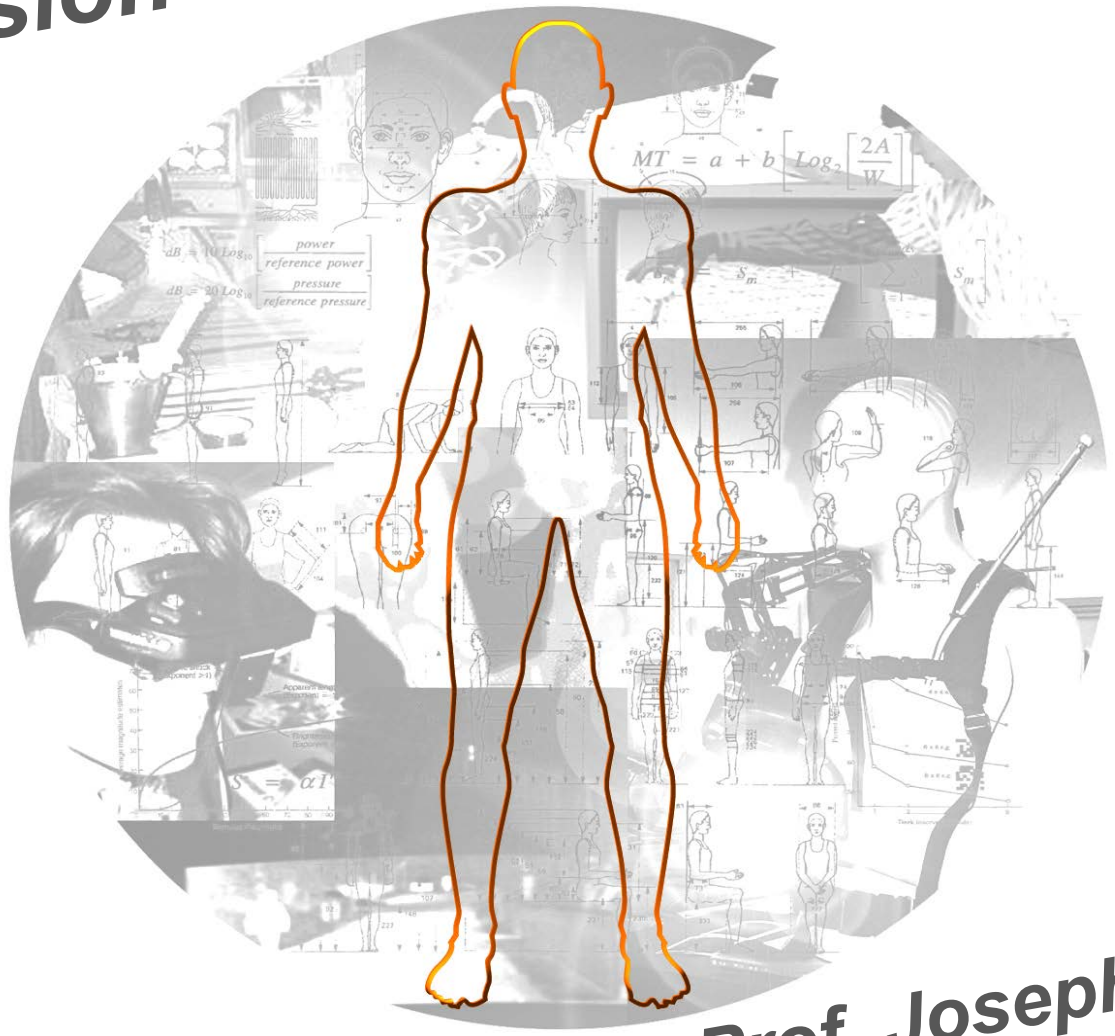
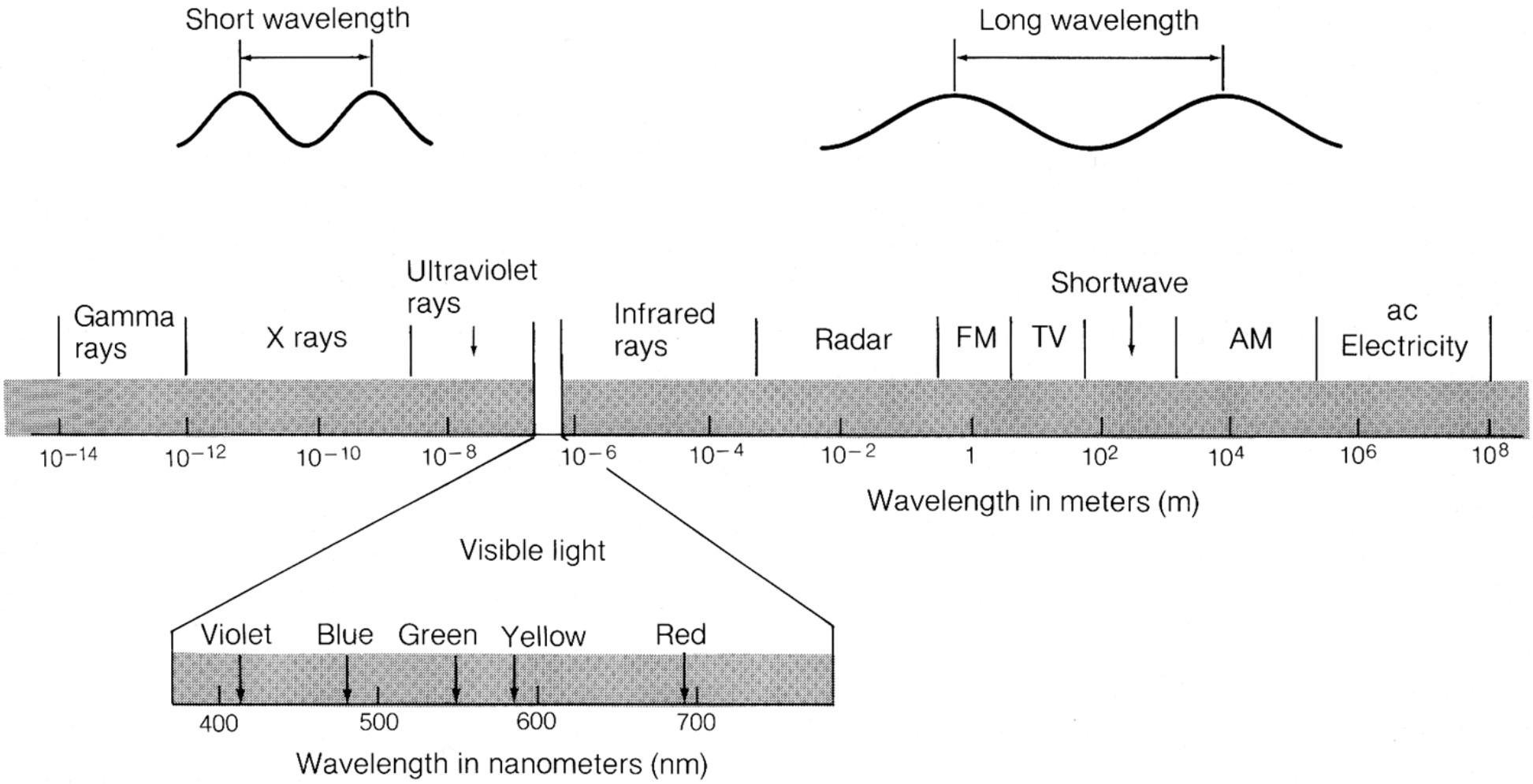
# Vision




Prof. Joseph Giacomin

**Light is a form of electromagnetic radiation which produces in humans the sensory response called vision.**

# Light

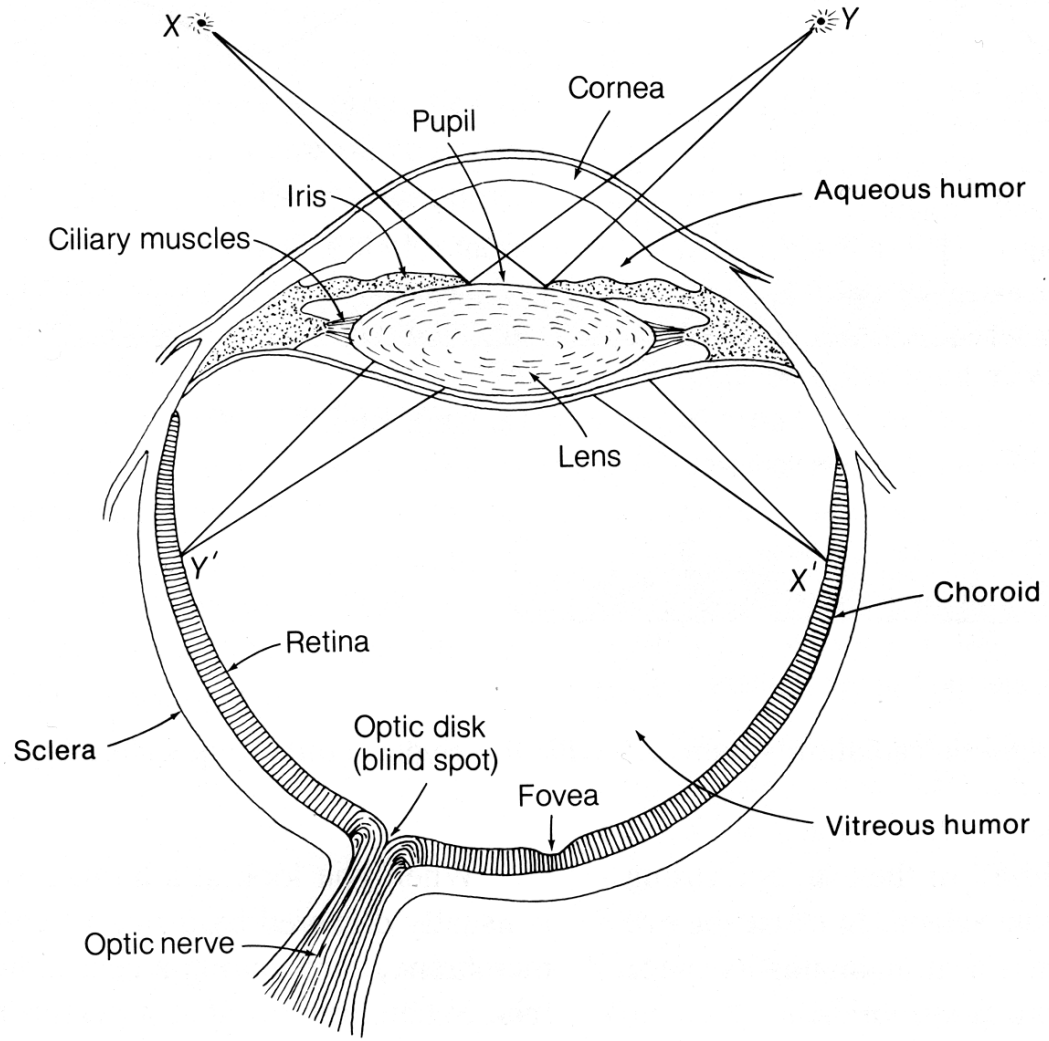



**The visible spectrum extends from violet at 400 nm to red at 700 nm.**

# The Eye

**The eyes are spherical structures of about 20-25 mm in diameter.**

**The outer covering, which is seen as the white of the eye, is a strong elastic membrane called the sclera.**

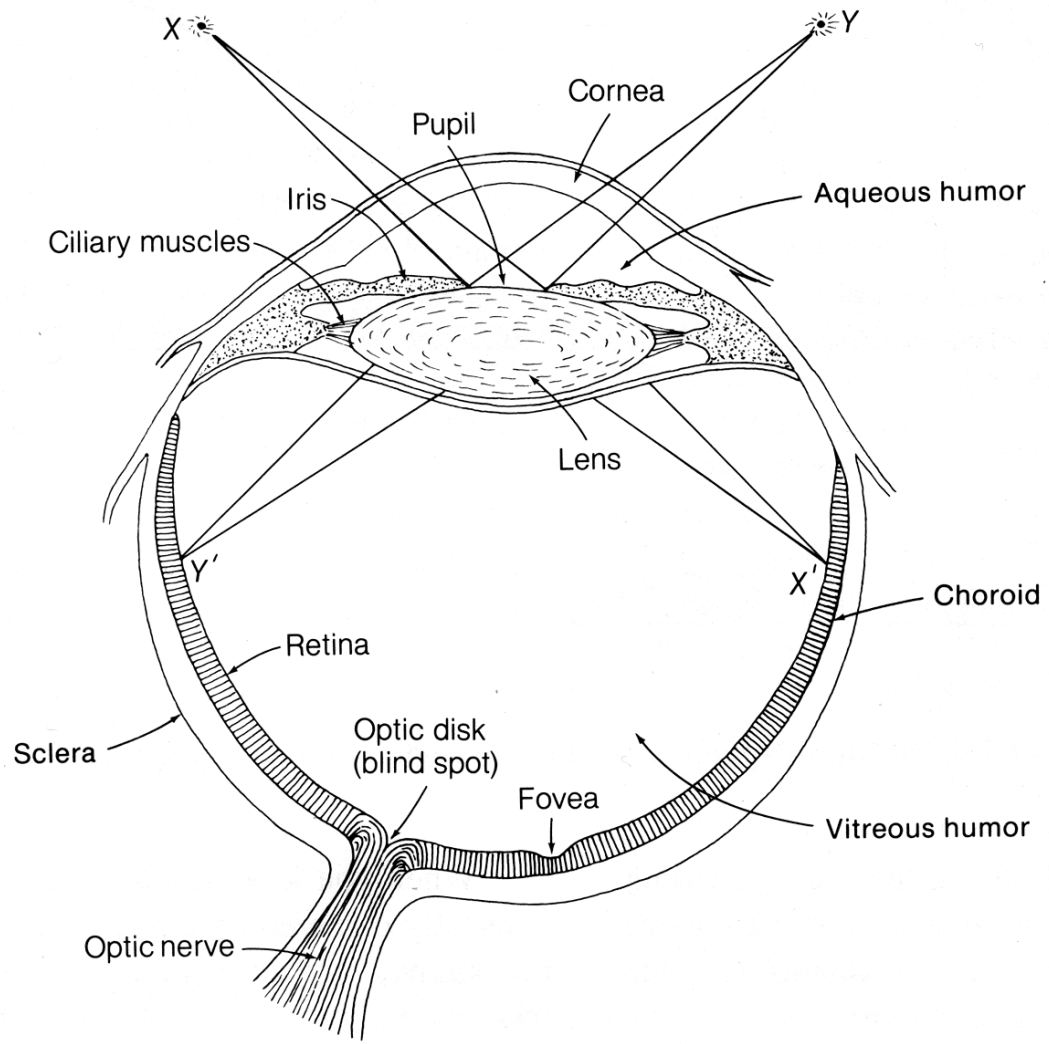



Human eye

# The Eye

**The front of the eye contains a region where the sclera bulges to form a clear domelike window of roughly 13 mm in diameter which is called the *cornea*.**

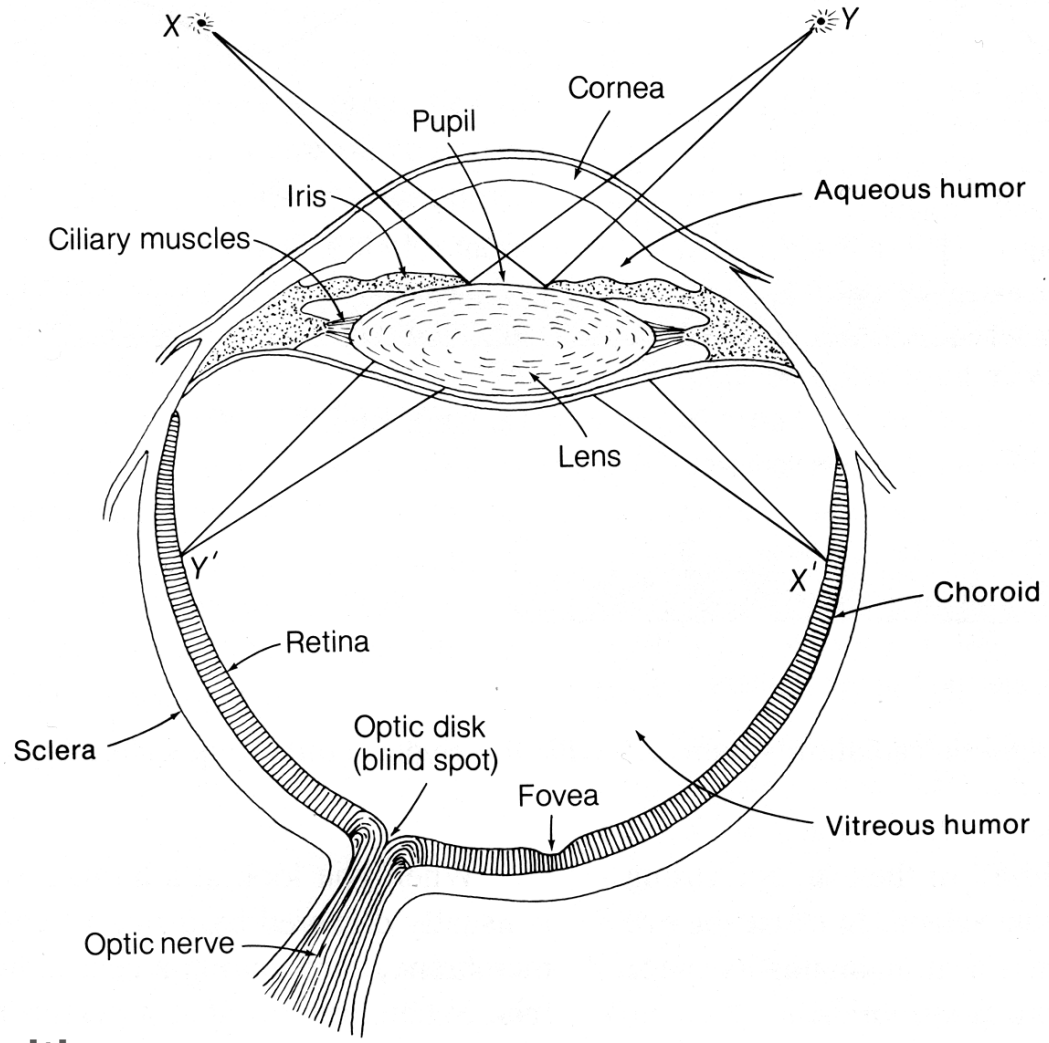
**The cornea acts as a simple fixed lens, gathering and focussing the light.**



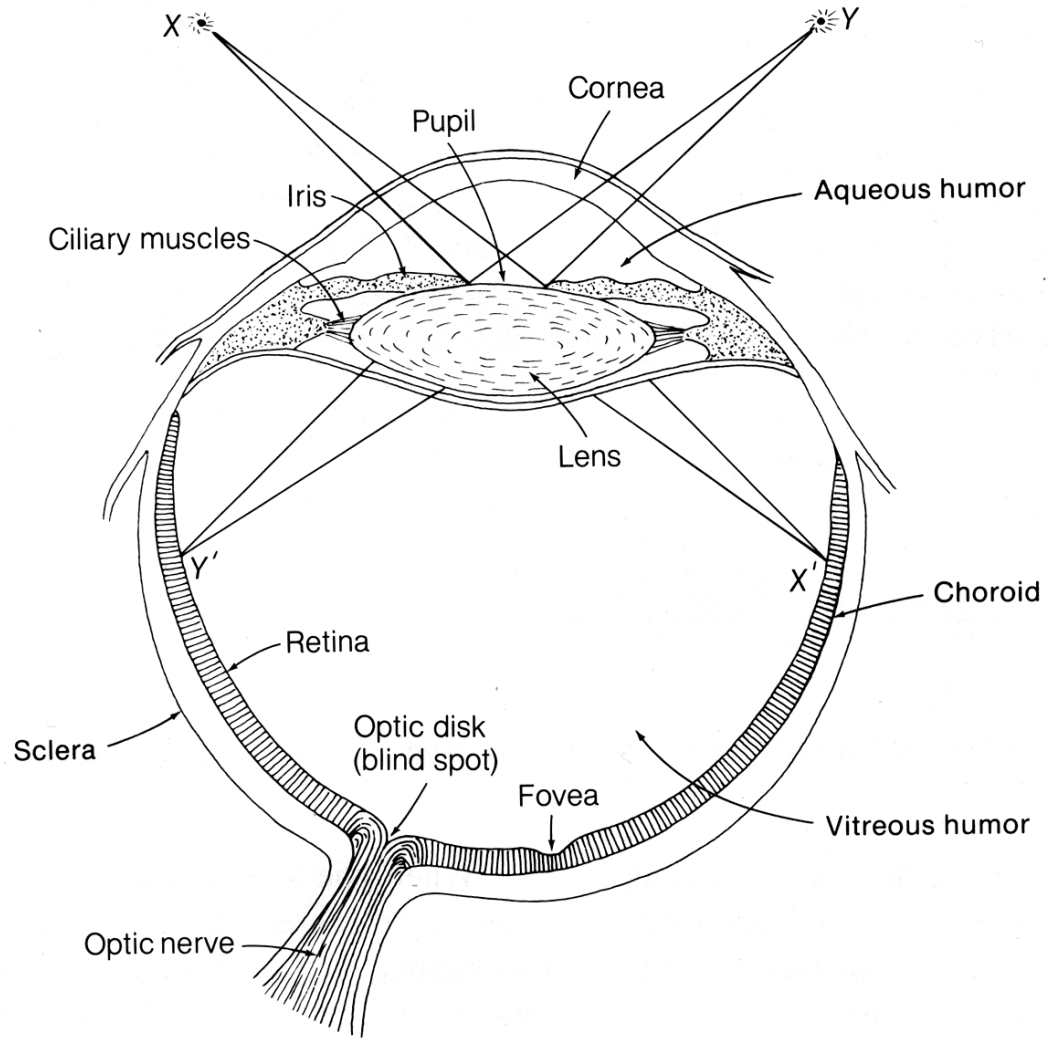

Human eye

# The Eye

**Behind the cornea is a chamber filled with a water-like fluid called the *acqueous humor*. The fluid is similar to the cerebrospinal fluid that bathes the inner cavities of the brain.**




Human eye

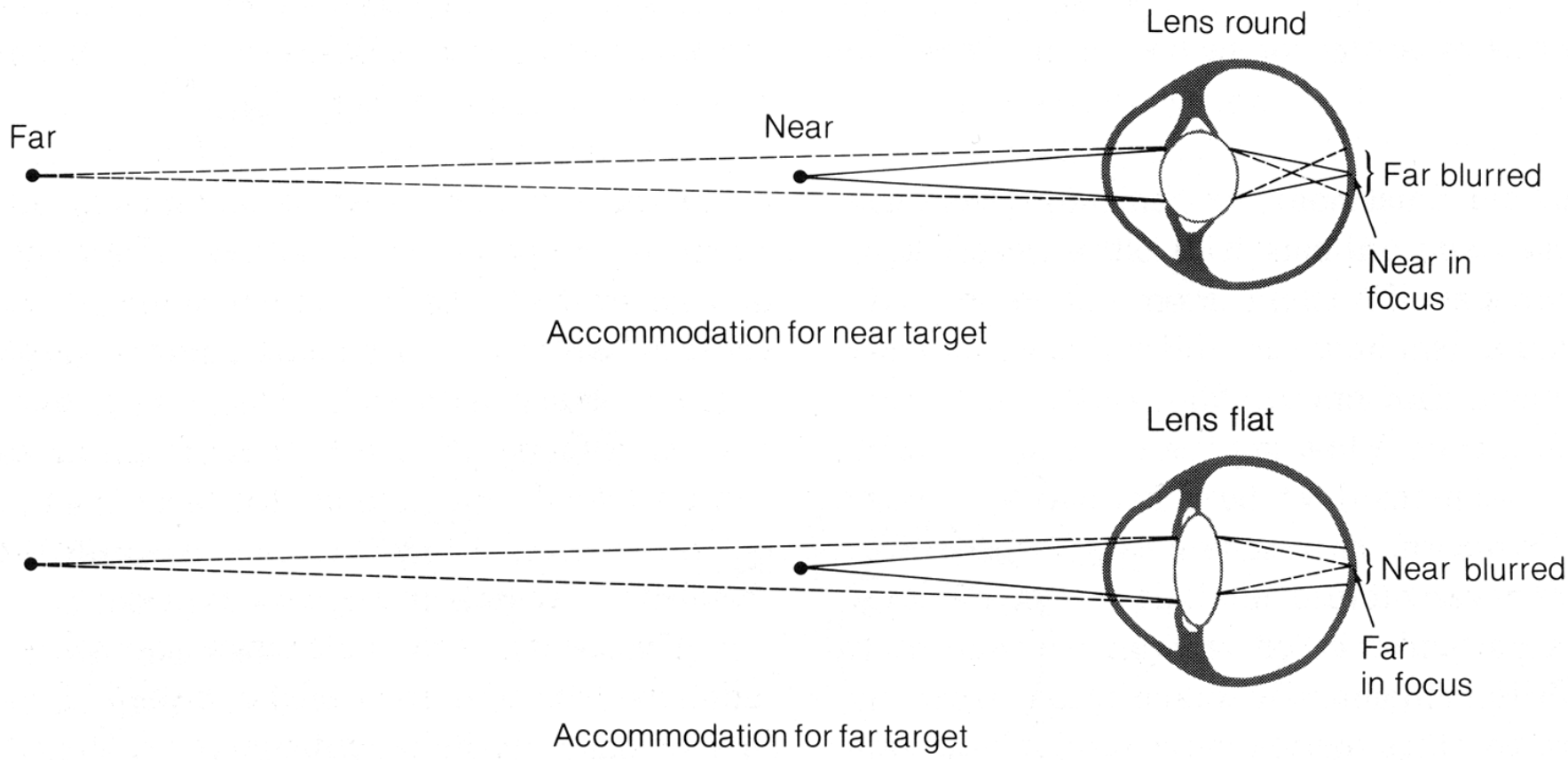



Human eye

# The Eye

**A coloured membrane called the *iris* surrounds the central hole called the pupil. In bright light the iris contracts until the pupil is as little as 2mm in diameter, while in dim light it will dilate to 8 mm. This is a sixteenfold change in the aperture area.**

# The Eye




**Directly behind the pupil is the lens which is the main focussing element of the eye.**

**Since a single fixed lens would not be able to focus on both near and far away objects, a process called *accommodation* varies the shape so as to change the focal length.**

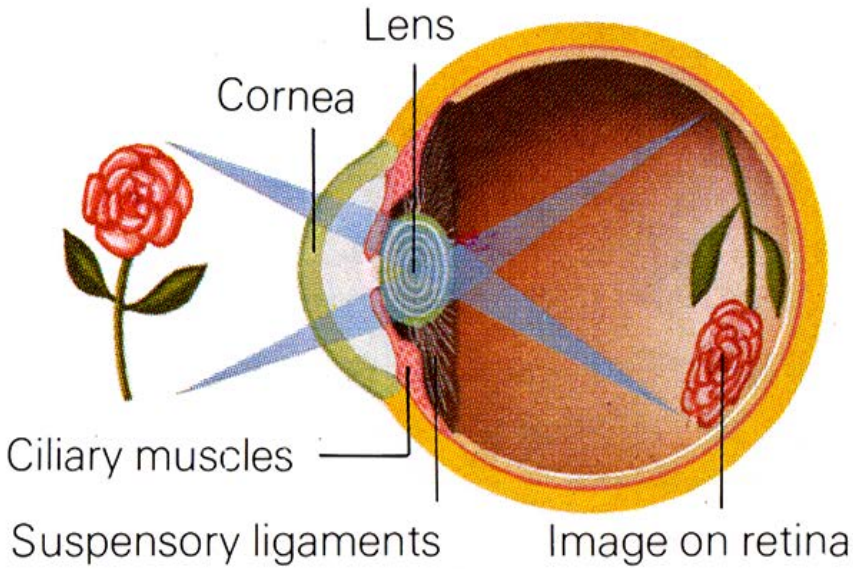
# The Eye

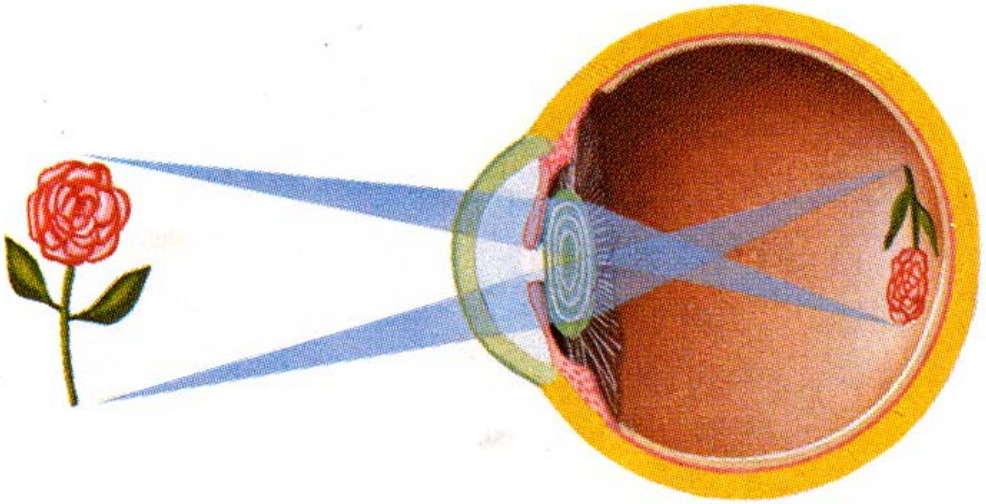
**The ability to focus changes over time.**

**From 16 years of age some cells of the of the lens die, making it less flexible.**

**The resulting condition is presbyopia, meaning old sightness. It consists of an increase in the minimum distance (the near point) at which an object can be held before becoming blurred.**

**The 10 cm near point of a 16 year old will gradually change until it reaches about 100 cm by age 60.**



# The Eye

**The human lens is not perfectly transparent. It is instead tinted yellow and the yellowness increases with age. Differences between people in what is to be considered blue or green are often due to the yellowing of the lens with age.**

**The example below illustrates how aging changes the transmission of light through the eye. Since the nervous system adapts to the changes the reduction in perceived luminance would be less than the pictures suggest. Nevertheless, the pictures provide a rough idea of the size of the changes.**

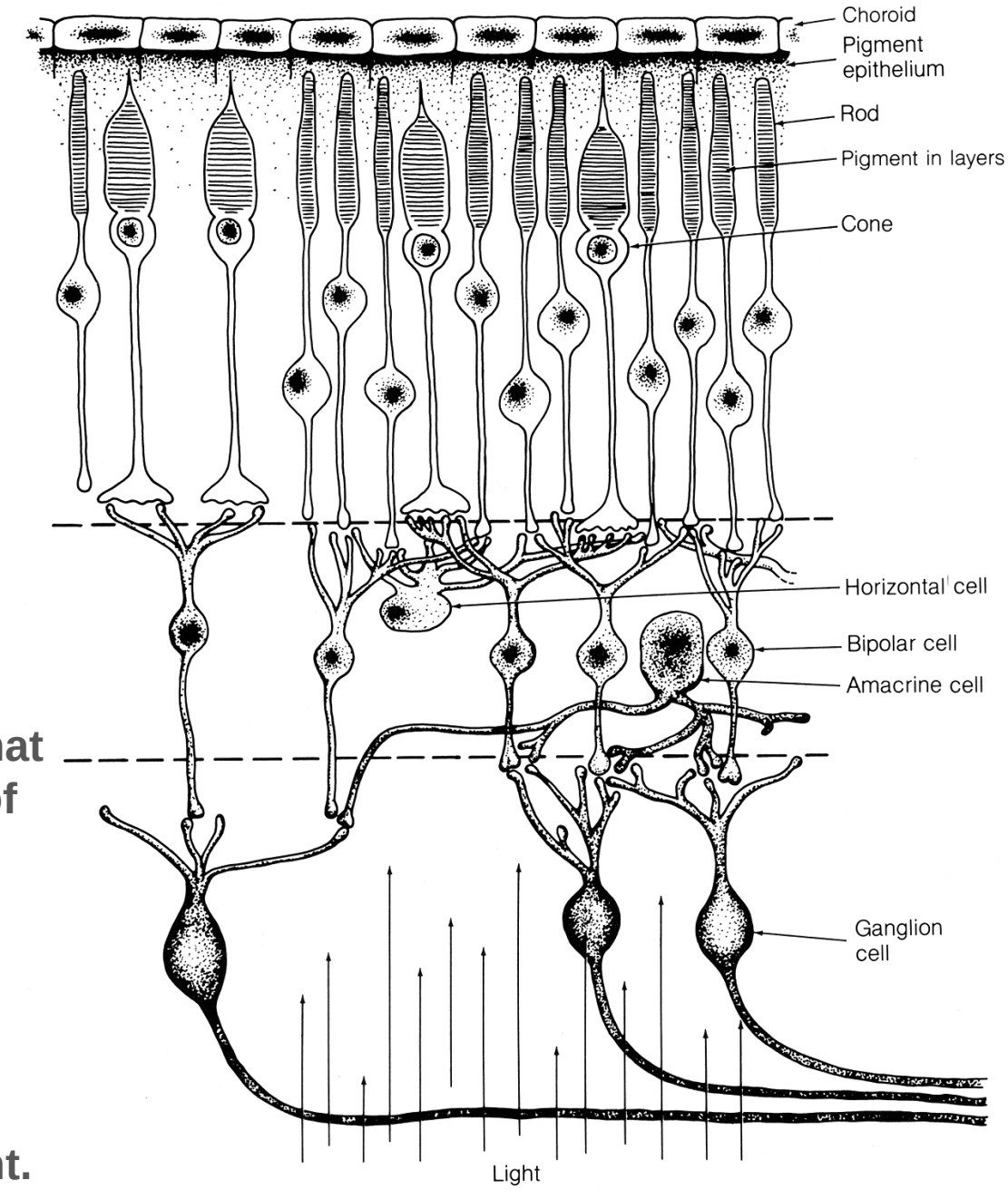


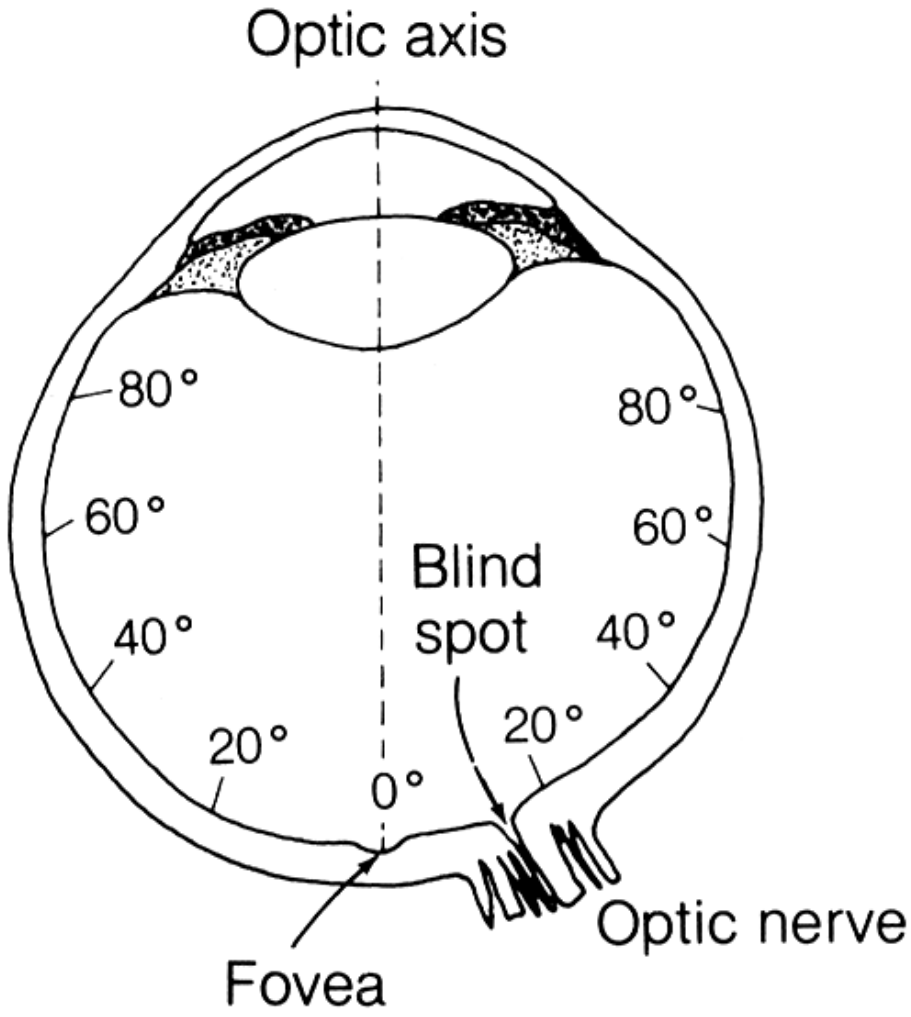
# The Eye

**The retina contains about 130 million photoreceptors, special nerve cells that convert light energy into the energy of electro-chemical signals.**

**Of these, about 120 million are *rods* which respond to low-intensity light and provide black-grey-white vision.**

**The remaining 10 million are *cones* which respond to coloured bright light.**

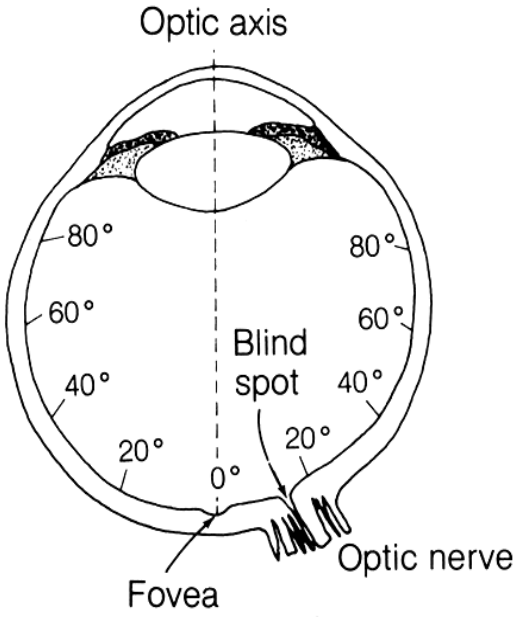


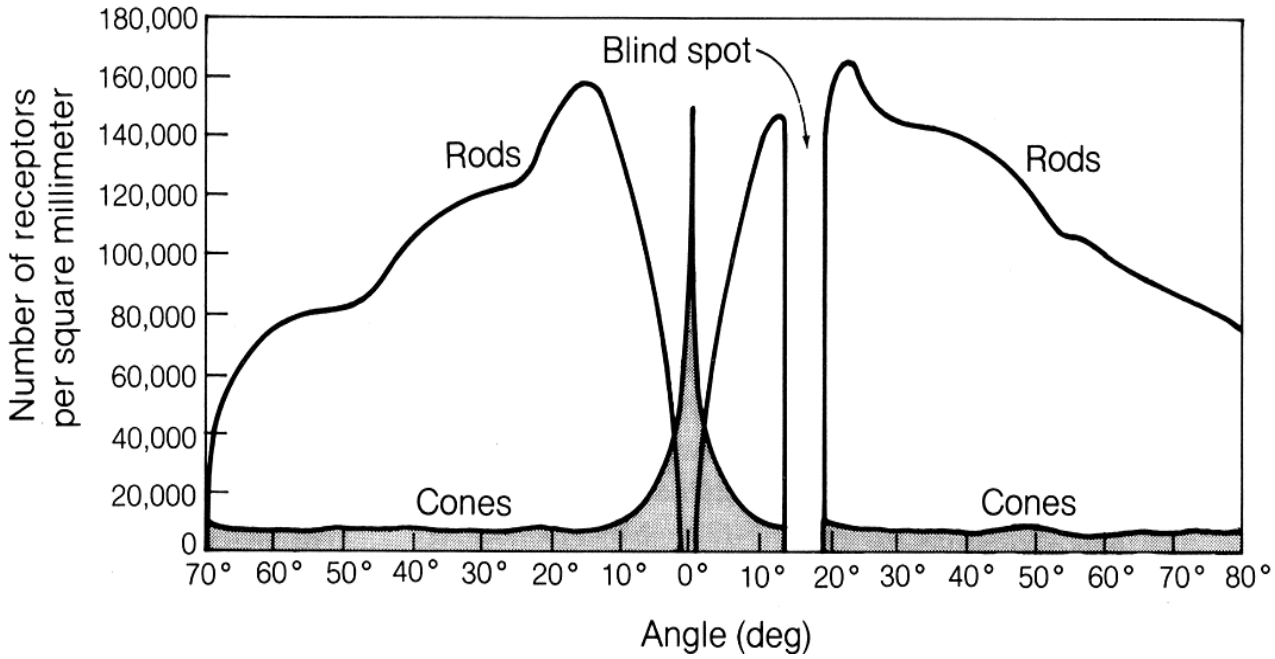



# The Eye

**The most important region of the retina is the *fovea* where the cone photoreceptors are located. It is the centre of colour processing.**

# The Eye

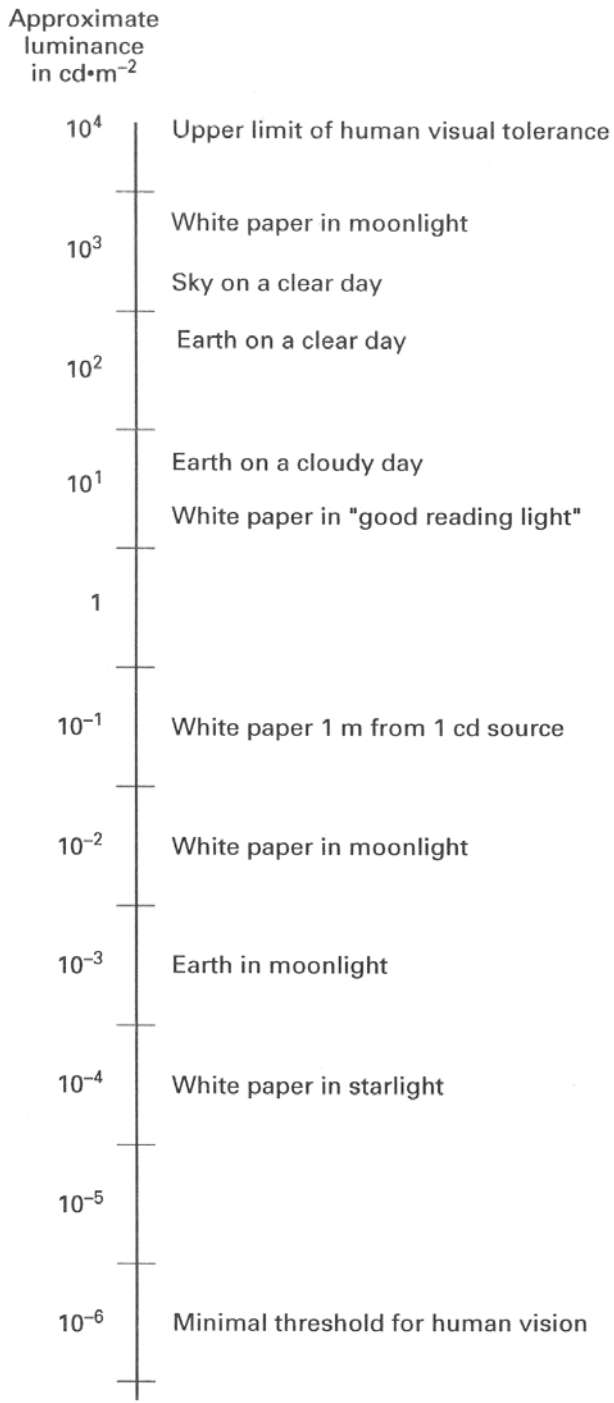



**In order to transmit the image signals out of the eye, the axons of the retinal cells gather together at a single hole in the retinal and scleral walls. The axon bundle is called the optic nerve, and the point at which it exits is called the *blind spot* since there can be no visual response at that point.**

# Vision

## Typical luminance levels experienced by humans



# Vision

**At illuminance values above 0.1 lux colour is perceived. Vision in these conditions is called *photopic* and is mostly by means of the cone photoreceptors.**

**For illuminances from 0.01 to 0.1 lux we see colour from brighter objects but only see shades of grey for the dimmer objects. This is called *mesotopic* vision.**

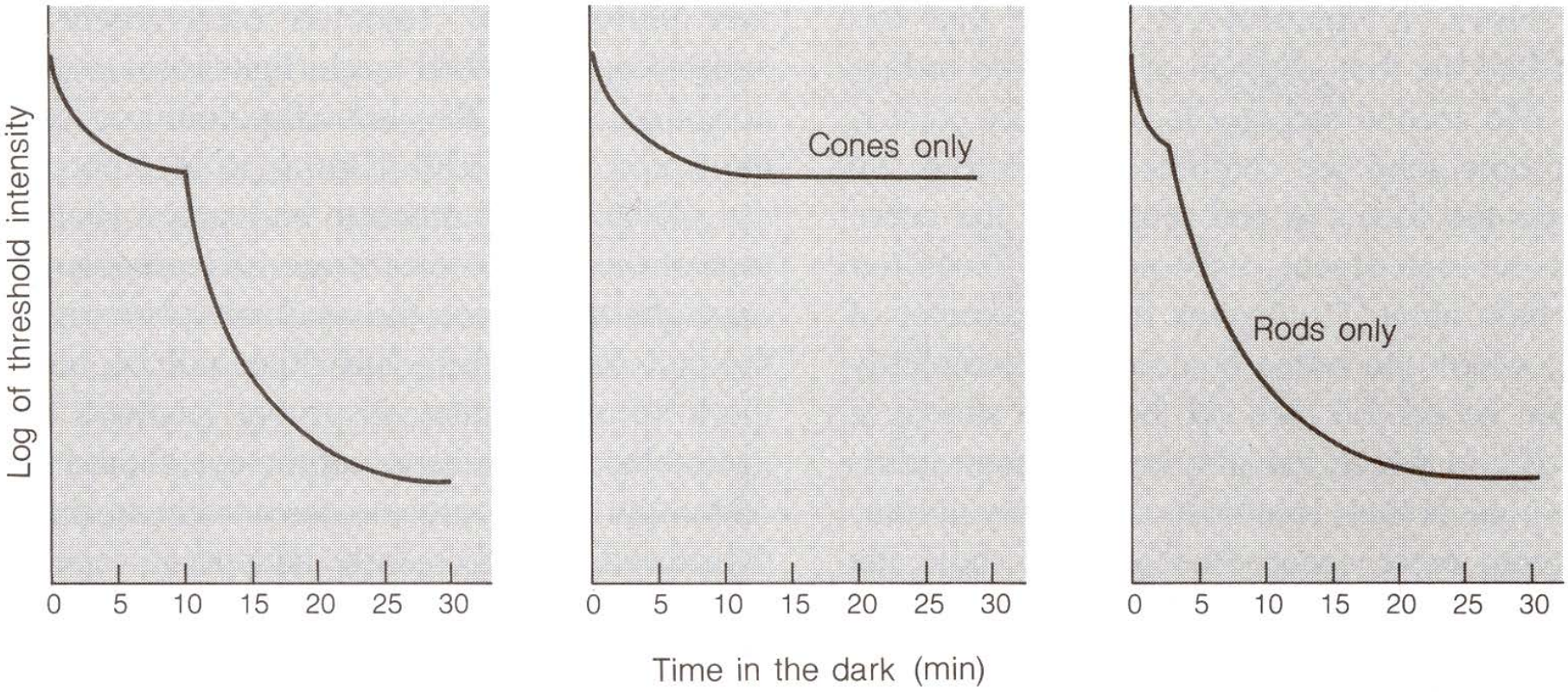
**In light below 0.01 lux only black, white and shades of grey are perceived. Such vision is called *scotopic* and is the work of the rod photoreceptors.**

# Vision

**Visual adaptation is the process by which the eye changes its sensitivity to deal with different intensities of illumination.**

**The process of adapting to a darker environment is called *dark adaptation* while that to a brighter environment is called *light adaptation*.**

# Dark Adaptation




**Adaptation from light to dark takes thirty minutes.**

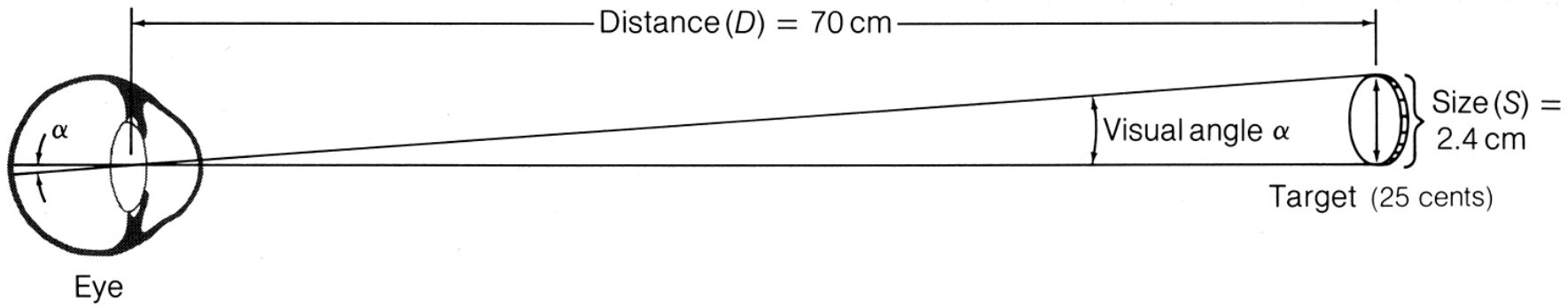
# Light Adaptation

**Adaptation to light is different from adaptation to darkness. Full adaptation to light is achieved within a few minutes.**

**Above 650 nm the spectral sensitivity of the cones is not very different during either dark or light conditions.**

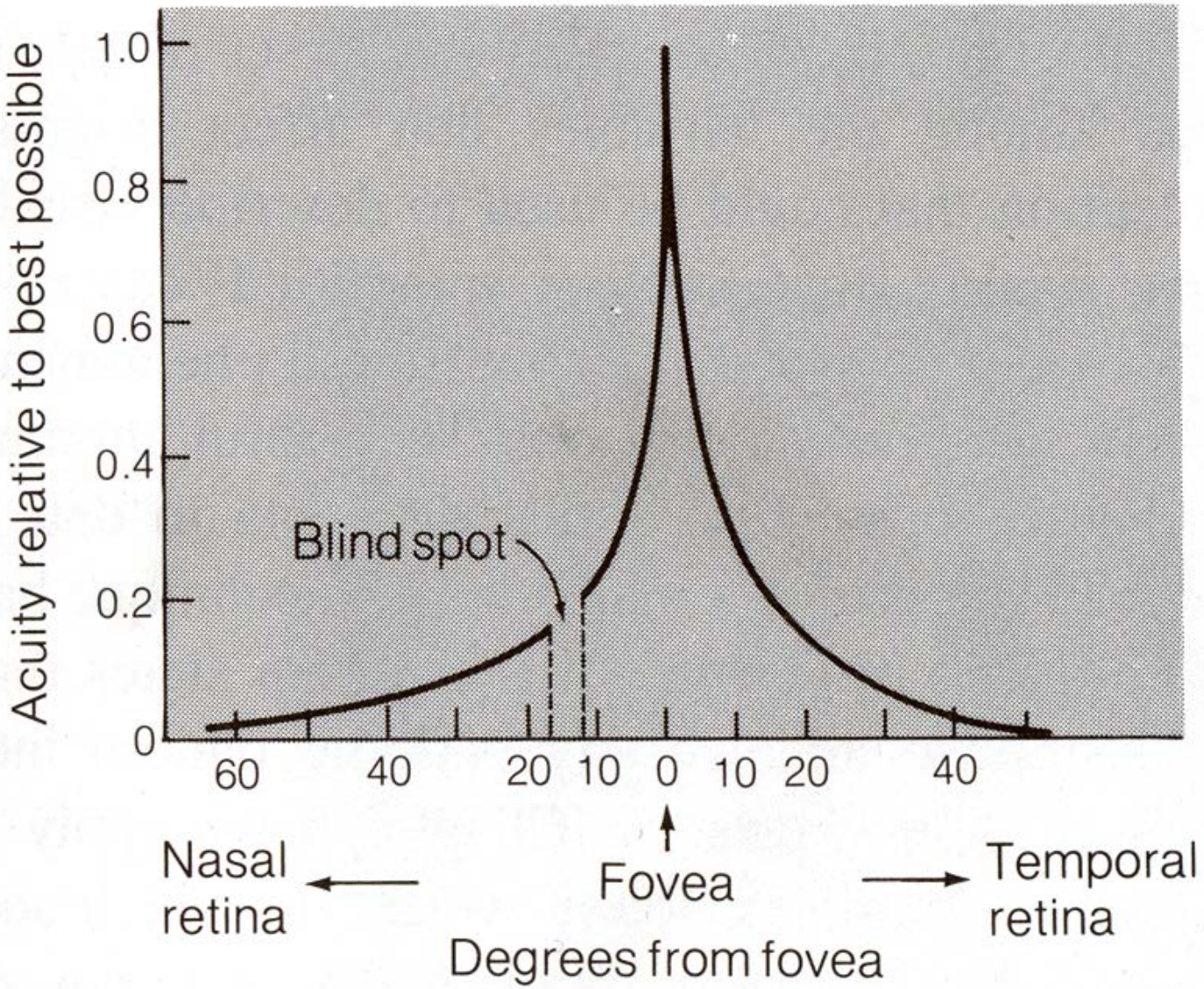
**Light adaptation therefore consists of lowering the intensity of colours below 650 nm from their night adapted state.**

# Visual Acuity



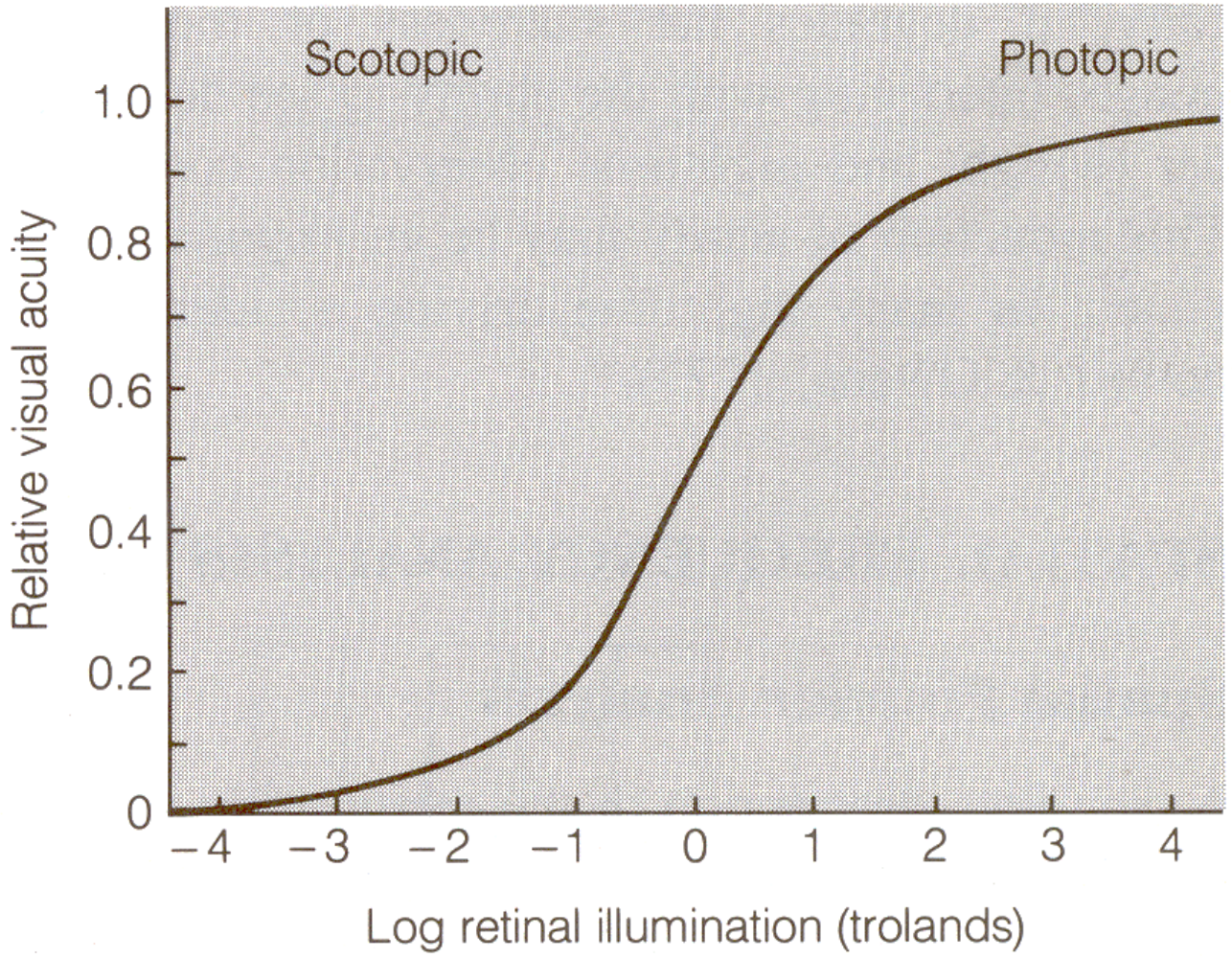

**A more general means of specifying visual acuity is by means of the minimum visual angle that can be resolved.**

**A normal observer can resolve details of 1 minute of arc, which is roughly the size of a coin at 80 meters distance.**




# Visual Acuity

**Visual acuity is not constant across the retina but is greatest in the fovea, thus acuity is greatest in the immediate direction of view.**




# Visual Acuity

**Visual acuity is closely related to the brightness of the object.**

**When illuminance is low (the scotopic range) the acuity is poor, and it improves only slightly with increasing intensity.**

**When the illumination shifts to the photopic range the acuity improves rapidly.**

# Design Classic: Times New Roman Font

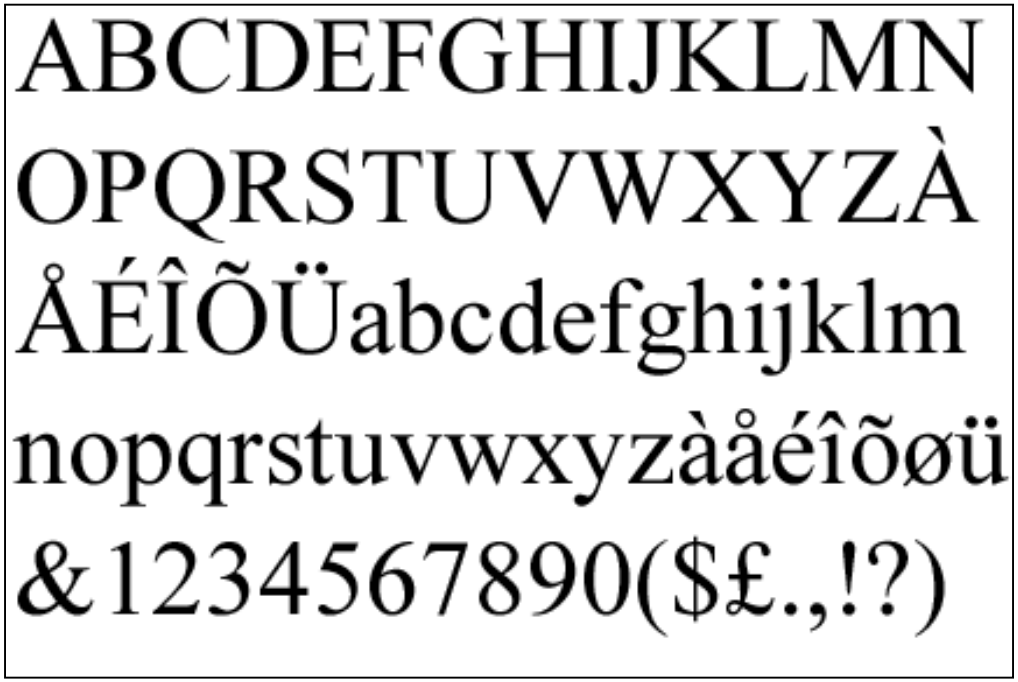
The font was created in 1931 by Victor Lardent of Monotype for *The Times.*

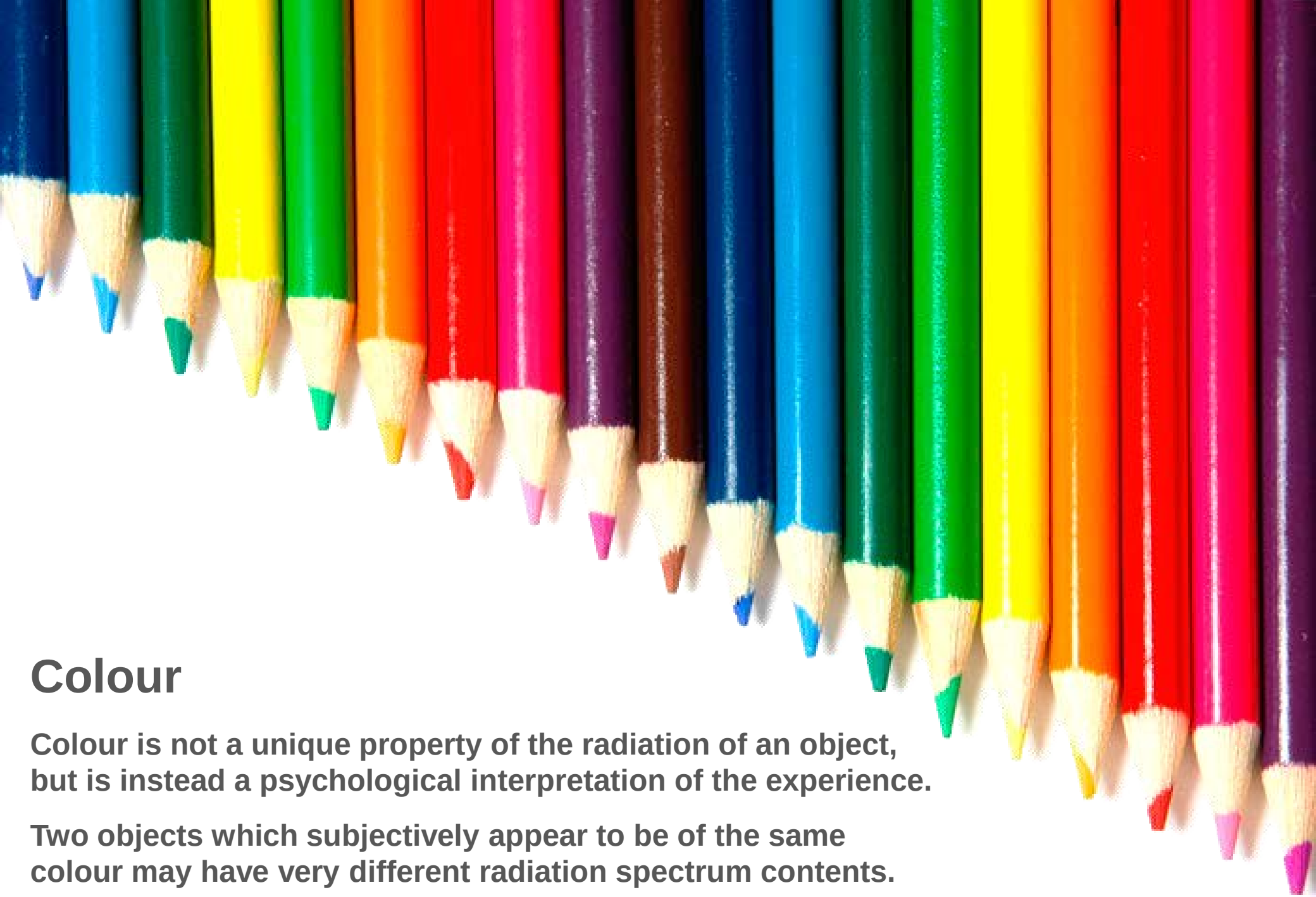
It was commissioned because the British newspaper had been criticised for being typographically antiquated and badly printed.

An older serif-based font called Plantin was used as the basis, but revisions were made for legibility and economy of space.

The new typeface made its debut in the October 3rd 1932 issue and was released for commercial sale after one year.

The newspaper continued with the font for 40 years but switched in 1972 to address changes in format. Nevertheless, all the new fonts used since 1972 are variants of the original.

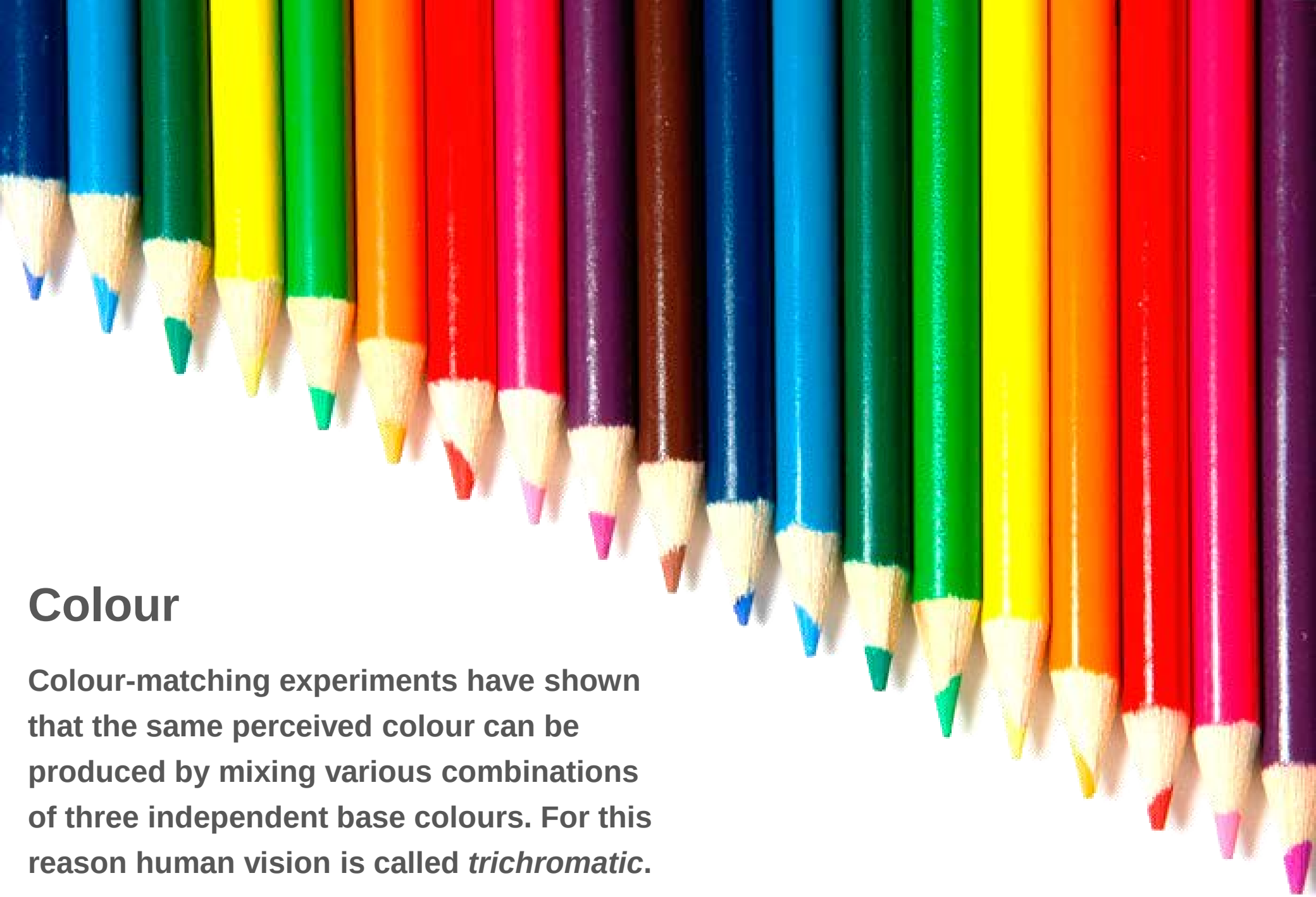




# Colour

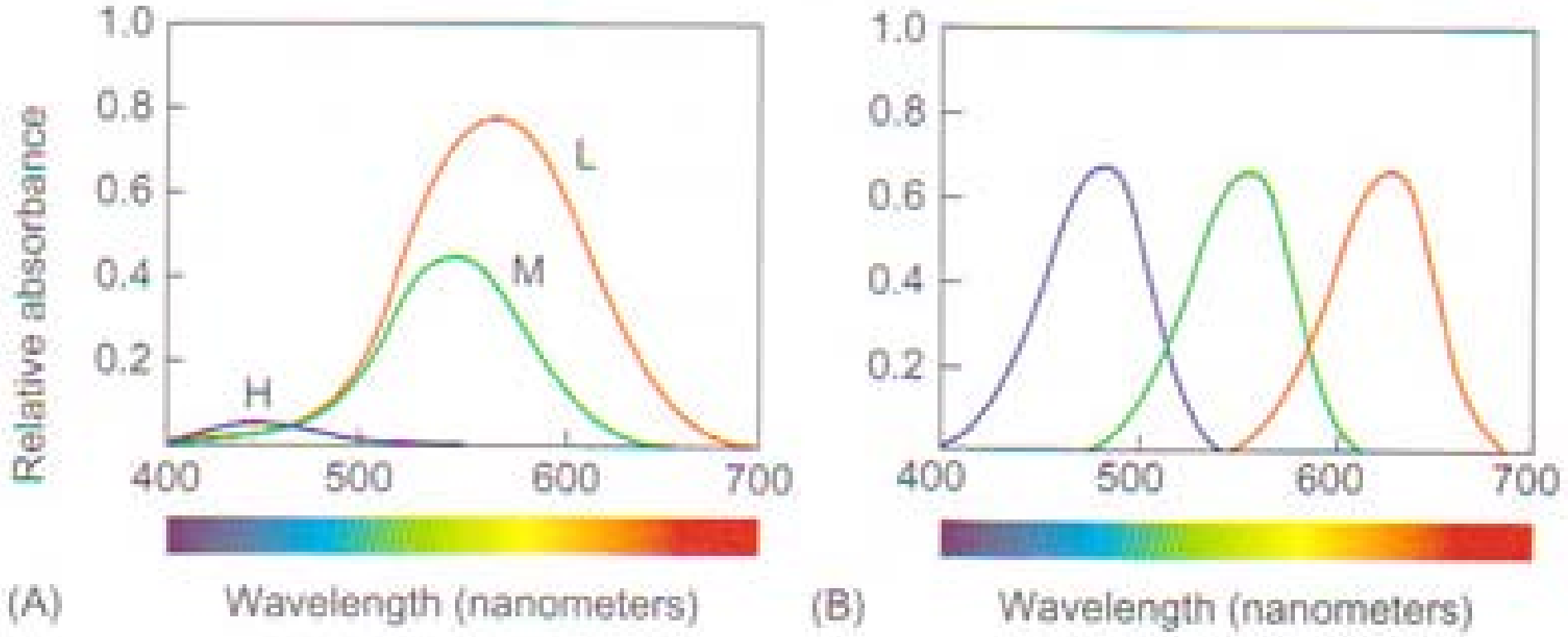
**Colour is not a unique property of the radiation of an object, but is instead a psychological interpretation of the experience.**

**Two objects which subjectively appear to be of the same colour may have very different radiation spectrum contents.**



# Colour

**Colour-matching experiments have shown that the same perceived colour can be produced by mixing various combinations of three independent base colours. For this reason human vision is called *trichromatic*.**




# Colour

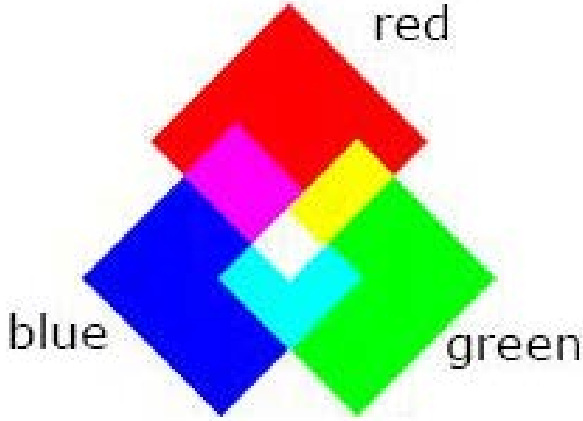
**The three forms of cone photoreceptor (A) have responses which span the frequency spectrum. While not equally spaced like the colours of a camera or a television (B), the brain is nevertheless able to separate light into different frequencies and interpret the result as a single colour.**

# Colour

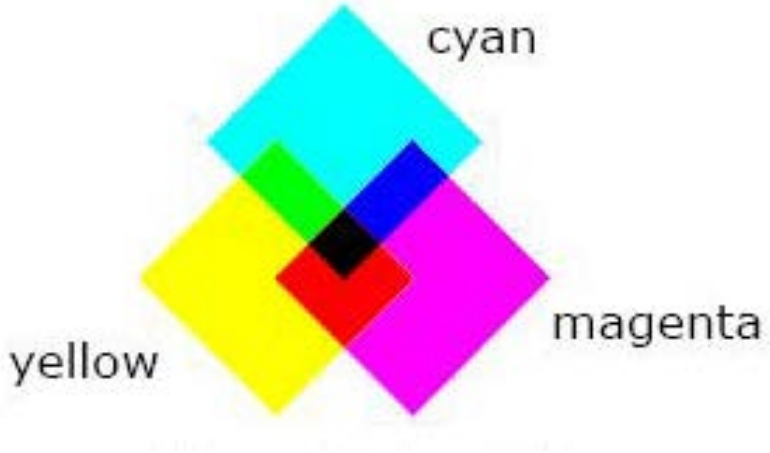
There are two ways to think about light mixtures.

One way is to consider what colours can be added together to produce a desired colour of light beam, as in the case of a computer screen. This approach is referred to as "*additive colour*".

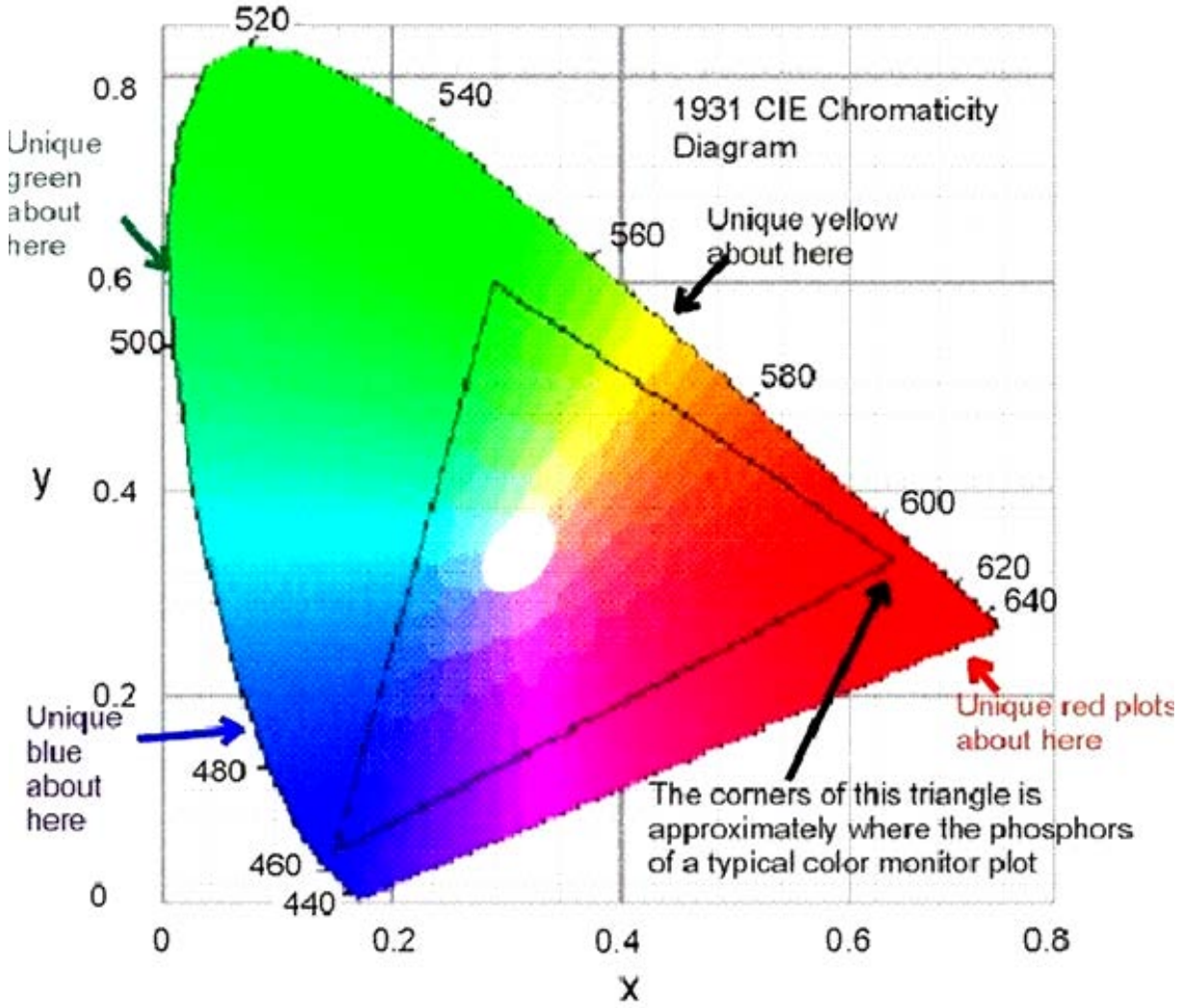
A second way is to consider what colours of paint or ink or dye or pigment can be added together to achieve the desired colour of light which is reflected from the surface. This approach is referred to as "*subtractive colour*".




RGB Model

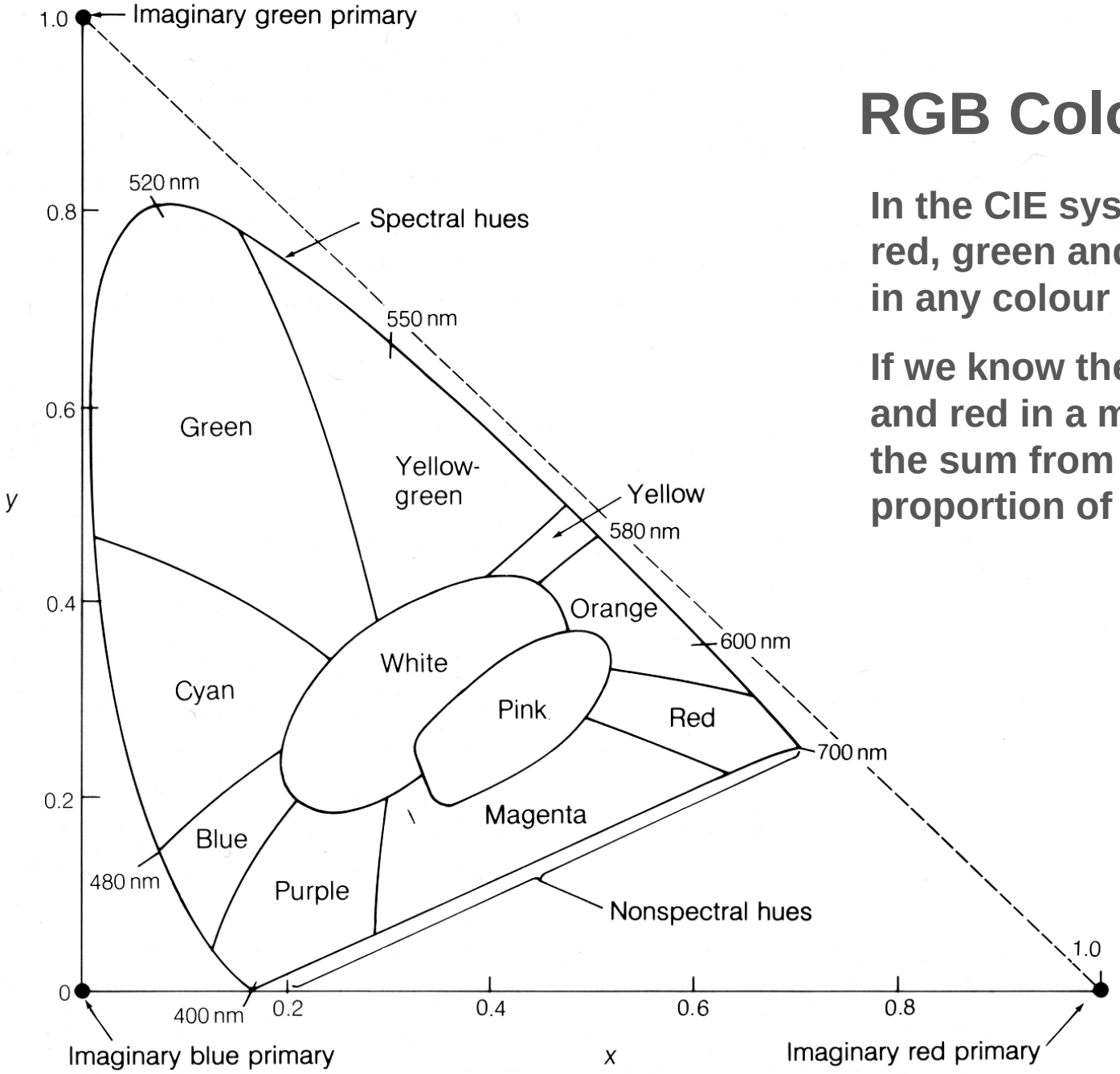



CMYK Model




# RGB Colour

**In 1931 the *Commission Internationale de l'Eclairage (CIE)* standardised a procedure for specifying additive colour. They used a colour space defined by the mixing of the three primaries of red, blue and green.**




# RGB Colour

**In the CIE system the proportions of red, green and blue must sum to 1.0 in any colour mixture.**

**If we know the proportions of green and red in a mixture we can subtract the sum from 1.0 to determine the proportion of blue.**

# CMYK Colour

CMYK colour printing refers to the four inks which are used: cyan, magenta, yellow, and key (black).

Ink is usually applied in the order of the abbreviation with each successive layer increasing the masking of the lighter, usually white, paper on which the ink is deposited.

The colour model is subtractive because the ink layers "subtract" brightness from the paper.




# CMYK Colour

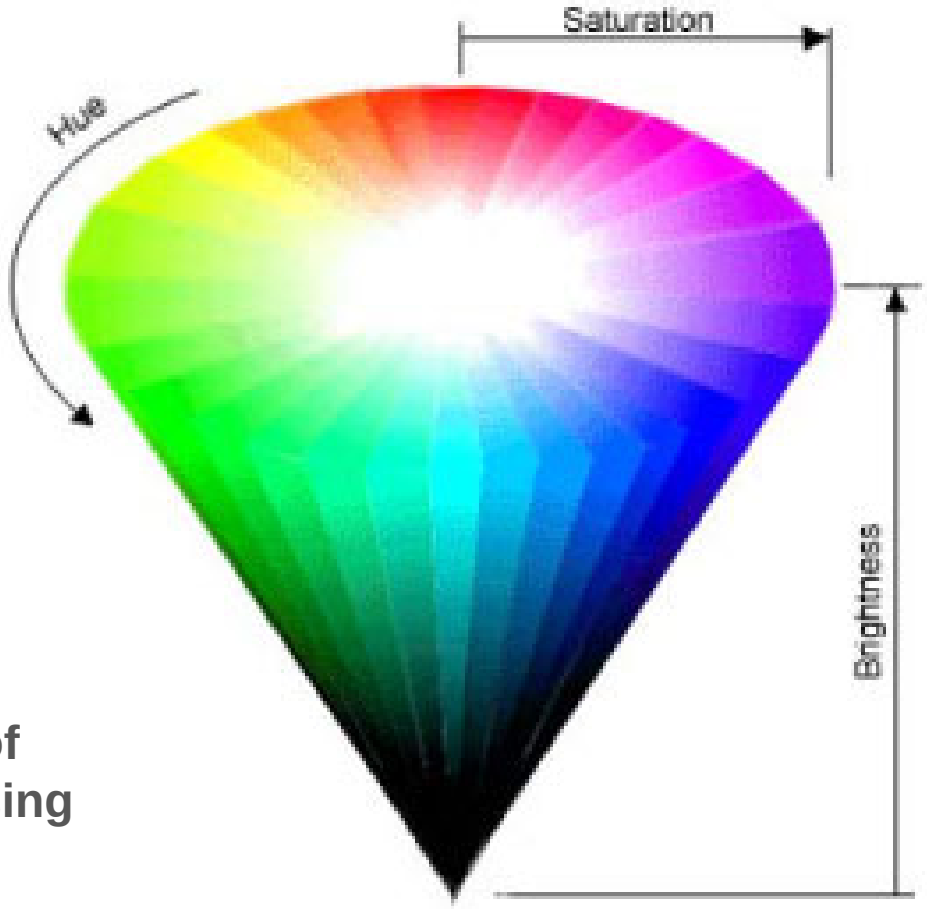
Guidelines and standards relative to CMYK printing are available from several international organisations:

ISO (International Organization for Standardization)

IDEAlliance (International Digital Enterprise Alliance)

GRACoL (General Requirements for Applications in Commercial Offset Lithography)

SWOP (Specifications for Web Offset Publications)



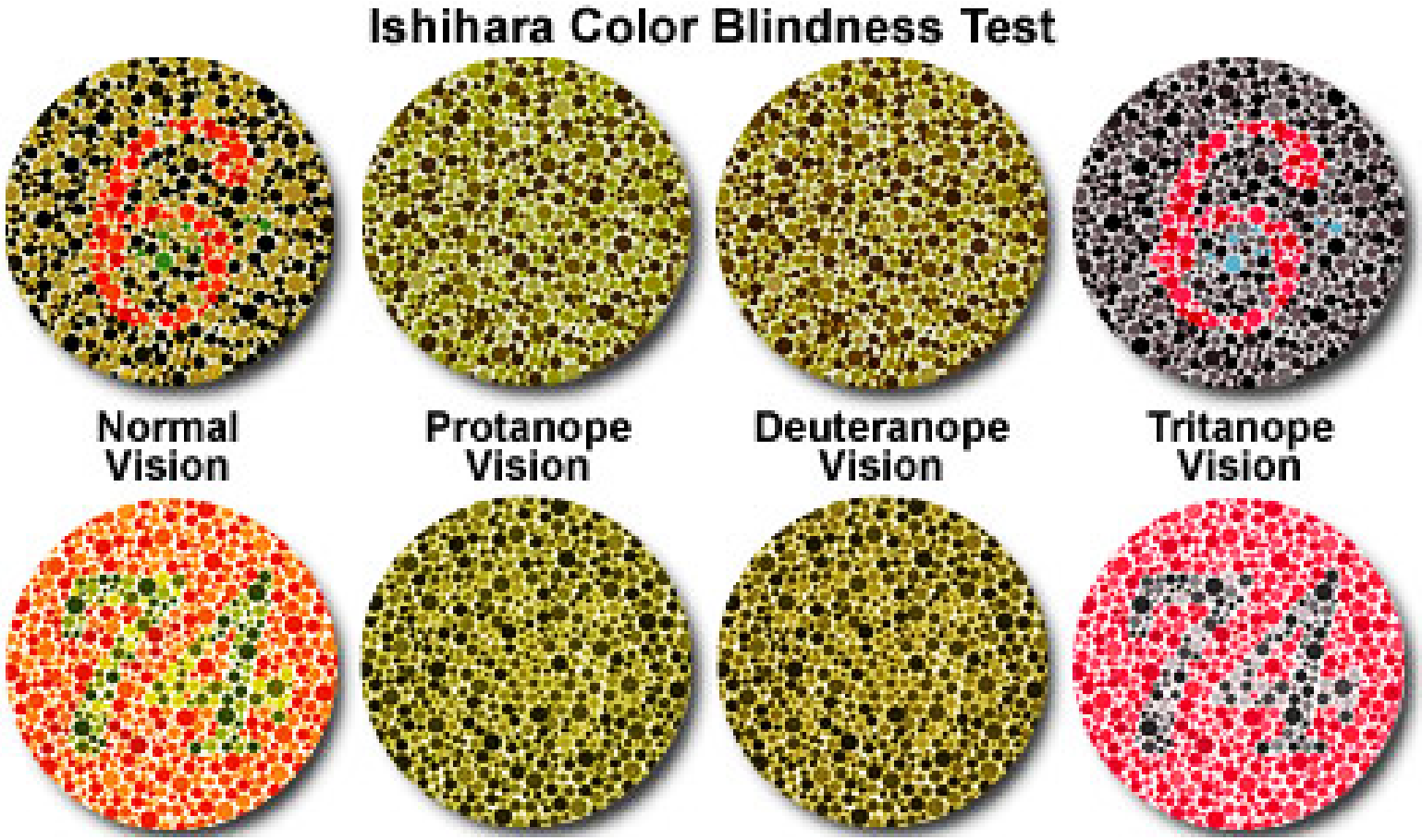

# Colour Properties

**Whether adopting an RGB or CMYK point of view, commercial systems define colour using values for hue, saturation and brightness.**

**Hue:** the common name of the colour which indicates its position in the colour spectrum.

**Saturation:** the intensity, strength, purity or chroma of the colour.

**Brightness:** the relative degree of lightness or darkness which captures its reflective quality.




# Colour Vision

**Many people have problems discriminating colours. For example, there are three forms *of dichromacy*, depending on whether it is the red, blue or green responding cones which are inoperative. Such colour defects are genetically transmitted.**

**Just over 8% of all males show colour weaknesses whereas slightly less than 0.05 percent of all females show similar defects.**



# Subjective Response to Colour

**While the colour of light can be precisely defined physically, the perception, interpretation and reaction to it is highly individual and variable.**

**Colours such as reds, oranges and yellows are usually considered “warm” and “stimulating”.**

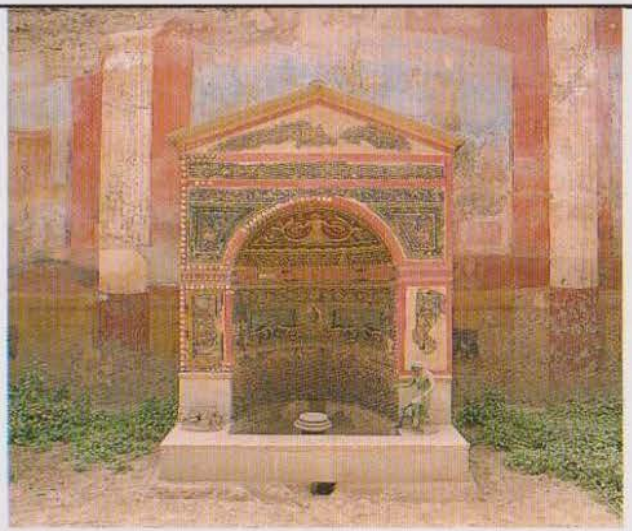
**Violets, blues and greens are usually considered to generate sensations of “calm” and “restfulness”.**

**Weak colours are usually considered to be more distant than intense colours.**


| | |
|---|---|
| A | Western / American |
| B | Japanese |
| C | Hindu |
| D | Native American |
| E | Chinese |
| F | Asian |
| G | Eastern European |
| H | Muslim |
| I | African |
| J | South American |

| | |
|---|---|
| 1 | Anger |
| 2 | Art / Creativity |
| 3 | Authority |
| 4 | Bad Luck |
| 5 | Balance |
| 6 | Beauty |
| 7 | Calm |
| 8 | Celebration |
| 9 | Children |
| 10 | Cold |
| 11 | Compassion |
| 12 | Courage |
| 13 | Cowardice |
| 14 | Cruelty |
| 15 | Danger |
| 16 | Death |
| 17 | Decadence |
| 18 | Deceit |
| 19 | Desire |
| 20 | Earthy |
| 21 | Energy |
| 22 | Erotic |
| 23 | Eternity |
| 24 | Evil |
| 25 | Excitement |
| 26 | Family |
| 27 | Femininity |
| 28 | Fertility |
| 29 | Flamboyance |
| 30 | Freedom |
| 31 | Friendly |
| 32 | Fun |
| 33 | God |
| 34 | Gods |
| 35 | Good Luck |
| 36 | Gratitude |
| 37 | Growth |
| 38 | Happiness |
| 39 | Healing |
| 40 | Healthy |
| 41 | Heat |
| 42 | Heaven |
| 43 | Holiness |
| 44 | Illness |
| 45 | Insight |
| 46 | Intelligence |
| 47 | Intuition |
| 48 | Religion |
| 49 | Jealousy |
| 50 | Joy |
| 51 | Learning |
| 52 | Life |
| 53 | Love |
| 54 | Loyalty |
| 55 | Luxury |
| 56 | Marriage |
| 57 | Modesty |
| 58 | Money |
| 59 | Mourning |
| 60 | Mystery |
| 61 | Nature |
| 62 | Passion |
| 63 | Peace |
| 64 | Penance |
| 65 | Power |
| 66 | Personal power |
| 67 | Purity |
| 68 | Radicalism |
| 69 | Rational |
| 70 | Reliable |
| 71 | Repels Evil |
| 72 | Respect |
| 73 | Royalty |
| 74 | Self-cultivation |
| 75 | Strength |
| 76 | Style |
| 77 | Success |
| 78 | Trouble |
| 79 | Truce |
| 80 | Trust |
| 81 | Unhappiness |
| 82 | Virtue |
| 83 | Warmth |
| 84 | Wisdom |

# 1/2 Italy



Italy has a fine cultural heritage, from ancient Rome through to the Renaissance. It is a major Catholic nation and the streets are dotted with churches, art galleries, and museums. There are many experiences to be had, such as a multitude of colors and a balance between light and dark derived from the various climates and Italian cuisine. We can glimpse this influence today in the mature Italian designs.

*Colors preserved in the ruins of Pompeii. The ancient city of Pompeii, buried by a volcanic eruption, provides a clue to understanding the culture.*

**19 Chianti** C20 / M100 / Y85 / K55

**[Italian] A strong, deep red, like the Italian wine Chianti.**

Delicious
Fulfilling
Ripeness
Opulent
Full-bodied

Chianti wine is made from red grapes grown in the outskirts of the Italian city of Florence. Although the red variety is more popular, white Chianti is also available. The bottle design is also interesting, with its base wrapped in straw.

**20 Sorrento Gold** C0 / M40 / Y100 / K0

**A strong orange yellow, reminiscent of the town of Sorrento.**

Emotional
Hot
Cheerful
Vigorous
Jolly

The town of Sorrento, known to us through the Napolese folk song *Return to Sorrento*, is perched on the cliff top overlooking the Bay of Naples. This port town is enveloped in a happy atmosphere, as the sun shines down on the many orange and lemon trees.

The Sistine Chapel is well known for Michelangelo's spiritual work *The Last Supper*. This color conveys the sublime atmosphere of the Chapel.

C40 / M40 / Y23 / K0 **Sistine Mauve 22**

**A pale purple, reminiscent of the Sistine Chapel.**

Mystic
Secret
Sublime
Noble
Sophisticated

Milan, the economic center of Italy, also commands international attention for its fashion. Modern office buildings and gothic domes live side by side. In winter the famous Milan fog rolls in, adding to the chic coloring.

C90 / M80 / Y35 / K5 **Milanese Blue 23**

**A subdued, chic blue which conjures up images of Milan in the north of Italy.**

Intelligence
Steady
Noble
Talented
Subdued

Florence, the birthplace of the Renaissance, is an international cultural holy-land, where great artists such as da Vinci and Michelangelo were born.

C80 / M30 / Y35 / K7 **Florence Blue 24**

**A subdued blue-green, reminiscent of Florence.**

Stylish
Chic
Classical
Tasteful
Melancholic

A beautiful blue that praises the Medici family for their support of so many scholars and artists during the splendor of Florence in the prosperous Renaissance period.

C90 / M25 / Y10 / K0 **Medici Blue 25**

**A bright blue, that is the image of the Medici family.**

Valuable
Clever
Supremely Beautiful
Robust
Limpid

# Subjective Response to Colour

**The "COLORSCAPE" guide contains 658 colours which are grouped into 56 themes. Each table entry includes the printed colour, the CMYK and Munsell values, an official name, a historical description and keywords which describe the subjective reaction.**


# Subjective Response to Colour

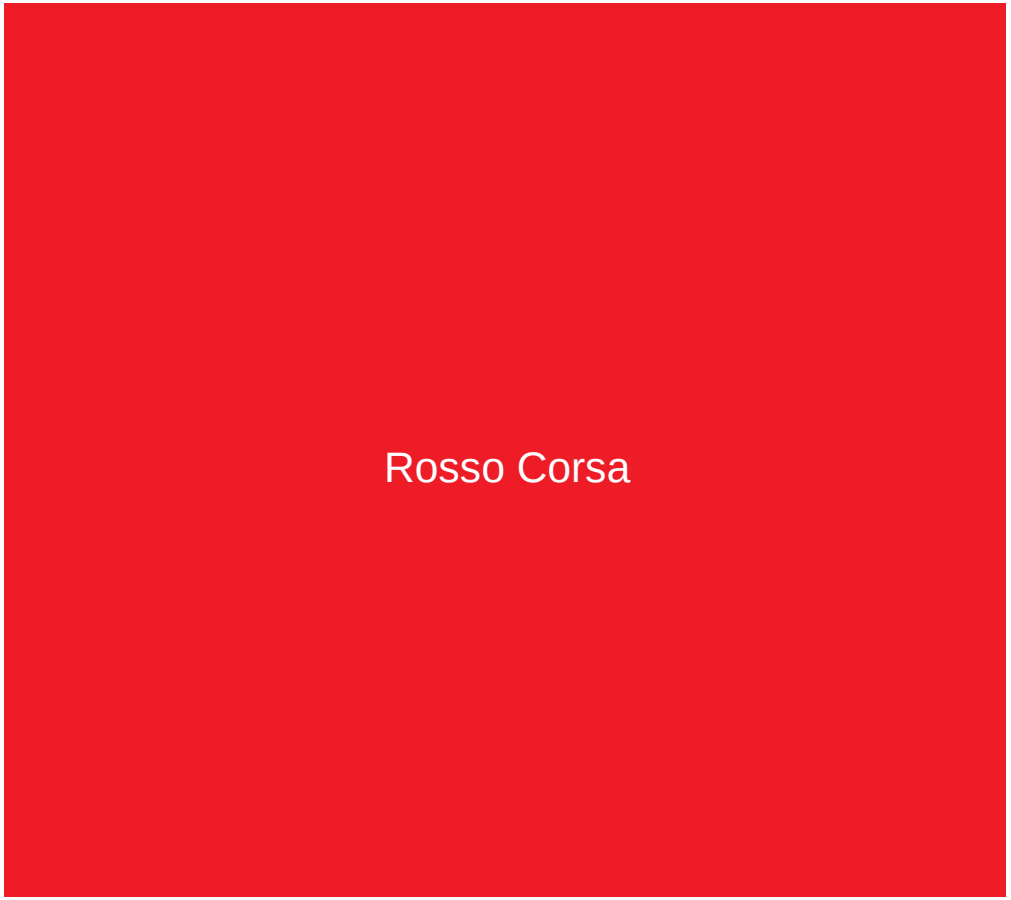
**According to the Web Online Analytics company KISSMETRICS the choice of colour has a large effect on customer purchasing behaviour. 85% of shoppers cite colour as the primary reason why they buy a product while 52% don't return to a website due to its aesthetics.**

# Design Classic: Ferrari Rosso Corsa

From the 1920s the racing cars of Alfa Romeo, Maserati and later Ferrari and Abarth were painted in “Rosso Corsa”. This was the assigned national racing colour of Italy. According to the rules the French cars were blue, the German cars were white (from 1934 also sheet metal silver) and the British cars were green.

In 1968 the national colours were replaced in F1 by commercial sponsor liveries, but unlike most other teams Ferrari maintained its traditional red.

From 1996 Ferrari F1 cars were painted a brighter red to adjust for the colour balance on television. The darker, more crimson, shade returned at the 2007 Monaco Grand Prix possibly due to the increasing market penetration of HDTV.



# Design Classic: Miss Sissi Lamp

The Miss Sissi table lamp was designed for Flos in 1991 by Philippe Starck.

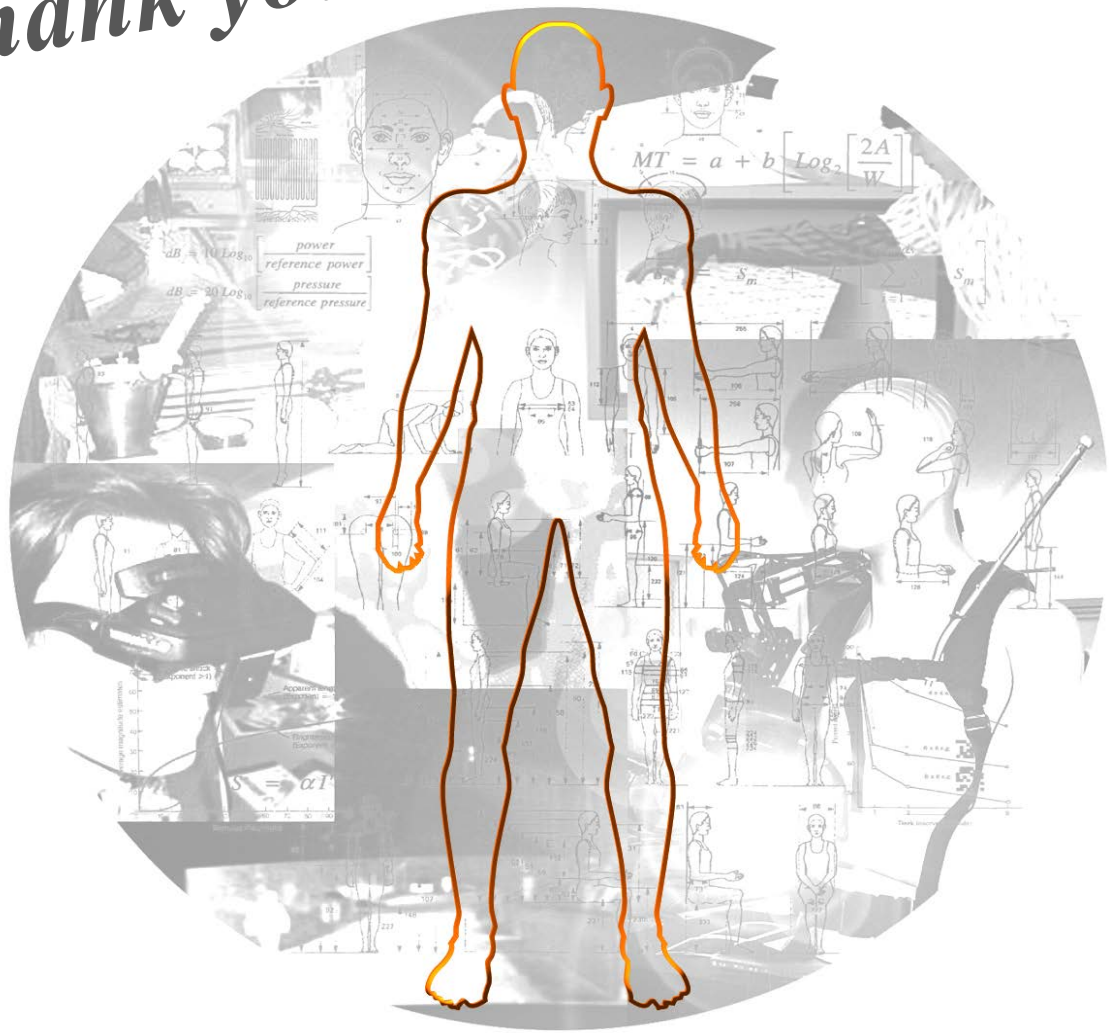
It provides both direct light and light which is diffused through injection-molded polycarbonate plastic which is available in a variety of pure tone colours.

# Design Classic: Carlton Room Divider

Between 1981 and 1988 Ettore Sottsass and the other members of the Memphis group designed items of nonconformist furniture.

The totemic "Carlton" room divider exhibits vivid colours and an interplay of solids and voids, suggesting avant-garde painting and sculpture.

# *Thank you.*


$MT = a + b \left[ Log_2 \left[ \frac{2A}{W} \right] \right]$
$dB = 10 Log_{10} \frac{power}{reference\ power}$
$dB = 20 Log_{10} \frac{pressure}{reference\ pressure}$