THE WORLD OF COLOUR

N.S.Sundaresan

The phenomenon of colour is explained fragmentarily in chemistry, biology and physics in schools. In this article, a case is made for teaching colour as a separate interdisciplinary unit in the middle school.

Colour is a universal phenomenon. Everyone, from a child to an adult, has some idea about colour. In almost every language, there are words for red, green, blue, yellow and many shades of colours in between. It is such an important topic that scientists from the different disciplines of chemistry, biology and physics, have studied its various aspects and applications. Colour has also been the subject of intense study by artists and poets. The former have studied the technique of creating different shades in their paintings; and, the latter have painted word pictures of colour for us. There are many examples of the important role colour plays in our everyday lives: red is used in traffic lights and in danger indication; big shops have colour codes for their merchandise; schools have coloured uniforms; football teams have different colours to distinguish them from each other; and national flags have colours. We use rangoli colour patterns on festival days to decorate the front of the house. The Indian festival of Holi is a festival that celebrates colours.

In the school science curriculum, however, the concept of colour is brought in piece-meal, at various stages. Every year, either in physics or in chemistry or in biology, it finds a mention, but never at the same time. Thus the student gets only a fragmented idea of the topic. They associate certain aspects with only physics and certain aspects only with chemistry, without realizing that the phenomenon is the same.

The purpose of this article is to draw the attention of my teacher colleagues and the odd syllabus maker who may read this article, to the possibility of including the concept of colour as an interdisciplinary topic in the science curriculum. It can be introduced in the middle school level before an introduction to topics like light, photosynthesis, chemical reactions etc. It is also suggested that the unit should be taught by one science teacher. Later in this article, an outline form for the contents of such a unit is given.

With this background, let us examine how colour is introduced in biology, chemistry and physics in the current school curriculum.

Colour in school science curricula

In chemistry, we introduce colour first through the physical properties of substances e.g. sulphur is a yellow coloured solid, copper sulphate is blue. We also show how solutions on mixing give a solid precipitate, which is coloured, and can be used to identify substances.

In biology, photosynthesis is discussed quite early, but without mentioning colour in light, and its absorption.

In physics, light and its transmission, reflection etc. are introduced much before concepts of colour, which do not appear until perhaps the 12th standard. Of course the prism and splitting of colours comes in somewhere in 9th standard, but again, the focus is not on colours.

Thus, a topic, which may be common to all the three subjects, is never discussed synchronously. It may be important to present a single unit on colour, integrating chemistry, biology and physics for this topic. Also, in order to make the student appreciate the universal nature of colour, it is suggested that the teacher should draw upon a large number of examples from all fields. A few examples are given below, but a teacher can, no doubt, expand this list.

1. Dyes, inks and other chemical examples: Natural and synthetic dye examples can be mentioned. The teacher can show an experiment in class with the familiar diazonium salt and beta naphthol coupling, which produces an azo dye. (This, of course, comes in 12th standard.) Black ink, which is a combination of many coloured dyes, may also be taken up; the separation of this ink into various colours can be shown using a filter paper (Paper chromatography).

Naturally coloured cotton: Coloured cotton, produced in places like Dharwad in Karnataka, may be mentioned. More details can be had from an article by Murthy (Never say Dye: The story of coloured cotton, Resonance, December, 2001).

In the 7th standard, we introduce acids and bases, but perhaps not indicators. Since indicators dramatically change colours depending on pH, they could be mentioned in greater details, with names and the kind of colour change they show. Home-made indicators, such as turmeric and radish leaf extract, must also be mentioned and demonstrated. The student is not introduced to dyes – natural and synthetic, until much later, in the 12th standard.

2. Photo-chromism: Another interesting example is photo-chromism, where changes in colour (or from dark to transparent) are caused by reversible chemical reactions. Such materials are often used in spectacle lenses. Though the student may not need to know the chemical nature of the substances, their names may be mentioned. e.g. azobezenes, spiropyrans and so on. Some of these materials are used in the modern 'Smart Windows' which automatically turn green (or dark) when sunlight falling on them reaches a certain intensity. (We can leave electrochromism for a later stage.)

3. Fluorescence: This is a well-known phenomenon. An explanation can be given in terms of light energy absorption by electrons in a substance, and immediate release of the energy, again, in the form of light. A solution of fluorescein, which is easily available, may be used. Workers at construction sites, as well as traffic policemen, wear overalls with fluorescent paint. This may be mentioned.

4. Colour in lasers: Either from watching TV shows or otherwise, many children are familiar with the word laser. It might be good to give a simple idea of this mechanism, in terms of energy absorption and release by electrons in the form of light. Unlike fluorescence, the release of energy is made coherent by a physical device such that all the photons have the same phase. Thus the emitted light is very intense. Colour in lasers is achieved by choosing appropriate materials with the required electronic energy levels. E.g. He–Ne produces a red colour.

5. Colour as camouflage and display in animals: If we want examples from the life sciences, we could draw upon how birds have colourful plumage to attract their mates; how certain predators blend with their surroundings in order to effectively catch their prey. Similarly, prey also can have colours that help them blend into their surroundings, to escape predators. Of course, the green colour of the leaf and its use in photosynthesis would have already been mentioned many times in the class.

Proposed contents for a combined unit on colour

As we have seen above, there is really a lot to convey about colour at all levels. However, for the middle school, we have to make a judicious selection from the various aspects of colour; we have to also present them interestingly, without the rigour and the dullness of formulae and equations. At the same time, we have to simplify difficult aspects by just the right amount so that facts are explained correctly.

The following is an attempt to outline the contents of a unit on colour.

Colour

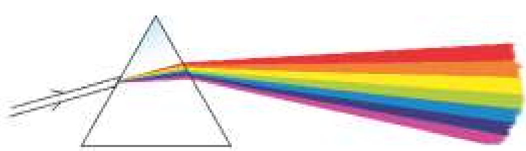
1. Colours around us – natural and synthetic phenomena. – Examples from everyday life

2. Light as a form of energy – infrared heaters, lenses concentrate sun light energy etc. – mention that white light is composed of different colours.

3. (i) What happens when light falls on objects – Transparent and opaque objects – Transmission through solution – Introduce coloured solutions.

   (ii) Refraction – a brief and qualitative explanation, using water (light bending)

   (iii) Dispersion – Experiment with prism – Connection with refraction



   (iv) Reflection of light from opaque objects – Cause of colour in objects – The idea of complementary colours – Explain why objects do not show colours in the dark.

4. Colour and chemistry – Coloured substances (both elements and compounds) in chemistry – as examples, display as many substances as possible; Production of coloured substances – a) inorganic: coloured precipitates such as Prussian blue – Cu-ammonia complex (Copper sulphate and ammonia), nickel dimethylglyoxime (scarlet), barium chromate etc. can be shown b) organic: simple azodye with aniline and β-naphthol can be prepared and shown. Explain, qualitatively, the emission of yellow orange light by sodium lamps. Simple ideas of specific absorption of energy by electrons and re-emission could be brought in if students are familiar with the basics of atomic structure.

5. How do we see – Absorption of light by the photoreceptors in the retina, rods and cones. Sensitivity of cones for various colours.

6. Absorption of red light by green leaves. Explain how the energy produced is used for synthesis of starch – photosynthesis – simple explanation only.

7. Camouflage – Colours on animals and insects.

Notes

1. Origin of the names of colours: The names of colours like red, blue, green, yellow etc. have their origin in languages older than English (as it is known today). These are mainly derived from some languages like Indo-European, Norse etc. A good article on this is to be found at http://www.gizmodo.in/datasearchresult.cms?query=how+colors+got+their+names&sortorder=score

2. Why is the sky blue or red? We know of course that the phenomenon that causes this is light scattering. However, it might be difficult to explain this qualitatively, in words. So, I have not included it in this unit. A partial explanation explaining what scattering means, and that blue light from the sun is scattered more than the others, might be attempted.

Conclusion

In conclusion, it may be said – though a bit optimistically – that this single unit can effectively be used as a bridge between chemistry, biology and physics; and make the job of the teacher easier when discussing other topics in detail.

N.S.Sundaresan *is a retired teacher of chemistry. He has taught both at the school and college levels. He did his PhD from the Bombay University. He can be contacted at kaone52@gmail.com*