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# The new physiology of vision—Chapter XXIII. The colours of the roses

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Roses have been known in India for ages past and have been highly esteemed for their beauty and fragrance. It is scarcely possible, therefore, to commence a paper on the colours of roses without some reference to the Indian rose known botanically as *Rosa indica semperflorence.* It is a shrub which is exceedingly vigorous in growth and flowers both freely and perpetually. The blooms are shapely, each having some forty petals. They appear as clusters at the end of tall canes growing up from the base of the shrub and are characterised by their soft pink colour and a sweet scent which perfumes the air around. These roses have been in extensive cultivation for various purposes, in particular for the production of the essential-oil perfume known as Attar. If groups of these shrubs are planted out in a garden, they make a very satisfying show of colour.

The reason why it appeared desirable to devote a whole chapter to the colours of roses is that the rose has long been a highly popular flower and enthusiastic rose-lovers are to be found all the world over. Interest in the rose continues unabated and thousands of varieties of it have been created by crossing and intercrossing the different species with each other. The colour of a rose forms a major part of its aesthetic appeal. Quite naturally, therefore, colour has been a decisive factor in the development, selection and propagation of new varieties. How far this activity has proceeded will be evident from *The Pocket Encyclopaedia of Roses* (1963), published by the Blandford Press in London. No fewer than 421 named varieties have been reproduced in full colour in that publication. It is stated that great care was taken to achieve a high degree of accuracy in the representation of the colours and to secure such accuracy, the illustrations were printed in six colours. Seeing these pictures, one may well ask, why do roses exhibit such colours and why do the different roses differ so markedly from each other? It is the purpose of this chapter to present answers to these questions.

*The colour categories*: The colour of a flower has its origin in the presence in its petals of a material which we may refer to as the floral pigment. This exercises an absorption on light which is of a selective nature, greater in some parts of the visible spectrum and much less or even absent in other parts of it. As a consequence, diffuse daylight which is incident on the petals before it can emerge again from them after internal scattering has its spectral constitution much altered, some parts of the spectrum being weakened relatively to the others. When the light having this altered spectral character reaches the eyes of an observer, the characteristics of the visual mechanism determine the results of the visual synthesis and hence also the perceived colour. Thus, the colour exhibited by a rose is determined by our faculties of perception and by the spectral characters of daylight as it emerges after diffusion within the petals, these characters being themselves dependent on the quantity of floral pigment contained in the petals and its absorptive properties.

In the preceding chapter, a scheme for the classification of floral colours was suggested, based on the subdivision of the visible spectrum into four parts, consisting respectively of the blue sector, the green sector, the yellow sector and the red sector. Of these four, the yellow sector covers the narrowest range of wavelengths but nevertheless transcends all the others in respect of its influence on the perceived colour. Placing the four sectors in the order stated and indicating by the symbol 1 the absence of absorption and by the symbol 0, a complete absorption of the sector concerned, we obtain sixteen categories of colour which are indicated by the appropriate symbols. The eight categories which here concern us are (1111), (0111), (0011), (0001), (0000), (1001), (1011) and (1101). These represent colours which may be termed respectively as white, yellow, orange, red, black, pink, rose and purple. These assignments are based on spectroscopic observations of a great many flowers exhibiting various colours. If the absorption of light is not actually complete for any particular sector, the colour sensation which results is weaker, but is not altogether different. Thus the categorisation of colour may be regarded as having an extensive range of validity. Its usefulness depends on the fact that it enables us from the perceived colour to infer the part or parts of the spectrum where the absorption by the floral pigment is effective, and then proceed to verify this by direct observation.

*Spectroscopic behaviour of roses*: To ascertain the region or regions of the spectrum on which the floral pigments exercise their specific absorption, all that is necessary is to hold the flower in sunlight, or alternatively in diffuse daylight of sufficient intensity and view it through a direct-vision spectroscope. Comparison with the spectrum of a white diffusing screen observed under similar conditions immediately reveals the nature and extent of the alterations in the spectrum of the flower resulting from the presence in its petals of the floral pigment or pigments. This simple technique reveals that the absorption in roses which exhibit the various shades of cream or yellow appears in the blue sector of the spectrum, in other words in the wavelength range between 400 and 500 m$\mu$, while other parts of the spectrum are entirely unaffected. The absorption is partial when the colour is a cream or a pale yellow. But it is more strongly manifested by the more vividly coloured roses and is complete in the cases of roses which exhibit a deep yellow colour.

The spectroscope reveals that the soft pink colour of the Indian rose referred to at the commencement of this chapter has an entirely different origin. On a comparison of the light diffused by it and by a white screen, it is seen that the red sector of the spectrum appears with undiminished intensity and that the blue sector also appears with practically undiminished brightness. On the other hand, the green sector ranging from 500 to 560 m$\mu$ is much weakened, and the yellow sector between 560 and 600 m$\mu$ is just perceptibly dimmed. A fuller idea of the spectroscopic behaviour of the floral pigment contained in the petals of this rose may be obtained by examining the light which penetrates through its individual petals when they are held up against the bright sky and the slit of the instrument is held immediately behind the petal. Making this observation first with a single petal held by itself and then with two petals, then with three petals and finally with four petals held together, we find that while the red sector comes through freely in all cases, the green sector is progressively weakened and is almost completely extinguished when three petals are held together. The blue sector which is conspicuously visible with one petal is weakened in its passage through two petals, and is only seen with difficulty through three petals. A progressive weakening of the yellow sector is also evident as the number of petals is increased. With four petals, we have a complete extinction of all the sectors except the red which remains conspicuously visible.

It may be inferred from what has been stated above that the pink colour exhibited by many roses has its origin primarily in the absorption of light appearing in the green sector of the spectrum; the more complete this absorption is, the deeper would be the pink. Observations with roses exhibiting different shades of pink indeed show a progressive change in the spectral characters of the light diffused by the petals analogous to those described above resulting from the passage of light through a number of petals held together.

*Red and crimson roses*: Examination of the light diffused by the petals of roses which exhibit a red colour as also of those which appear of a crimson hue, reveals some remarkable features. The green sector of the spectrum is much weakened. But, in addition, we observe a dark band covering the wavelength range from 560 to 600 m$\mu$, in other words a complete extinction of the yellow sector of the spectrum. The blue sector of the spectrum is much weakened but is not totally extinguished. The wavelength region between 480 and 500 m$\mu$ also appears distinctly darker than the parts of the spectrum on either side of it. In the spectrum of the light transmitted through a petal of a red or a crimson rose, the extinction of the green sector between 500 and 560 m$\mu$ is complete, while the red sector is seen in full strength. The blue and yellow sectors are much weakened but not totally extinguished.

*Scarlet roses*: The roses exhibiting a scarlet hue form a distinct class by themselves. The difference in colour between a scarlet rose and a red rose is sufficiently striking to be unmistakable. It also reveals itself in the character of the spectrum diffused by the petals. The scarlet colour arises from a strong absorption in the wavelength range between 480 and 560 m$\mu$. Light of greater wavelengths however comes through freely. The blue sector is weakened but can nevertheless be observed. As seen by transmission through the petals, the same features are noticed but are then more accentuated. The difference between scarlet and red roses thus lies in the greater transparency of the former to the yellow sector of the spectrum.

*Orange roses*: The transparency to the yellow of the spectrum exhibited by the scarlet roses is shown even more conspicuously by the roses of an orange hue. Here again, the perceived colour is a consequence of the absorption in the green sector between 500 and 550 m$\mu$ which is complete, while all greater wavelengths appear with undiminished strength. The blue sector is weakened but can nevertheless be observed in the wavelength range between 420 and 470 m$\mu$. The blue sector is still weaker in the transmitted light, while the rest of the spectrum shows features similar to those observed by reflected light. The orange roses can thus be placed in the category (0011), but this description ignores the presence of the blue sector though much weakened in the spectrum. We have here a clear case of the masking of a weaker by a stronger sensation, the effect of the yellow and red sector acting in concert overpowering that of the weakened blue sector.

*Extraction of the floral pigments*: It is quite easy to remove the pigments from rose petals and thereby enable their absorption spectral to be independently studied. All that is necessary is to place the petals in a glass beaker and pour sufficient acetone to cover them completely. In a very few minutes, the pigments are dissolved out by the acetone, leaving the petals free from colour. The extract is quickly filtered and poured into the observation tube. It is useful to have four such tubes of different lengths, viz., 3, 5, 8 and 10 cm, each provided with flat ends. The quantity of the petals used can be varied suitably according to the depth of colour of the rose. For a deeply coloured extract, the tubes of smaller length are more useful. Vice versa, for weakly coloured extracts, the longer tubes are more convenient. Using this technique, a proper comparison between the pigments of roses exhibiting different depths of colour becomes possible. Two matters of detail may be mentioned here which are of some importance. The source of light used for the observations should be a tungsten filament lamp run at a high temperature to give white light of sufficient intensity. The observations should also be made with the acetone extract immediately after its preparation.

*The absorption spectra of the floral pigments*: It will suffice here briefly to record the results of the studies of the colour of roses as observed with the acetone extracts. With yellow roses, we obtain solutions having a golden-yellow hue. Examination of the light transmitted through the observation tube containing the solution shows a complete absorption of the blue sector of the spectrum. Such absorption also extends a little beyond 500 m$\mu$, exhibiting an ill-defined edge in the wavelength range between 490 and 520 m$\mu$. The absorption spectra of the pigments contained in yellow roses thus resemble those of the carotenoids.

The colour of the extracts made with other roses depends a good deal on the quantity of the material used for the extraction and the volume of acetone added. Speaking generally, however, it may be said that the colour of the extract resembles the colour of the roses from which it is derived. The studies establish clearly that the pigments appearing in pink roses of various shades, in the red roses and in the crimson roses, are of an identical nature, the quantities of pigment present, however, being very different. In all such cases, with the appropriate concentrations, we observe a powerful absorption in the green sector, and in addition a fairly well-defined dark band in the wavelength range between 530 and 555 m$\mu$. There is also a general absorption in the yellow sector extending from 555 to 600 m$\mu$ and in addition a well-defined absorption band between 580 and 600 m$\mu$. A general but rather weak absorption is also noticeable in the blue sector. It is most marked between 490 and 510 m$\mu$.

The acetone extracts from the scarlet and from the orange roses differ from those of the other roses principally in respect of the absorption of the yellow sector of the spectrum. Such absorption is present in the extracts from scarlet roses, though it is not quite as strong as in the case of the pink, red, or crimson roses. On the other hand, the acetone extracts from the orange roses do not exhibit such absorption.