperscript{1} (Ms 822, Lu 810a) (dated 1508–10), in which he writes: ‘Ben è vero che nella Natura la prospettiva de colori mai rompe la sua leggie, et la prospettiva delle grandezze è libera perch’vicino all’occhio si trovara un piccolo colle e da lontano una montagna grandissima et cosi deli alberi et edifici.’
THE COLOUR PERSPECTIVE SCALE

Not surprisingly, similar connections between pictorial practice and scientific theory characterise Leonardo’s discussion of the apparent colour of objects seen through the air. Here, his theory of colour perspective reveals its debt to Aristotle’s *Sense and Sensibilia* as well as to *On Colours*. The generation of the apparent blue colour of distant mountains is explained exactly as the blue colour of the sky: the mountains behind are dark, and they are seen through the light air. This is clearly stated in Libro A, carta 1 (CU 154v), in what we recognise as a circular argument. After summarising the theory behind the sky blue colour, Leonardo cites the blue colour of mountains as a sensory verification:

Of this we can see an example in the air interposed between the eye and some dark mountains, rendered so by the shadow of a great quantity of trees above it; or else shaded on that part where the rays of the sun do not strike: this air becomes blue, but not where [the mountain] is luminous, and worse on the parts covered by snow.

This passage raises a particularly important issue for our study of colour perspective: the relationship between real colour value and colour appearances. Leonardo distinguishes the beautiful blue generated by dark and shadowy colours from the unattractive colour of dark, illuminated parts, and from the even more unattractive colour of light parts of the mountain. This idea that apparent blue is most beautiful against the darkest background was touched upon in the passages in the Codex Hammer, but several earlier and later passages reveal that Leonardo developed this idea in conjunction with the Aristotelian theory of a colour scale.

The colour scale was a theoretical way of ordering colours at regular intervals like musical notes, which became exceedingly popular during the Renaissance. It was based upon Aristotle’s notion in *Sense and Sensibilia* that all colours are composed of different proportions of white and black (or light and darkness), and could be ordered rationally like notes on a musical scale. From the practical standpoint of the science of painting, as Leonardo conceived it, the colour scale was a useful guide to quantifying the relationship between colour and light. Scholars have proposed that Leonardo wanted to devise a method by which the natural value difference of pigments could be arranged and adjusted in accordance with the painter’s objective of representing the effects of light and shade. The ranking of each colour according to its relative lightness or darkness would provide guidance for how much a light colour like yellow, for example, might be toned down when placed next to a darker blue in order for both to appear to be seen in the same way.

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62 Mc 519, Lu 490.
63 L’azzurro dell’aria è di color composto di luce e di tenebre. La luce dirò per causa dell’aria alluminata nelle particelle dell’umidità infra essa aria infusa. Per tenebre dirò l’aria pura la qual non è divisa in attimi, cioè particelle d’umidità nella qual s’abbia a percevere li razzi solari; e di questo si vede l’esempio nell’aria che s’interpone infra l’occhio e le montagne ombrose per l’ombra della gran copia dell’alberi che sopra di essa si trovano, ovvero ombrosa in quella parte che non è percorsa dalli razzi solari; la qual aria si fa azzurra e non si fa azzurra nella parte sua luminosa, e peggio nella parte coperta di neve.”

64 See the excellent summaries in Barash (as in n. 41), pp. 171–84, esp. 172–73 on Aristotle; Gavel (as in n. 41), pp. 44–55; and Kemp (as in n. 41), pp. 264–73.
intensity of light. In the practice of colour perspective, the colour scale helped the painter to determine the relative distance at which the appearance of colours would differ from their ‘pure’ appearance in the foreground.

The problem was conceived by Leonardo in two ways. As in the description of the mountain, examined above, he could take a constant distance and compare the degradation of hues, leading to the assertion that dark colours produce a more beautiful blue than light ones. This hypothesis follows directly from his study of the sky colour, and recalls experiments in the Codex Hammer on the colour of smoke seen against backgrounds of black and white cloths. Alternatively, he could think about the distance required before a given colour would seem to turn blue. This mode of thinking transformed the colour value scale into a colour perspective scale in which the position of colours was determined by their proximity to black.

In Manuscript L, folio 75\(^v\), dated around 1502, he wrote:

Among colours that are not blue, the one will partake most of blue which is closest in nature to black, and thus, conversely, the one will retain its own colour over a longer distance that is most dissimilar to the said black. Therefore the green of meadows will be transmuted into blue more than will occur with yellow or white, and thus conversely yellow and white will transmute themselves to a lesser degree than green and red.\(^66\)

Thus we can reconstruct Leonardo’s colour perspective scale as follows: blue, black, green, red, yellow, white. Blue is first because, although lighter than black, it looks blue in the distance before black.

In addition to the Aristotelian tradition underlying the colour scale, Leonardo was aware of the medieval theory of optics which stated that the quiddity of colours varied in accord with their lightness and intensity. In the \textit{Optics}, Ibn al-Haytham stated that distances vary with the lights, that a more illuminated object will be seen from a greater distance, and that white and bright-coloured bodies are visible from greater distances than dull or dark bodies.\(^67\) The idea of a colour scale from light and bright through dull and earthy is implicit but never directly stated. Leonardo was, of course, aware of this optical tradition in which discernibility of colour was connected with lightness and proximity.\(^68\) Since colours lost their quiddity in shadow, it could be said that shadowed colours were more susceptible than light ones to transmutation, while illuminated colours, conversely, would maintain themselves longer.

I cannot therefore support Barasch’s conclusion that Leonardo’s colour scale is purely ‘practical’ and ‘does not rest upon theoretical foundations’.\(^69\) Rather, Leonardo’s discussion of a colour scale in the context of colour perspective testifies to his knowledge of scientific colour theory and also to his efforts to discover its relevance to pictorial practice.

\(^{66}\) \textit{Infra i colori che non sono azuri quello in longha distantia parteciperà più d’azzuro il quale sarà più vicino al nero e così di converso si manterà per longha distantia nel suo proprio colore il quale sarà più disimile al detto nero. Adonque il verde delle campagne si trasmuterà più in azuro che non fa il giallo o bianco e così de converso il giallo e ’l bianco manco si trasmuta che el verde e ’l rosso.’

\(^{67}\) \textit{Optics} (as in n. 37), pp. 10–11 (i.2.14–20).

\(^{68}\) See the discussion of MS A, fol. 98\(^v\) and several passages from MS C in Bell (as in n. 2).

\(^{69}\) Barasch (as in n. 41), pp. 176–77, in his discussion of CU 75\(^v\)–76 (Mc 176, Lu 254), a passage deriving from Libro A.
Leonardo continued to think about the colour perspective scale in the years 1506–09, seeking to reduce his advice to a succinct precept. There are several formulations in the Codex Urbinas and Codex Atlanticus, each with a slightly different emphasis. Leonardo conceived of pictorial precepts on the model of the mathematical axioms in Euclid’s *Geometry*: the ideal was as general as possible and also as concise. On Codex Atlanticus folio 305r (about 1508), he wrote: ‘In the far distance that object will show itself bluest which is darkest in colour’,70 In another place on the same sheet he restated the precept to account for the affinity between darkness of hue and darkness created by accidental illumination:

Of objects far from the eye, of whatever colour you wish, that will appear to be bluest in colour, which is the darkest, either naturally or accidentally. That object is naturally dark which is dark in itself and that one is accidentally so which is darkened by shadow cast by other objects.71

Finally, a passage from a lost manuscript copied into Codex Urbinas folio 205r (Mc 812) reads: ‘That colour will be visible at a more distant location that is most removed from black’.72

Thus, the susceptibility of colours to transmutation by the intervening medium depended upon the natural lightness or darkness of the object, but it also depended upon the illumination of the object as we have seen above in our discussion of Libro A, carta 21.

REFLECTED COLOUR

The degree to which the colour of light and dark objects was susceptible to change was complicated in Leonardo’s mind by the tradition of reflected colour. The author of *On Colours* has listed the colour of reflected light from adjacent objects as the third significant determinant of apparent colour, and Leonardo was fascinated, even fixated, by this idea. He states in numerous passages that ‘the surface of every opaque body partakes of the colour of the object opposite it’. His early interest was fueled by the perspectivist tradition,73 and possibly also from the living workshop tradition, if we are to agree with Barasch in interpreting the opinions of ‘adversaries’ as evidence of real debates.74 In several of these passages, white was regarded

71 Codex Atlanticus, folio 305r-a, which was copied into CU 145 (MC 518): ‘Delle cose remote dall’occhio le quali sien di che color si voglia quella si dimostra di colore piu azuro la quale sia di maggiore oscurita naturale, o accidentale, naturale è quella ch’è scura da se e accidentale è quella ch’è oscurata mediante l’ombra che gli e fatta d’altri obbieti.’
72 Mc 812: ‘Quel colore sara veduto di piu distante locho che sara piu remoto dal nero.’ CU 189r (MC 814) is another restatement but not as a general axiom. The wording suggests to me that it predates CU 145 above: ‘L’ombre delle cose remote parteciperanno tanto piu di colore azuro quanto elle saranno in se piu oscure e’ piu remote, e questo accade per la interposizione de la chiarezza de l’aria che s’in tramette infra la oscurita de corpori ombrosi interposti in fra ’l sole e l’occhio che la vede… (‘Shadows of distant objects partake so much more of the colour blue inasmuch as they are in themselves darker and more distant. And this happens due to the interposition of the brightness of the air which comes between the darkness of shadowed bodies lying between the sun and the eye that sees them…’)
73 See Mc 812. Some of the significant passages are MS A, fols 112r (MC 791, Ri 267), 100r (MC 786), and 19r (Ri 281); all three are parts of trattato sequences identified by Farago (as in n. 7), pp. 414–23, which begin with definitions of aerial perspective and/or linear perspective, Barasch (as in n. 41), pp. 62–67, emphasises Leonardo’s debt to the optical tradition in his section on reflected light.
74 Barasch (as in n. 41), p. 63. Farago (as in n. 7), has shown convincingly that this was one of two typical methods of argumentation used by Leonardo in the *Paragone*, known as *vituperatio*, a form of epideictic rhetoric concerned with blame. Although evidence of a
as the universal recipient of reflected colour, as it was in the medieval optical tradition derived from Ibn al-Haytham. Leonardo's two examples of a white wall revealing the reflected colours of objects opposite it and a woman in a white dress passing through green fields are also found in the Optics of Ibn al-Haytham. As Leonardo stated in Manuscript A, folio 100f, 'white has no colour in itself, but is tinged and transformed in part by the colour which is in these objects [opposite it].' The complication for the theory of different transmutability was how to reconcile this quality of white with its high position on the colour value scale, which dictated that white would maintain its quiddity longer than any other colour.

Leonardo's desire to discover the first principles of the science of colour led him to search for relationships between the laws of colour appearance from nearby and from a distance. In Codex Hammer folio 4f (4A), he had validated mixing by vellation in the sky colour by an example of the same procedure nearby: a fine white glaze over a black background. In other roughly contemporaneous manuscripts, he examined the validity of reflected colour, which he and his optical predecessors had already established for nearby colours, for explaining the appearance of coloured objects at a distance.

A passage from Manuscript F folio 75a (1508) reveals his ability to generalise from laboratory situations to the open countryside:

Since white is not a colour but the neutral recipient of every colour, when it is seen in the open air and high up, all its shadows are bluish; and this is caused, according to the fourth [proposition] which says: the surface of every opaque body partakes of the colours facing it. Now since this white [body] is deprived of the light of the sun by the interposition of some body between the sun and itself, all that portion of it which sees the sun and the air will partake of the colour of the sun and the air, and that part which does not see the sun, remaining shadowed, will partake of the colour of the air. And if this white object did not see the green of the countryside all the way to the horizon, nor the whiteness of the horizon itself, without a doubt this white [body] would appear to be the same simple colour as the air.

Here we see Leonardo explaining the tinging of white at a distance by the concept of participation. Whatever white sees it takes on, whether the real green of the countryside or the apparent blue of the sky. This is a real alternative to the vellation theory in which objects which were said to be 'dark' took on blue tints when seen through the lightened atmosphere—a theory that was overly cumbersome in explaining the apparent blue of light coloured objects. Perhaps it is more accurate to regard it as a revision, because Leonardo does not discard vellation but adds participation, in a process of accretion that was typical of Renaissance thought. We

standard literary device does not preclude a veritable workshop polemic, such passages can no longer be used as evidence of such debates.

75 MS A, fols 100v (Mc 786) and 19v (Ri 281). These same examples are found in Ibn al-Haytham, Optics (as in n. 37), p. 44 (1.3.115–16).

76 CU 229v–30, Mc 786, Lu 785.

77 Ri 278, CU 74r, M 204. Perché il bianco non è colore, ma è inpotentia ricettiva d’ogni colore, quando esso è in campagna alta tutte le sue ombre sono azzurre; e questo nasce per la 4.a che dice: la superficie d’ogni

opaco partecipa del colore del suo obbietto; Adunque tal bianco essendo privato del lume del sole per interposition di qualche obbietto infra messo infra ’1 sole e esso bianco, resta adunque tutto il bianco che vede il sole e l’aria participante del colore del sole e dell’aria, e quella parte che non vede il sole, resta onbrosa participante del colore dell’aria, e se tal bianco non vedesse la verdura della campagna in sino all’orizzonte, né ancora vedesse la bianchezza di tale orizzonte, sanza dubbio esso bianco parrebbe essere del semplice colore del quale si mostra essere l’aria.
also see evidence here of Leonardo’s intervening study of the colour of the luminous source on the apparent colour of objects, for it is the brightness of the sun which colours the white ‘bright’, now explaining what he had merely observed in Manuscript A, folio 100\(^r\), by the universal principle of participation.\(^{78}\)

Another passage on CU 194\(^r\) shows him explaining the colours of the countryside by the same theory of participation. ‘The shadows and lights of the countryside partake of the colour of their sources’.\(^{79}\) Leonardo then goes on to make a remarkable conflation between the two theories of apparent blue. The countryside is not directly shadowed, but is darkened ‘because the darkness which originates from the opaqueness of the clouds, combined with the absence of direct sunlight, tinges whatever it impinges upon’.\(^{80}\) It is also lighted indirectly by the surrounding air beyond the clouds and shadows that ‘see’ it.\(^{81}\) Thus far, we see only the theory of reflected light. However, Leonardo then brings in the theory of vellation: ‘the surrounding air makes the countryside participate in its blue colour, and the air, penetrated by the solar rays which are found between the darkness of the said shadows on the ground and the eye which sees them, further colours this location with the colour blue. This is proved by the origin of the blueness of the air from light and shade’.\(^{82}\)

However, Leonardo recognises that the illuminated parts of the countryside cannot be said to be ‘dark’, so their blue colour can be attributed only to participation in the blue colour of the air. He argues that the colour of the sun effects the apparent colour less than the air, because the air is greater in extent and less farther away. He concludes that distant landscape is more blue as a result of a greater quantity of air to reflect its colour.\(^{83}\)

Leonardo has not resolved the apparent paradox of differential transmutability. He has postulated different explanations for the blue appearance of high value colours (based upon participation and reflection) and the blue appearance of dark colours (based upon vellation). In subsequent years, he would explore the role of reflections on dark surfaces as well, and thus it was the field of dioptrics and catoptrics to which he turned for inspiration in his late studies of colour perspective in verdure in Manuscript G.

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I have tried to show that Leonardo’s study of colour perspective during the first decade of the sixteenth century expanded in response to his acquaintance with Aristotelian texts. Although he continued to explore visual problems with which he

\(^{78}\) CU 229\(^r\), Mc 786, Lu 785; see p. 116 above.

\(^{79}\) ‘Le ombre e lumi delle campagne partecipano del colore delle lor cause’. Mc 836, Lu 661, KW p. 83 n. 211. The manuscript from which this passage derives is lost. Pedretti dates it 1568–10.

\(^{80}\) ‘...perche la oscurita composta dalle grosseze de nuvoli oltre alla privacione de razi solari tingan’ di se cio che per lor si tocca’.

\(^{81}\) ‘Ma la circostante aria fuori de nuvoli è ombra, vede et aluminia il medesimo sito...’

\(^{82}\) ‘...e fallo partecipante de colore azureo et l’aria penetrata da razi solari che si trova infra l’oscurita della predetta ombra della terra e l’occhio di chi la vede, tinge ancora lei esso sito di colore azureo, come si prova de l’azureo de l’aria esser nato di luce et di tenebre’.

\(^{83}\) ‘Ma la parte delle campagne aluminata dal sole partecipa del colore de l’aria e del sole ma assai parte-cipa de l’aria, perche fa ufficio di maggiore, per essere l’aria piu propinqua et fassi campo d’innumerabili soli, in quanto a l’occhio. Et queste campagne parteciparon tanto piu d’azure quanto esse son piu remote dall’ occhio...’
had become familiar through the study of optics, he was inspired by Pseudo-Aristotle’s *On Colours* to explore the variables affecting apparent colours. These variables included (1) the intrinsic colour of the object, (2) the colour of the luminous source, (3) the colour of indirect (reflected) illumination, and (4) the quality and quantity of the medium. Leonardo isolated each variable and formulated precepts that looked at the relationship between variables. But as in his studies of human anatomy, every investigation raised more new questions about relationships, and stimulated him to undertake new investigations. Thus, a few first principles of colour perspective were distilled, but a set of definitive pictorial precepts was never formulated.\(^{84}\)

KENYON COLLEGE, OHIO

APPENDIX

THE LATIN TEXT OF *ON COLOURS* FROM ARISTOTLE, *OPERA*, VENICE 1496\(^{85}\)

Colorum autem nullum videmus scienterum [= sincerum] ut est, sed omnes commixtos in aliis. Etenim utique dativus est nullum aliorum lucis splendoribus et umbris mixti alterati et non quales sunt videntur... Lumen enim quando incidens a quibusdam coloratur et fit puniceum aut herbeum et quod repercitur incidit in alterum quendam colorem iterum ab illo commixtum alium quendam accipit coloris occasum, et hoc sustinens continue quidem non sensibiliter autem quandoque accedit ad visus ex multis quidem coloribus, uno autem maxime dominantium faciens sensum... Album autem et lucidum quando quidem rarum erit vehementer videtur quaedam nebula sicut in aqua vitro et aer quando erit grossus, splendoribus enim propter densitatem undique efficientibus non possimus quae intra ipsa sunt videntur. Aer autem prope quidem visus nullum videtur habere colorem propter raritatem enim splendoribus vincitur; separatus autem ab ipsis densis existentibus et visis per ipsum. In profunditate autem visus proximo videtur colore kyanoides propter raritatem inquantum deficit lux sicut tenebra involutus videtur kyanoides densatus sicut et aqua omnium albissima est.

\(^{84}\) This essay was written during a Mellon Fellowship at the American Academy (1990–91) and has not been revised since it was accepted for publication in 1991 to take account of three important new publications: J. Gage, *Color and Culture: Practice and Meaning from Antiquity to Abstraction*, Boston 1993; M. Rzepinska, ‘Leonardo’s Colour Theory’, *Achademia Leonardo Vinci*, vi, 1993, pp. 11–33; and C. Pedretti, ‘Three Texts on Color’, ibid, pp. 34–46.

\(^{85}\) Fol. 350\(^{v}\).