1. **Origin of Colour**

Some of the early studies and theories about light were done by Aristotle. He discovered that by mixing two colours, the third is produced. He did this with a yellow and blue piece of glass, which when brought together produced green. He also discovered that light travels in waves. Plato and Pythagoras also studied light. In the 10th century, Al-Haytham researched into colour and his findings inspired Newton. During the Middle Ages, Paracelsus reintroduced the knowledge and philosophy of colour using the power of the colour rays for healing along with music and herbs. Unfortunately, he was hounded throughout Europe and ridiculed for his work. Most of his manuscripts were burnt, but now he is thought of, by many, to be one of the greatest doctors and healers of his time. A man, it would seem, very much ahead of his time. Not only do we now use Colour Therapy once again, but, his other ideas, using herbs and music in healing, can also be seen reflected in many of the complementary therapies now quite in commonplace.

A pioneer in the field of colour, Isaac Newton, in 1672 published his first, controversial paper on colour, and forty years later, his work 'Opticks'. Newton passed a beam of sunlight througha prism, when the light came out of the prism it was not white but was of seven different colours: Red, Orange, Yellow, Green, Blue, Indigo and Violet. The spreading into rays of these colours was called ‘dispersion’ by Newton

and he called the different coloured rays the ‘spectrum’. He discovered that when the light rays were passed again through a prism, the rays turned back into white light. If one ray was passed through the prism it would come out the same colour as it went in. Newton concluded that white light was made up of seven different coloured rays.

Colour comes from light. We can see seven main colours of the Visible Spectrum. The retinas in our eyes though have three types of colour receptors in the form of cones, we can actually only detect three of these visible colours – red, blue and green. These colour s are called additive primaries. It is these three colours that are mixed in our brain to create all of the other colours we see. The wavelength and frequency of light also influences the colour we see. The seven colours of the spectrum all have varying wavelengths and frequencies. Red is at the lower end of the spectrum and has a higher wavelength but lower frequency than that of violet at the top end of the spectrum which has a lower wavelength and higher frequency.

To physically see this, we need a prism. When light from the sun passes through a prism, the light is split into the seven visible colours by refraction. Refraction is caused by the change in speed experienced by a wave of light when it changes medium.

1. **Highlight the content of visible spectrum.**

The electromagnetic spectrum is the range of all possible frequencies of electromagnetic radiation. The electromagnetic spectrum of an object is the characteristic distribution of electromagnetic radiation emitted or absorbed by that particular object. The electromagnetic spectrum

extends from below frequencies used for modern radio through to gamma radiation at the short wavelength end, covering wavelengths from thousands of kilometers down to a fraction of the size of an atom. The long wavelength limit is the size of the universe itself, while it is thought that the short wavelength limit is in the vicinity of the Planck length, although in principle the spectrum is infinite and continuous. Generally, electromagnetic radiation (EM) is classified by wavelength into radio wave, microwave, infrared, the visible region we perceive as light, ultraviolet, X-rays and gamma rays. The behaviour of EM radiation depends on its wavelength. When EM radiation interacts with single atoms and molecules, its behavior also depends on the amount of energy per quantum (photon) it carries.

1. **Explain in detail why objects possess a particular colour.**

Everything we can see has a colour. Around us, in our homes, at work, in nature, in space - it is universal; everywhere has a colour, of some sort. The colour of anything we observe depends upon a few factors. Firstly - *Everything* is made up of electrons and atoms. Different materials, objects and items have a different make up of atoms and electrons. Any object, by its nature, will, when exposed to light, do one of the following: reflect or scatter light (reflection and scattering), absorb light (absorption), do nothing (transmission) and refract light (refraction).

**Reflection and Scattering**

A lot of objects reflect light to some degree, but something that is particularly reflective, has more free electrons that are able to pass from one atom to another with ease. The light energy that is absorbed by these electrons is not passed onto any other atoms, instead, the electrons vibrate and the light energy is sent out of the material at the same frequency as the original light coming in. Smooth surface reflect light while rough surface scatter it and the angle of incidence is always equal to angle of reflection.

**Absorption**

When something appears to have no reflection or is opaque, then the incoming light source frequency is the same as, or very close to the vibration frequency of the electrons in the given material. The electrons of the material absorb the energy of the light source, and because the light is absorbed, the material or object appears opaque - it has very little or no reflection.

**Transmission**

This occurs when the energy of the incoming light is either much lower or much higher than the energy or frequency required to making the electrons in the particular material vibrate. As a result of this, the electrons in an object that appears to be transparent, instead of capturing the light energy, allows the light wave pass through the object/material unchanged, thus the object/material is transparent to that frequency of light.

**Refraction**

If you have ever put a straw in a drink, then you may have noticed that the straw appears to be bent under the water. The reason for this is ***Refraction***. If the energy of the incoming light is the same as thevibration frequency of the electrons in the material, the light is able to go deep into the material and causes small vibrations in the electrons. These vibrations are passed on to the atoms by the electrons, and in turn they send out light waves at the same frequency as the incoming light. Although this happens extremely quickly, some of the light that is inside of the material slows down, but the frequency of the light outside the material remains the same. The result of this is that the light inside the material is bent. The angle of the distortion (refraction) depends upon how much the material is able to slow down the light, in this case as in the image above water.

A good example as to why objects possess a particular colour is shown in the picture below (of ripe tomatoes). Tomatoes appear to be red because when ripe, tomatoes contain a carotenoid known as "Lycopene". Lycopene is a bright red carotenoid pigment, a phytochemical found not only in tomatoes but also other red fruits. Lycopene absorbs most of the visible light spectrum, and being red in colour, Lycopene reflects mainly red back to the viewer, and thus, a ripe tomato appears to be red.

1. **Mention the relationship between colours and the eyes.**

The eye picks up colour and light by the rods and cones. It is the *Cones* that detect colour. Each cone contains one of three pigments sensitive to either red green or blue. There are about 120 million rods and about 6 to 7 million cones in the human eye. Rods are more sensitive than the cones but they are not sensitive to colour, they perceive images as black, white and different shades of grey. More than one thousand times as sensitive, the rods respond better to blue but very little to red light.

Each pigment absorbs a particular wavelength of colour. There are short wavelength cones that absorb blue light, middle wavelength cones that absorb green light, and long wavelength cones that absorb red light. When we observe a colour that has a wavelength between that of the primary colours red, green and blue, combinations of the cones are stimulated. An example could be that yellow light stimulates cones that are sensitive to red and green light. The result is that we can detect light of all colours in the visible spectrum.

People who suffer from colour blindness have less numbers of particular cones than normal, so they get confused with colours. If we lose our eye sight, the body adapts and receives colour rays through the skin. It takes time for the body to adapt, but it has been shown that people, who are blind, can differentiate between different colours.

**5. What is colour perception?**

 The perception of color is formed in our brain by the superposition of the neural signals from three different kinds of photoreceptors which are distributed over the human eye's retina. These photoreceptors are called cones and are responsible for photopic vision under daylight conditions. Scotopic (night) vision is caused by photoreceptors called rods, which are much more sensitive than cones. As there is only one kind of rods, night vision is colorless.

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