

## A DEFENCE OF ARISTOTLE, *METEOROLOGICA* 3, 375<sup>a</sup>6 ff.

ARISTOTLE believed that there were actually only three colours present in the rainbow, *φοινικοῦν*, *πράσινον*, and *άλουργόν*: of these, the first is produced by the dulling of white light when it is reflected in or obscured by a dark medium such as smoke, cloud, or water, and exemplified in the redness of the sun as seen through haze around the horizon. Successive failures of sight weaken the colour further, first to *πράσινον* and then to *άλουργόν*. Between the first two colours a fourth, *ξανθόν*, is often apparent, being the result of the juxtaposition of the two colours. This last statement, where it has not been ignored as one of the inexplicable or misguided things Aristotle says from time to time, has met with considerable criticism.

To see how justifiable the statement is, we need to try to evaluate the colours concerned. All Aristotle says about them is (*Meteor.* 3, 372<sup>a</sup>) ἔστι δὲ τὰ χρώματα ταῦτα ἅπερ μόνᾳ σχεδὸν οὐ δύνανται ποιεῖν οἱ γραφεῖς· ἔνια γὰρ αὐτοὶ κεραυνήσουσι, τὸ δὲ φοινικοῦν καὶ πράσινον καὶ ἄλουργόν οὐ γίνεται κεραυννύμενον. With H. D. P. Lee (in the Loeb edition of the text) we might think that the colours painters cannot mix are red, yellow and blue; but that is surely not what Aristotle intended. Carl Prantl, *Aristoteles ueber die Farben* (Munich, 1849), and Carl Boyer, *The Rainbow*, (New York, 1959), translate *άλουργόν* 'blue', the latter perhaps under the influence of modern trichromaticism: but no one, I hope, would want to translate *πράσινον* 'yellow'.<sup>1</sup> Is Aristotle giving himself a let-out here with *μόνα σχεδόν*?

Alexander explains at some length (ed. Hayduck, p. 161):

αὐτοφυὲς μὲν γὰρ φοινικοῦν χρώμα τό τε κιννάβαρι καὶ τὸ δρακόντιον, ὃ τοῦ αἵματος τοῦ ζώου· ἐκ μίξεως δὲ φοινικοῦν χρώμα ἐκ τε τοῦ κουφολίθου καὶ ἐκ πορφυροῦ μιννυμένων, ὃ πολὺ ἀπολείπεται τῶν αὐτοφυῶν. πράσινον δὲ καὶ 5 ἄλουργόν αὐτοφυῆ μὲν ἢ χρυσοκόλλα καὶ τὸ ὀστρεῖον, αἶμα δ' ὦν καὶ τοῦτο πορφύρας τῆς θαλασσίας, σκευαστὰ δὲ πράσινον μὲν ἐκ κυανοῦ τε καὶ ὠχροῦ, ἄλουργόν δὲ ἐκ τε κυανοῦ καὶ φοινικοῦ.

If what Aristotle meant was the superiority of natural vermilion, green, and purple over mixtures, and if the pigments referred to by Alexander were the same as those known to Aristotle, then we can say that the colours intended are spectral red, green, and violet: which would seem only reasonable. As to *ξανθόν*, we should expect that to be yellow, which is often very noticeable between red and green. W. Schultz, *Das Farbenempfindungssystem der Hellenen* (Leipzig, 1904), would like to translate it 'orange', for no real reason, unless perhaps he thinks it more likely that a pale red would look orange: or because his book aims to demonstrate eventually that the Greeks were *blaugelb-blind*, and so had no word for or concept of yellow. Perhaps, too, he is remembering Newton's arbitrary division of the spectrum, with orange and indigo

<sup>1</sup> Unless they accept the (probably corrupt) text of Thphr. *De Sensu* 77, which gives *πράσινον* as the colour of sulphur (τὸ θείον).

very much makeweights to produce the mystic seven. Certainly orange is not an important component of the rainbow.

Aristotle's own explanation of the yellow is this (op. cit. 375<sup>a</sup>6) :

τὸ δὲ ξανθὸν φαίνεται διὰ τὸ παρ' ἄλληλα φαίνεσθαι. τὸ γὰρ φοινικοῦν παρὰ τὸ  
 πράσινον λευκὸν φαίνεται. σημεῖον δὲ τούτου· ἐν γὰρ τῷ μελαντάτῳ νέφει  
 μάλιστα ἄκρατος γίνεται ἡ ἶρις· συμβαίνει δὲ τοτὲ ξανθότατον εἶναι δοκεῖν τὸ  
 5 φοινικοῦν. ἔστι δὲ τὸ ξανθὸν ἐν τῇ ἰριδι τοῦ τε φοινικοῦ καὶ πρασίνου χρώματος.  
 διὰ τὴν μελανίαν οὖν τοῦ κύκλῳ νέφους ὅλον αὐτοῦ φαίνεται τὸ φοινικοῦν  
 λευκόν· ἔστι γὰρ πρὸς ἐκεῖνα λευκόν, καὶ πάλιν ἀπομαρανομένης τῆς ἰριδος  
 ἐγγυτάτῳ, ὅταν λύηται τὸ φοινικοῦν· ἡ γὰρ νεφέλη λευκὴ οὔσα προσπίπτουσα  
 10 παρὰ τὸ πράσινον μεταβάλλει εἰς τὸ ξανθόν.

Some points: I should translate λευκόν and μέλαν as 'light' and 'dark', not 'black' and 'white'. If the red is looking yellow, it can hardly be looking white as well.

ἐκεῖνα in line 7 must mean both the green and the cloud.

Rainbows have no red in them if the raindrops are 0.3 mm. or less in diameter, so that if the bow fades because the rain is lightening red is the first colour to go. Aristotle's account of yellow in such circumstances is a separate case, and not relevant to this discussion.

As an account of the colours in the rainbow, this is of course quite wrong: but it is hard to believe that Aristotle would have said this unless he was convinced that the juxtaposition of red and green could produce virtual yellow. Commentators who do not ignore the issue or skirt it with paraphrase invariably think that if Aristotle is not trying to account for simultaneous contrast then he ought to be: they translate τὸ παρ' ἄλληλα φαίνεσθαι by 'contrast', and then say he is wrong because simultaneous contrast will not account for the phenomenon he is describing.

'Simultaneous contrast' is the term for the strengthening of contrast in colour, not tone, between two adjacent colours. Each produces on the retina a kind of exhaustion, so that if you look away, you see white light minus the original colour, i.e. its complementary in the form of a negative after-image. Involuntary eye movements superimpose the after-image of each colour on the other, so that each is tinged with the complementary of the other and the contrast increased. Aristotle's red should become pinky, the green bluish, to give a very sharp contrast of hue.

However, in the last few years some remarkable discoveries have been made about colour: in some cases the adjacent colours do *not* throw each other into contrast, but in some way mix, rather as coloured lights mix, to produce a new colour somewhere between them. Professor W. D. Wright, in an article 'Colour under scrutiny', *New Scientist*, 10 July 1969, puts it briefly, if rather technically:

'The interaction between colours located alongside each other generally produces an enhancement of the contrast between them. This can be explained, at least in general terms, as due to lateral inhibition between the neighbouring areas of the retina upon which the colours are focused. Yet with some types of pattern, *especially fine striped patterns*, a reverse effect seems to occur. This is in part due to the physical spreading and scattering of light on the retina, but quantitative studies of the colour changes suggest that some more subtle factors must also be at work.' (My italics.) A painted representation of

the rainbow in red, green, and violet stripes would provide the ideal model for such changes, which are known as optical or visual mixtures.

The prime condition, after the linear pattern, is the one which Aristotle specifies, and which suggests to me that he had some example in mind: the colour to be changed must be lighter than the colour by which it is to be changed, and a dark background will help to show the change up. The ordinary principles of additive mixture apply, and the red, or that part of it next to the green, looks yellow.<sup>1</sup>

The three most detailed commentaries, taken in chronological order, show how what Aristotle said has been discredited, even if time has brought more general knowledge of theories of colour vision.

1. 1849: Carl Prantl (op. cit.) quotes the passage in *De Insomniis* 2, 459<sup>b</sup>5 where Aristotle discusses the *positive* after-images of luminous or very brightly lit objects (which are to begin with the same colour as their originals), and he says, 'Eine solche complementäre, also nur subjective, Farbe ist bei Aristoteles das Gelb im Regenbogen, indem der Eindruck desselben dadurch entsteht, daß das Rothe in dem tiefen Schwarz der Wolke neben dem Grünen heller erscheint . . .' Now the positive after-images of the *De Insomniis* are not complementary but, as mentioned above, the same colour as the original; and in any case, yellow is not a complementary of red or green. Complementaries, pertaining to *negative* after-images and simultaneous contrast, do not come into it, or positive after-images either. Prantl's emphasis on the importance of the tonal contrast is fine as far as it goes, but he is unable to explain why Aristotle should seriously claim this as a way of making yellow. Admittedly Prantl precedes Helmholtz's theory of trichromatic vision, but he seems unacquainted with even the basic terminology of colour vision.

2. 1904: Wolfgang Schultz (op. cit.), as we have seen, is handicapped by the belief that the Greeks could not see yellow and blue, could not distinguish *πράσινον* and *πορφυροῦν*, and were shaky on red and *χλωρόν*. Even so, he talks of *simultaner Kontrast*, which is not the cause of the phenomenon Aristotle is trying to explain. In a footnote he adds: 'Hierfür spricht auch, daß selbst *ξανθόν* nicht als Mischung sondern durch Kontrast erklärt wird.'<sup>2</sup> He refers to Helmholtz's theory, which led me to think he was going to give the right cause under the wrong name: but apparently since Aristotle had no notion of primary colours of light, he could not perceive the effects of their mixture (and being colour-blind could not see yellow anyway!). Schultz's grasp of trichromaticism is shaky at best, since he thinks red and green are complementaries—it should be red/cyan and green/magenta—and also yellow and violet—pure yellow is complementary to blue, citrus-yellow to violet.

3. 1961. I had real hopes of Carlo Mangio, 'Cenni sulle teorie cromatiche dei Greci e loro applicazione architettonica', *SCO* x (1961), 214–23. He speaks of temples painted in the complementaries of red and cyan, which at a distance

<sup>1</sup> It works best at a distance of several feet, and with light pink rather than red—cf. G. S. Merker, 'The Rainbow Mosaic at Pergamon and Aristotelian Color Theory', *AJA* lxxi (1967), pp. 81–2. It is even better for myopes without glasses: Aristotle could well have been myopic, but this is not the place to go into the question.

<sup>2</sup> One might quote back Olympiodorus

ad loc., Stüve 243: τὸ γὰρ ξανθὸν οὐ γίνεται κατὰ ἀνάγκασιν, ἀλλὰ μάλλον κατὰ κρᾶσιν τοῦ φοινικοῦ καὶ τοῦ πρασίνου χρώματος. But then Olympiodorus rebukes Alexander for saying that the rainbow is caused by refraction, not reflection, which Alexander quite definitely did not. How reliable is Olympiodorus, therefore, as an interpreter of other, earlier, authors?

blend into a tactful grey; the cyan he speaks of as darker than the red. If it were a true complementary it would be lighter, and they would in theory make white, though pigments will never do more than produce light grey. He also describes accurately the phenomenon of simultaneous contrast which red and cyan would produce from close at hand: 'Ma Aristotele conosceva anche il contrasto simultaneo dei colori; egli cita l'esempio delle stoffe ricamate: a seconda di come le tinte vengono accozzate, ora appaiono certi colori, ora altri, ora con una intensità, ora con un'altra.'<sup>1</sup> But present him with the disputed statement, and he says: 'È chiaro che nel caso del giallo presente nell'iride Aristotele confonde l'intensità del colore col colore vero e proprio: il rosso accanto al verde scuro può indebolirsi, ma non può assolutamente divenire giallo', which in combination with his thesis on painting temples is damning. To know enough to say that red+cyan = white, but not enough to extend it to red+green = yellow, is more culpable than knowing nothing at all.

Aristotle seems to have been acquainted with the phenomenon of visual mixing, even if he had no very good explanation for it (but then, as Wright indicates at the end of the excerpt on p. 398, neither have we), and no way of conceiving the mixture as that of primaries of light, since the only primaries in his system are black and white. After all, it is only recently that we have learned the difference between additive mixtures of light and subtractive mixtures of pigment. The Impressionists hoped to produce a purer green from blobs and flecks of blue and yellow—and if they chose a warm yellow, got a dirty pink. Our colour televisions, on the other hand, produce yellow from tiny spots of red and green. But even if Aristotle could not know how he was seeing it, he knew he was seeing a light red by a darker green as yellow. He tells us he got the idea from *ἄνθη*, meaning not flowers but either dyed yarns used in embroidery or the embroidered figures, where threads of a particular colour may look entirely different on different grounds.

He also wondered whether something similar might be the basis of all colour in nature. He believed that black and white were the only primaries, and that all other colours lay somewhere between them, determined in a way reminiscent of Plato by the proportions of each primary present. Before he eventually decided that the colours were homogeneous mixtures, he looked at two other ways of explaining the different colours. One was the idea of layers of colour, like his favourite example of the low sun looking red through cloud: white overlaid with black. The other is atomic, and seems to be based on one point of visual mixing, that two colours in small areas next to each other, areas too small to be discerned at a distance, still produce the appearance of a third colour. He is not, of course, talking about mixing paints, but colours produced in nature; *De Sensu* 439<sup>b</sup>21:

ἐνδέχεται μὲν γὰρ παρ' ἄλλα (cf. *Meteor.* passage) τιθέμενα τὸ λευκὸν καὶ τὸ μέλαν, ὥσθ' ἑκάτερον μὲν εἶναι ἀόρατον διὰ σμικρότητα, τὸ δ' ἐξ ἀμφοῖν ὁρατόν, οὕτω γίνεσθαι. τοῦτο γὰρ οὔτε λευκὸν οἶό ντε φαίνεσθαι οὔτε μέλαν· ἐπεὶ δ' ἀνάγκη μὲν τι ἔχειν χρῶμα, τούτων δ' οὐδέτερον δυνατόν, ἀνάγκη μικτόν τι εἶναι καὶ εἶδος τι χροῶς ἕτερον.

<sup>1</sup> The flickering after-images which cause this are the reason why certain black-and-

white striped or checked patterns may be almost painful to look at.

In conclusion, either Aristotle is describing his own experience of the products of visual mixing when he 'explains' the yellow in the rainbow, or by coincidence he has put forward the conditions which are incidentally necessary for the production of yellow by visual mixture, without ever having experienced it, out of his imagination; which I find the less likely alternative.

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