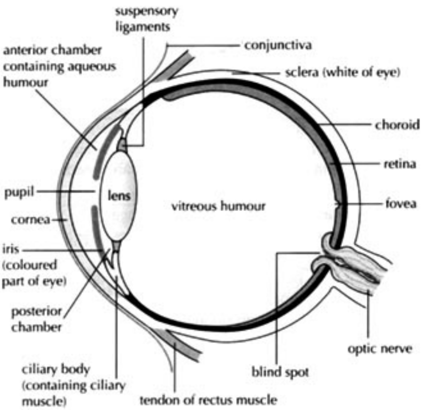
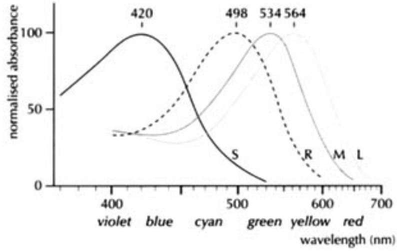
The eye and sight

HUMAN EYE

The structure of the human eye is shown below:



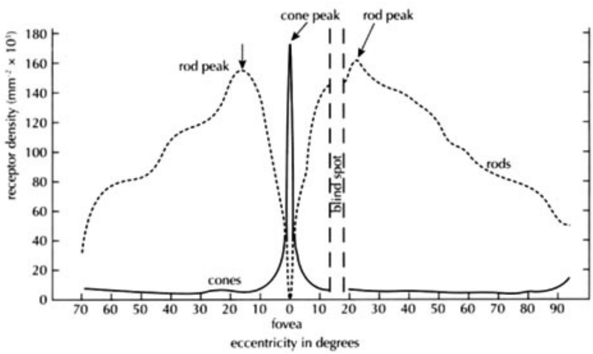
Refraction takes place as light enters the eye. Light passes through the cornea, aqueous humour, lens and vitreous humour in turn before striking the retina. The retina contains two different types of light-sensitive cells – the rods and cones. The light-response curves for the three different types of cones (labelled S, M and L) and the rods (labelled R) are shown top right.



Photopic vision is the colour vision that takes place at normal light levels. It is provided by three different **cone** cells which have peak sensitivity in the short (S), medium (M) and long (L) visible wavelengths, respectively.

Scotopic vision is the black and white vision that takes place in dim light. It is provided by the **rod** cells as shown in the above response curve (R). The chemical necessary for this "night vision" can take several minutes to be synthesized once light levels have been reduced.

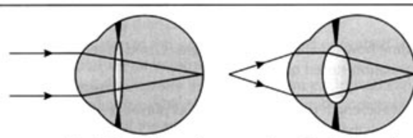
The rods and cones are not evenly distributed across the retina. The density of the cones is at a maximum in the centre whereas rods peak in density at an angle of approximately 20° away from the centre. There are no rods or cones in the region where the optic nerve leaves the back of the eye. This is known as the **blind spot**. The graph below shows the vertical variation of the density of the cells.



POSSIBLE CHANGES TO THE EYE

Accommodation is name given to the process by which the eye can focus on different objects. The eye lens is naturally "short and fat" but can be pulled to be "long and thin" by taut **suspensory ligaments** which attach the lens to the circular **ciliary muscle**. The ciliary muscle controls the tension in the ligaments. A relaxed circular ciliary muscle means the lens is thin so the eye is focused on infinity.

The pupil contracting or expanding controls the amount of light that enters the eye.



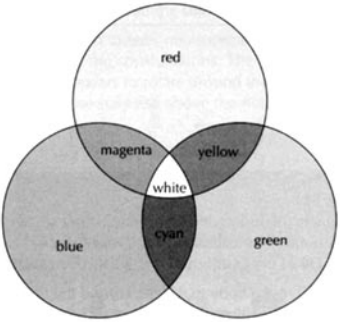
distant object is focused with thin lens – the circular ciliary muscles are relaxed, making the suspensory ligaments taut

close object is focused with fatter lens – the circular ciliary muscles are contracted, making the suspensory ligaments slack

Perception

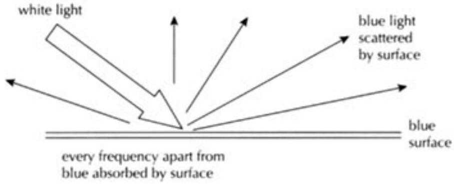
PERCEPTION OF COLOUR

Every monochromatic frequency in the visible portion of the electromagnetic spectrum is perceived by the eye as a different colour of the spectrum (red, orange, yellow, green, blue, indigo, violet). When two or more frequencies of light enter the eye at the same time this can also be perceived as one colour as represented below.



In this context of mixing different frequencies of light, red, green and blue are known as primary colours. In combination they produce the secondary colours: magenta (purple), cyan and yellow.

A filter placed in front of a source of light absorbs most frequencies and only lets through a particular combination of frequencies. A coloured surface absorbs most frequencies and only scatters the colour seen.



A blue surface will appear black when illuminated by red light.

The **trichromatic** theory of colour vision explains our perception of colour by the brain interpreting the different information received from the three different types of cones. The cones that are most responsive to short, medium and long wavelength are sometimes known as the blue, green and red sensitive cones, although these colours do not exactly correspond the wavelengths at which the cones are most sensitive.

Colour blindness is often caused by the failure of one or more types of cones to respond. Red–green colour blindness is the most common hereditary problem and is much more common in males than in females. The genes responsible for the red and green proteins are on the X-chromosome so males only have one copy. A defect on either gene causes red–green colour blindness.

PERCEPTION OF VISUAL DEPTH

There are many visual clues that are used by our eye/brain system that result in our sense of three dimensions. One very important process in the perception of depth is the brain's interpretation of the different images that are seen by each of our two eyes. Each one views any given scene from a slightly different perspective. When an object is far away, the relative difference between the locations of these two images will be small whereas a close object will have a greater difference between its two image locations. This process of stereoscopic vision requires both eyes to be functioning properly.

Other clues of the location for an unknown object come from the extent to which eyes are 'crossed' when focused on it, a comparison between objects of known size and an analysis of the order in which object must be located gained from knowing that closer objects can 'get in the way' of seeing more distant ones.

A normal human eye can focus on objects located between the **near point** (the closest point that can be focused upon without straining or optical aids – taken to be at a distance of 25 cm) and the **far point** (the furthest point that can be focused upon - taken to be at infinity).

PERCEPTION OF LIGHT AND SHADOW

As well as stereoscopic vision, the brain also interprets a wide variety of other visual signals to complete the perception of an object. For example:

- Architectural effects can be created by the use of light and shadow; deep shadow gives the impression of massiveness.
- The brain is very good at fitting blocks of colour into an outline picture. When a line picture is 'coloured in' using crayons, colour that spreads over a line tends to be ignored.
- We perceive the colour of an object to remain essentially constant even when the illumination used changes from sunlight to artificial light.
- Colour can be used to:
  - give an impression of 'warmth' (e.g. blue tints are often perceived as 'cold')
  - change the perceived size of a room (e.g. light-coloured ceilings seem to heighten the room).

The rest of Standard level Option A is identical to Chapter 11.

Options B, C and D

- Standard level option B is identical to Chapter 13.
- Standard level option C is identical to Chapter 14 in addition to pages 149–153 in Chapter 17.
- Standard level option D is identical to pages 171–5 in Chapter 19 in addition to pages 198–201 and 205–6.