Proc. Indian Acad. Sci. **A58** 67–69 (1963)

Floral colours and the physiology of vision—Part III. The spectrum of the morning glory

SIR C V RAMAN
(Memoir No. 137 of the Raman Research Institute, Bangalore-6)

Received June 4, 1963

As has been remarked in the first part of this memoir, a vast mass of material suitable for investigations on the perception of colour is available to us in the products of the plant world. The reason for the choice of the "Morning Glory" as the first of the flowers to receive attention in this memoir is the remarkable nature of the chromatic effects which it exhibits. These are of a challenging nature and present features of fundamental interest.

The botanical name of this climbing and twining creeper is *Ipomea learii*, and it is to be found in many Indian gardens. When trained to cover a screen, it presents a magnificent sight in the early mornings, its green foliage appearing studded over with numerous trumpet-shaped flowers (*see* figure 1, front view and figure 2, side view in which the flower appears with half its natural size). The five divisions of the trumpet-shaped expansion are very thin and are held together by five ribs of a

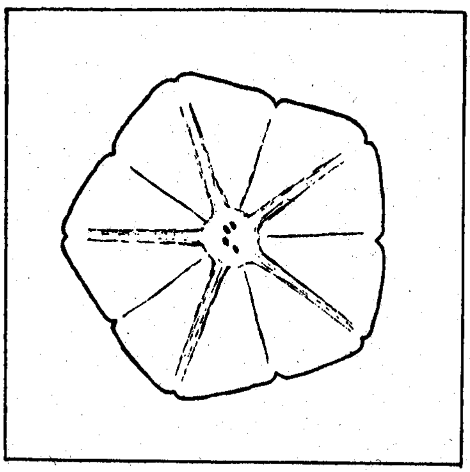


Figure 1. Morning glory (front view).

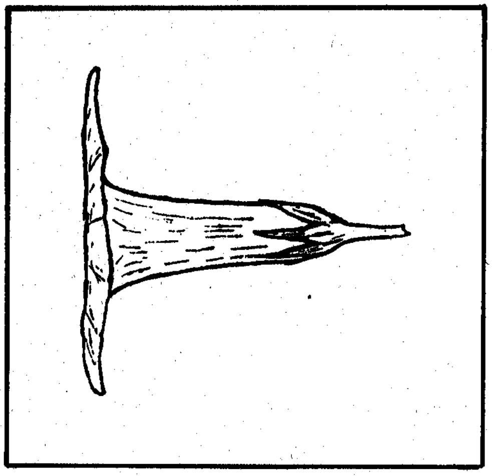
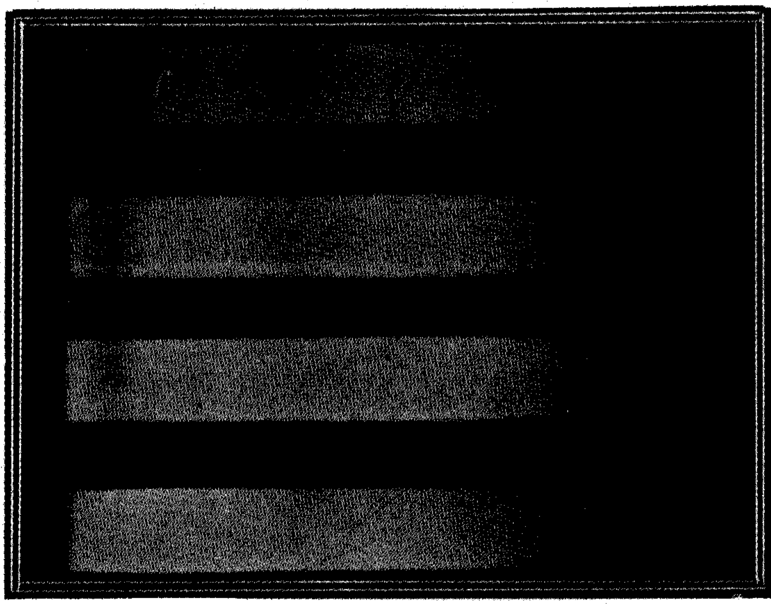


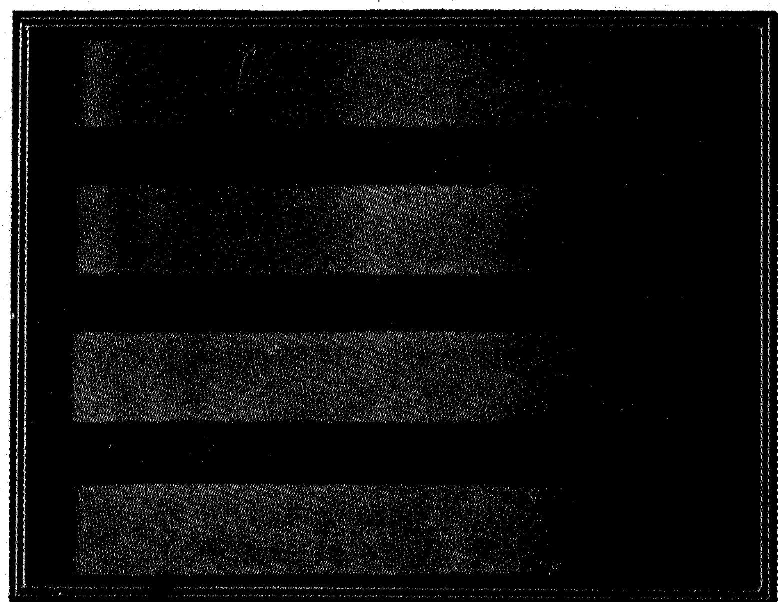
Figure 2. Morning glory (side view).

purplish tint, while the intervening membranes exhibit a brilliant blue colour of almost spectral purity. The colour is best seen when the flower is viewed from the front and is then a deeper blue than that seen by the light which has traversed the membranes. The reason for the difference is obvious. When the flower is viewed from the front, in other words, by the light that is thrown back towards the source of light, the thickness of the absorbing layer is effectively doubled. Though the membranes exhibiting the colour are thin, they do not allow the sun to be seen through them when the flower is held between the light and the eye. In other words, they function as diffusing media for all wavelengths in the spectrum.

A surprising fact emerges when a spectroscope is used to examine the composition of the light perceived by the eye as being of a brilliant blue colour. The spectroscope may be directed towards the flower, either from the front or from the rear. In the former case, the light examined is that diffused backwards, while in the latter case the light examined is that diffused forwards. The effect observed is very similar but differs in detail in the two cases, by reason of the effective thickness of absorbing material being greater in the light diffused backwards. In either case, the spectrum exhibits a strong absorption in the region of the spectrum extending from 590 to 635 mμ. The absorption terminates sharply at the latter wavelength, while in the region between 570 and 590 mμ, it is also observable but less strongly. The rest of the spectrum between the extreme violet and the extreme red exhibits no other absorption or change of relative intensities. As observed through the spectroscope, the red of the spectrum appears the most intense, the green follows next in order, while the violet and blue sectors appear as visually the weakest.

We may now ask, why does the flower exhibit a brilliant blue colour to the eye?





Figures 1 and 2. **1.** Spectrum of the morning glory and comparison spectrum. **2.** Spectrum of the blue lily and comparison spectrum.

Plate I.

The red and the green sectors are present in their full strength relatively to the blue sector and indeed they appear in the spectroscope as much brighter than the blue. Nevertheless it is the latter that is perceived by our eyes and not the former. The situation may be stated as follows: The complete spectrum extending from the extreme violet to the extreme red presents to our visual perception the sensation of white light. When we remove from the spectrum the strip of wavelengths between 570 and 635 mμ, in other words, we cut out the yellow and orange sectors, the visual effect is transformed to a bright blue of almost spectral purity. The only reasonable explanation appears to be that in the particular circumstances of the case, the red and green in the radiation are masked or screened off from perception by the blue part.

It appeared desirable to confirm the visual observations described above by objective methods. For this purpose, the spectrum of the light transmitted through the flower was recorded photographically using a Higler constant deviation spectrograph on an Agfa panchromatic film. A tungsten filament lamp was used as the source of light in conjunction with a filter of copper sulphate solution so as to reproduce daylight conditions as nearly as practicable. To enable the effects of the varying sensitivity of the photographic film over different parts of the spectrum to be recognised and taken account of, a spectrogram of the light-source alone was recorded with a suitable exposure on the same film and the spectrogram of the flower was recorded with three different exposures so as to admit of a proper comparison with it. Figure 1(a), (b), (c) and (d) in plate I reproduce the spectra thus recorded. Figure 1(d) is that of the source of light alone, while figures 1(a), (b) and (c) are the spectra of the flower recorded with three different exposures. In each case, the red end of the spectrum appears on the left while the violet end appears on the right.

In figure 1(d) in plate I, the region in the middle of the spectrum of low photographic sensitivity is recognisable. This also appears prominently in the three other spectra (a), (b) and (c). It should, therefore, be excluded from consideration. The strong absorption by the flower in the orange sector is recorded as a dark band in the spectra. It is also evident on comparing them with figure 1(d) in the plate that the material of the flower does not exercise any sensible absorption elsewhere in the spectrum.

Summary

The flowers of the Morning Glory (*Ipomea learii*) exhibit a bright blue colour of almost spectral purity in daylight. Visual observations, confirmed by spectrum photographs, show that this visual sensation results from the removal of the yellow and orange radiations from the complete spectrum, the relative intensities of the red, green and blue-violet regions remaining unaltered. The effect observed may be interpreted as the result of the masking of the visual effect of the red and green sectors by the blue sector in the spectrum in these circumstances.