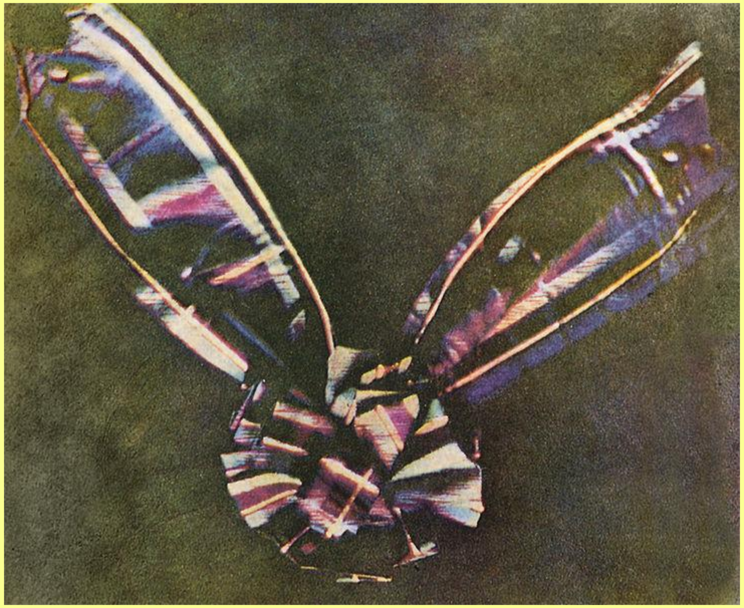
Colour
A cultural history



Prof. Will Ayliffe
Gresham College
31/3/2011

- www.webexhibits.org
- Colour and Meaning: Art, Science and Symbolism: John Gage
- Colour and Culture: John Gage
- Kimberly Jameson
- Color Ordered: Rolf Kuehni, Andreas Schwartz
- Alchemy of paint: Spike Bucklow

What is colour
What is colour vision
Train crashes and colour blindness
Antique use of colour and pigments
Ancient red Welsh “Ladies”
Meaning of colour in Medieval Europe
Discovery of new pigments
Talking about colour
Language and colour
Colour systems
Psychology of colour

Light

Light is the part of the electromagnetic spectrum that we can see.

The Sun: Black body 6000K

Immersed in a sea of radiation; a cacophony of electromagnetic waves.

We evolved in a dark universe.

Receptors developed to detect radiation.

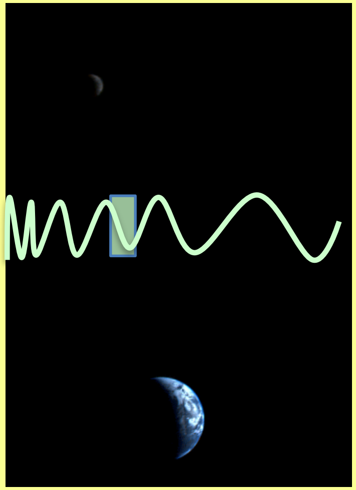
Contain chromophore (Vit A derivative) linked to membrane protein-enzyme (opsin)

Eye sensitive to a small fraction of the energy the spectrum between 400-700nm.

Captured photons cause a chemical reaction; the first step in the miracle we call sight

The altered chromophore leads to a change in shape of the opsin, activation and eventually to electrical signals which travel to the brain: data needed for survival; reconstruction of the world.

Sir Isaac Newton: “For the Rays to speak properly are not coloured. In them there is nothing else than a certain Power and Disposition to stir up a sensation of this or that colour



Colour

Colour: noun for spectral composition of light: derives from Latin 'color' combined with the Anglo-Norman 'culur'. American

Colour Vision

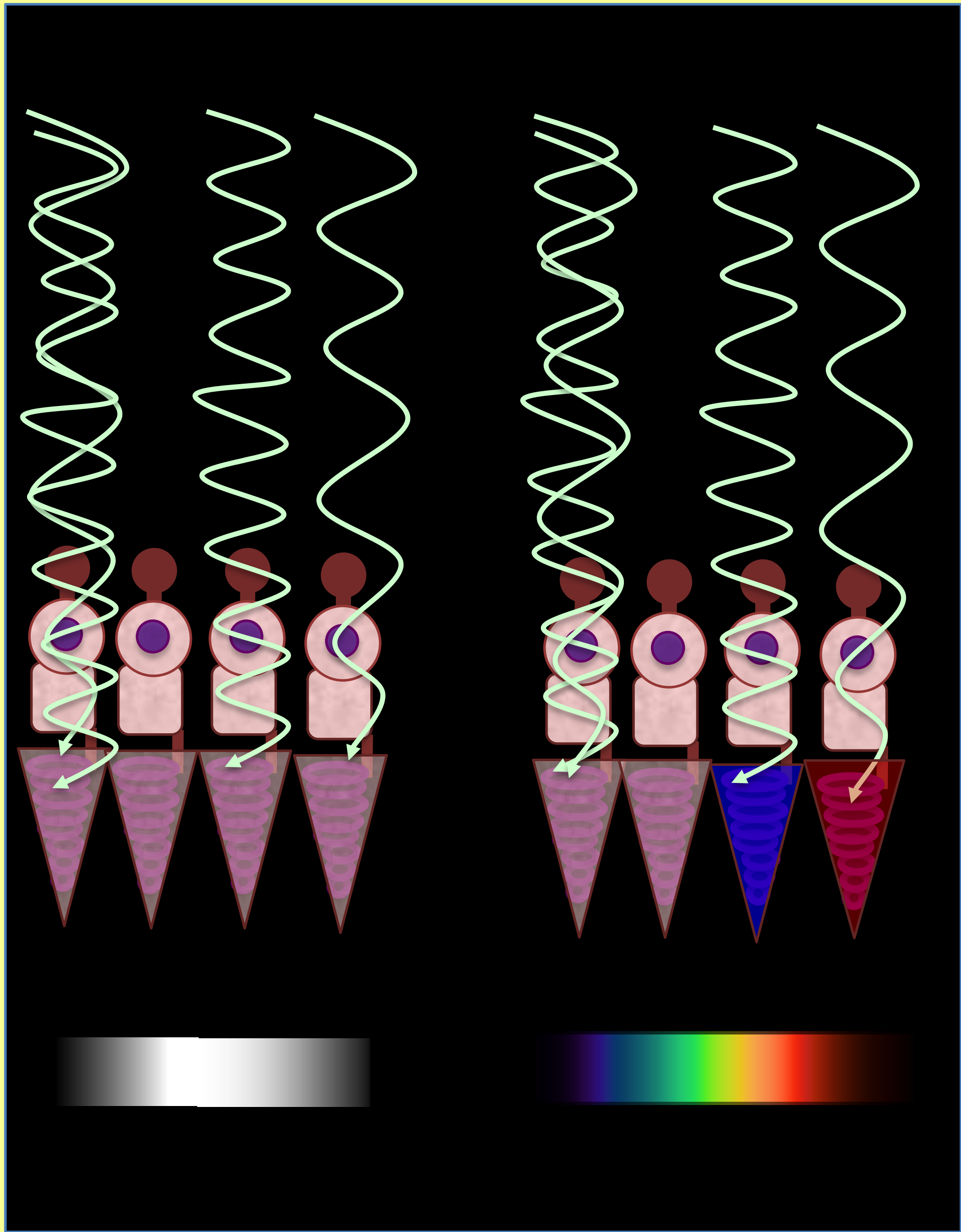
The capability of discriminating between light sources on the basis of their emitted or reflected wavelengths (spectral content), even when those sources are equally bright.

To do this the animal must have at least 2 different types of light receptor which respond optimally to different wavelengths of light.

Light receptors do differ. Some respond maximally to **short wavelength**. **Long wavelengths** must be more intense to stimulate them.

Others respond more readily to **longer wavelengths**. This is called **spectral sensitivity**.

- Identification of the spectral sensitivities of cone pigments by retinal densitometry (Rushton, 1963).
- Identification of the genetic code for L, M and S opsins (Nathans et al, 1986a,b).



Spectral Sensitivity

Different mechanisms could be used to discriminate between wavelengths, eg coloured oil droplets masking the chromophore, different chromophores.

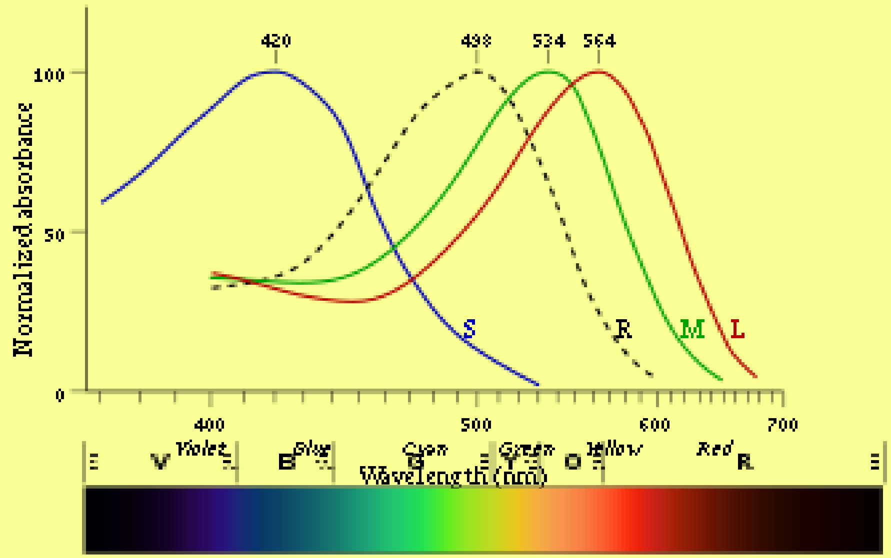
However we use different genes to code for different opsins which determine which wavelengths of light optimally optimally stimulate the receptor.

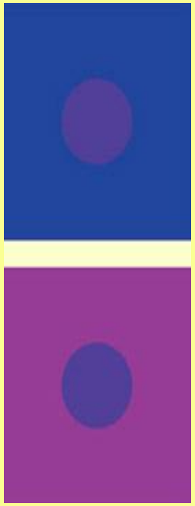
However receptors are only the first stage in colour vision

I’m responding. **Not** I’m responding and I’m greenish.

That comes from comparing the responses of different receptors

The next stage is the development of retinal wiring to segregate the spectral signals and to enhance their borders.





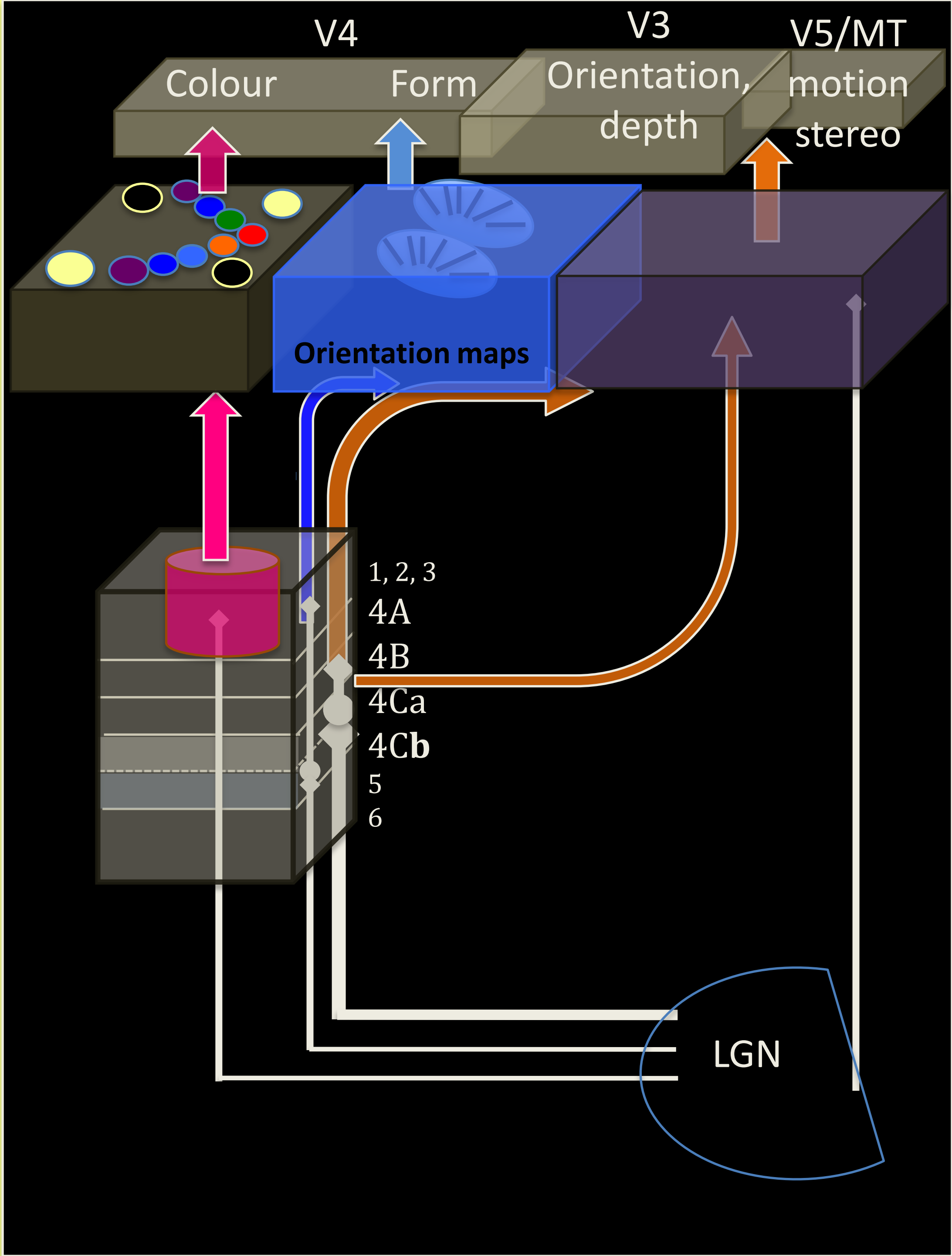
Analysis of Colour

V2: Thin stripe, interstripe, Thick stripe.

Thin stripes: contain regions responsive to chromatic modulation. Also have cells in a different channel that process apparent brightness Luminence increment/decrement channels. (Wong & Fellman)

V4: Semir Zeki. Input from the **thin** and interstripe of V2, also from V1 and V3. contains many cells that are colour selective, for **colour analysis**.
Also cells with complex spatial and orientation preference, suggesting that the area is also important for spatial vision.

Profiles of light reflected off objects are not uniquely coloured.
reflectance spectra are only electrical and magnetic pulses of photon energy waves, which do not contain any colour.
Colour is a process of the brain



Colour blindness

John Dalton: Quaker from Lakes moves to teach at New College in Manchester.

1789: Philosophical and Literary Society first paper on "Extraordinary facts relating to the vision of colours",

That part of the image which others call red appears to me little more than a shade or defect of light. After that the orange, yellow and green seem one colour which descends pretty uniformly from an intense to a rare yellow, making what I should call different shades of yellow

postulated that shortage in colour perception was caused by discolouration of the liquid medium

Daltonism: colour blindness. Preserved eyeball 1995 missing **M** pigment.

Chromosome 7: **S** Opsin blue-yellow 0.005% pop

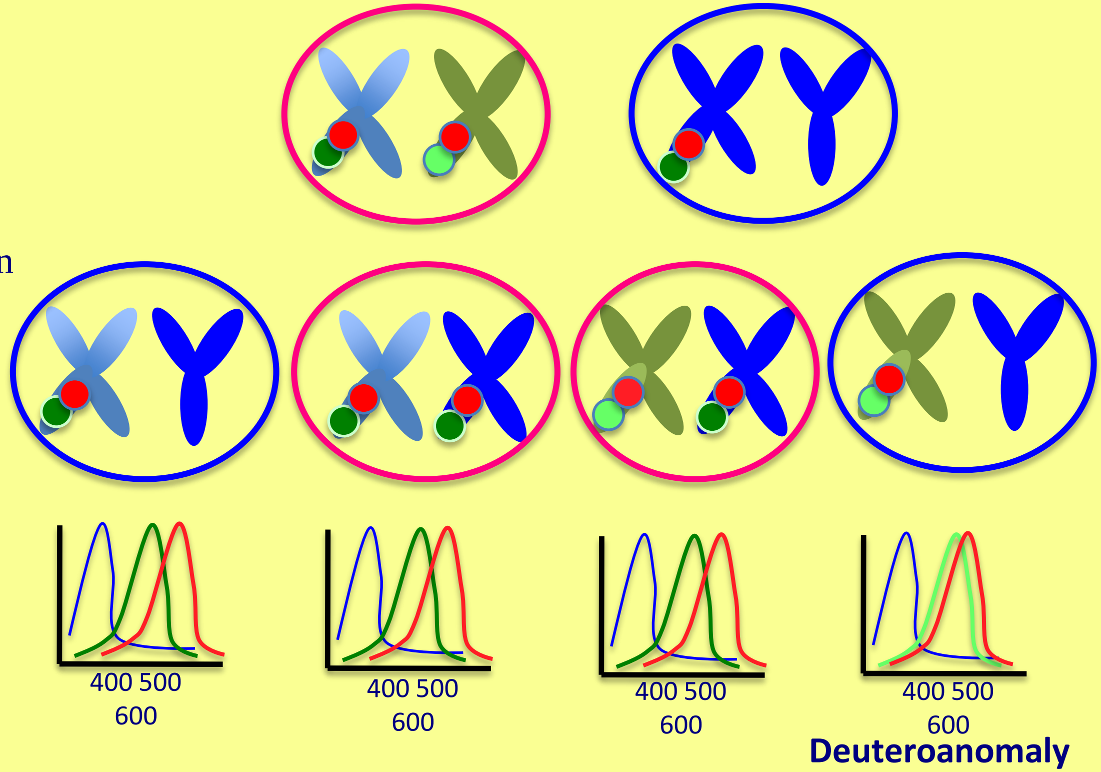
X Chromosome: **M** and **L** opsin red-green 8% M

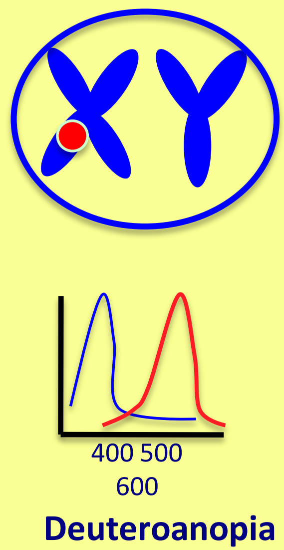
Protanopia: **L** cones missing. Severe 1% males

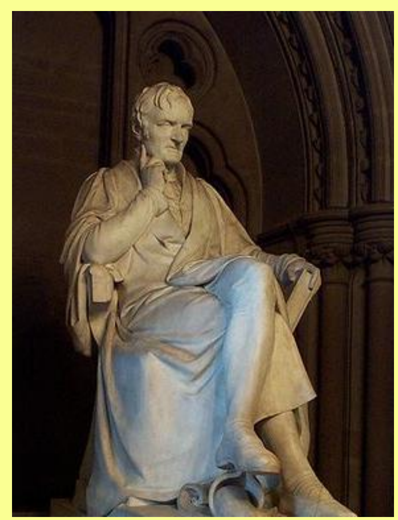
Deuteroanopia; **M** cones missing

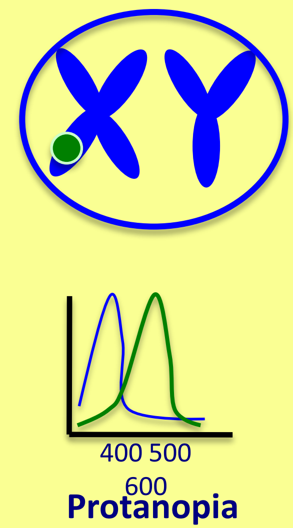
Deuteroanomaly: one of the opsin genes (**M**) is defective, anomalous, the most common type of colour blindness 5% of males.

Protanomaly **L** opsin gene defective 1% males.









Tests for colour vision

1684: Turberville: 32yo F. Excellent vision but couldn’t distinguish one colour from the next. Name the colours of everyday objects. “He generally prescribed to all, shaving their heads and taking tobacco, which he had often known to do much good, and never any harm to the eyes. He cured the poor gratis.

'without doubt this is a married man otherwise 'twere impossible he should be so patient'; replyed, 'No indeed, I am but a batchelor”.

1777: Mr. Huddart: letter to Priestly: Cumberland shoemaker, Harris who was struck by the naming of a stocking red. To his eyes it was the same as any other sock. 2 brothers also affected.

1837: Seebeck. Berlin schoolchildren: Matching not naming; samples of paper, wool or glass. Identified 2 types of colour defects and recognised partial defect.

1879: Holmgren: first successful attempt to standardize the detection of colour-blindness

Detection of colour-blind employees 3 test worsteds (based on Young-Helmhlotz) match with 40 colours. Tested 2,220 soldiers, 1 min to complete. If confusion colours instead of match colours, colour blind.

Colour vision and employment

15th November 1875 Lagerlunda:

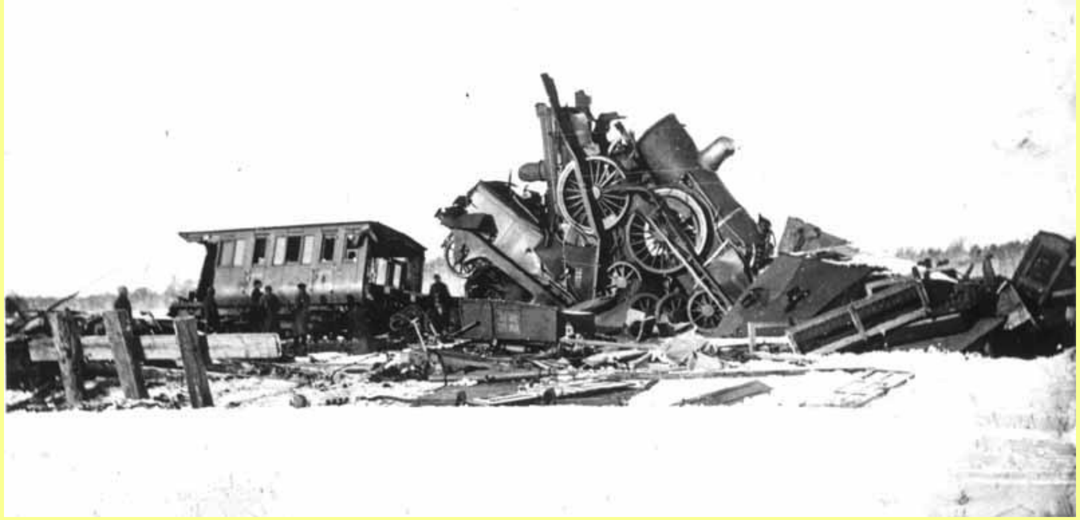
Unclear signaling between a station master and engine driver; train leaves but another train is approaching on the single line track. 9 killed in the head-on collision. Station master 6 months of prison.

Alarik Frithiof Holmgren (1831–1897) Upsala University, opponent of vivisection, use of curare paralysed subjects in pain appearing peaceful. Despite protestations permitted to test railway employees for colour-defect. 13/266 color-blind 4.8%. concluding that defective colour vision was cause of mistaken interpretation of signaling. Laws to prevent defective color vision people from railway.

Actually due to the engine-driver and stationmaster acting contrary to regulations.

September 10, 1874: Thorpe rail accident, Norfolk: Head-on collision on single track, 25 killed 100 injured. A series of misunderstandings between stationmaster, night inspector telegraph clerk, and the sending of a message without the required signature resulted in two trains being dispatched from each end of the single line

Accident engineer Edward Tyer: tablet system a token given to train driver; must be slotted into an electric interlocking device at the other end of the single-track section before another train is allowed to pass



Developments in tests

1881: Lord Rayleigh: Mixing lights to match.

1899: Nagel Anomaloscope.

1903: Williams lantern test; 1912: Board of Trade lantern. Parliament Committee. reproduce typical ships' lights at a certain distance. The patient viewed it in a darkened room sitting six metres away.

Pseudoisochromatic plates:

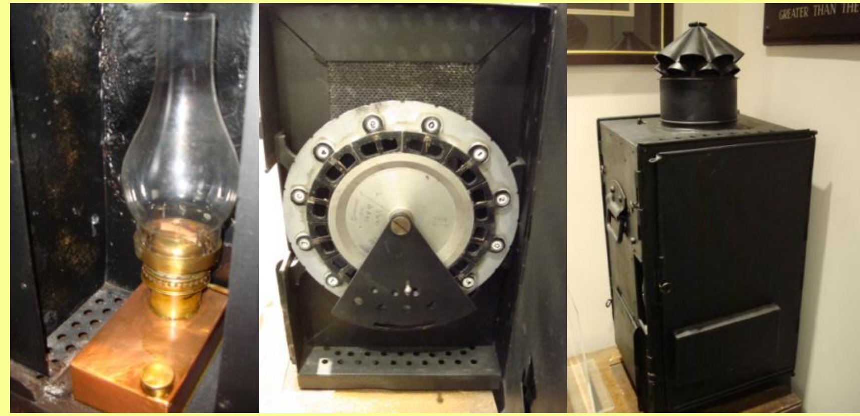
City University:

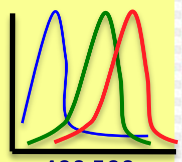
1934: Pierce: 16 Nitrocellulose Chips to grade colour

1943: Farnsworth-Munsell 100 hue

Whewell proposed the term **Idiopts=peculiarity of vision**

Sir David Brewster pointed out the obvious pronounciation error "so the last state would be worst than the first" Suggested **Colour-blindness**





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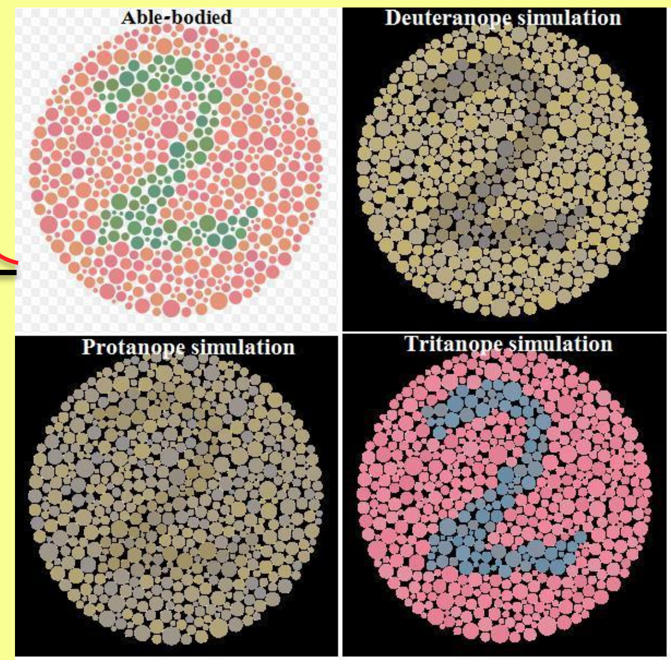

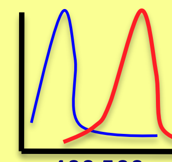

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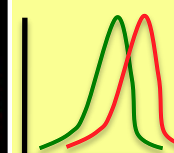

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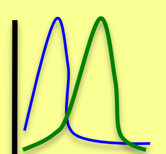


Tetrachromats

Vertebrate visual pigments evolved 500mya

Flexible gene structure

Precursors of human visual pigments evolved in cretaceous period 150mya

each cone can detect 100 different gradations.

Dichromat: Mammals; able to distinguish about 10,000 different colors

Trichromat: Old world primates; total number of colors discernible 1 million upwards.

Tetrachromats and upwards

Birds

Fish

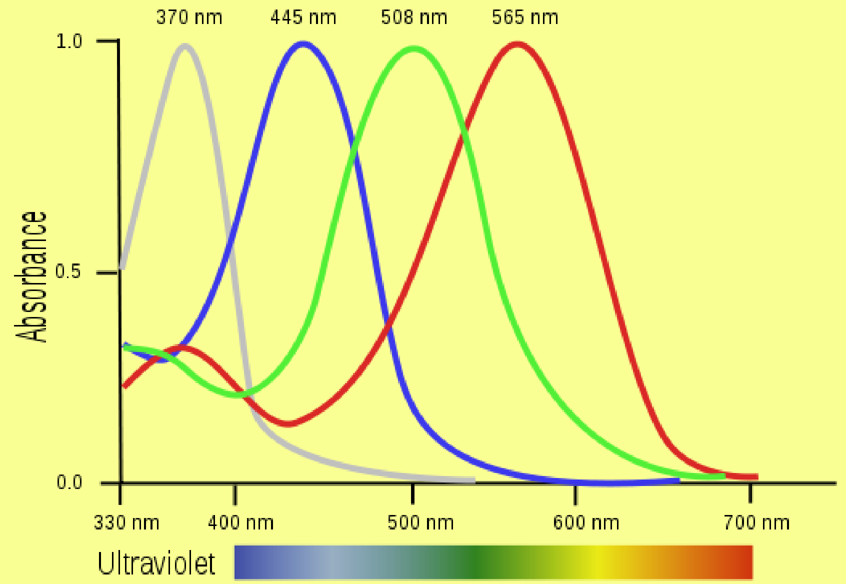
Spiders

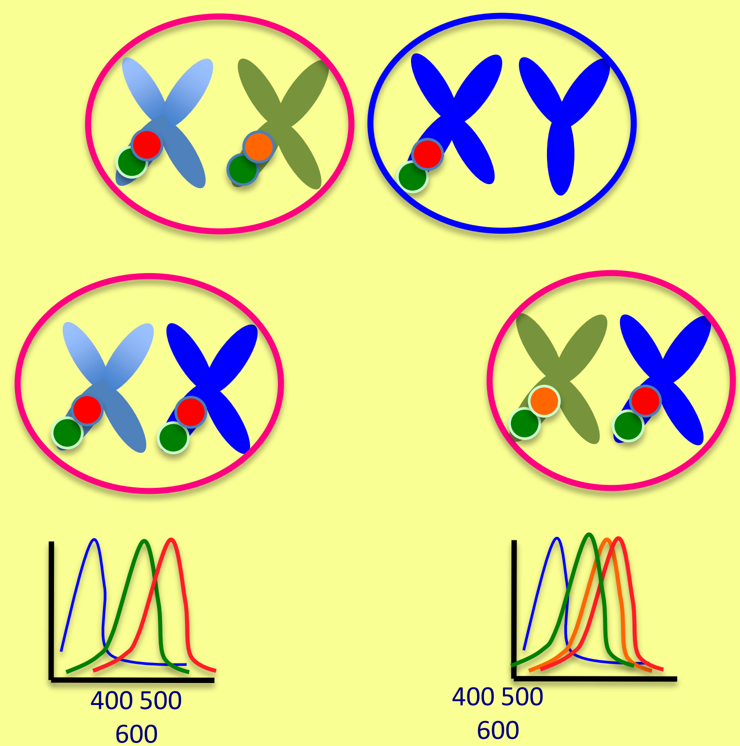
Shrimp

Reptiles

Insects

Possibly some women: Kimberly Jameson





Objects in a scene can now be classified by their colour.

“The fruit detector”

Old world vs New World

Females lead the troupe

“Emotion detector” (blood oxygen concentration)

Transfecting mice (dichromats). Found their brains could use the extra colour channel!

Colour in prehistory

Prehistoric painters used materials around them to create coloured images;

earth pigments, (minerals limonite and hematite, red ochre, yellow ochre and umber),

Black: charcoal from the fire (carbon black), burnt bones (bone black)

White: from grounded calcite (lime white).

Red and yellow: Iron containing earths

Cave men traveled up to 25 miles for earth pigments in the Lascaux.

Stains on the floor of caves reveal where lumps were ground to powder using bones of large animals.

The pigment was made into a paste with water, vegetable juices, urine, animal fat, bone marrow, blood, and albumen.

Ochre

Iron oxide: Oldest pigment

Red ochre is composed mainly of iron oxide, hematite Gk, hema blood. permanent pigments can be safely mixed with other pigments. Ochres vary widely in transparency;

Blombos cave south Africa: Ochre engraved 75,000 yrs old

Red Lady of Paviland: Paleolithic male skeleton 30,000 years old before Ice Age. Dyed in red ochre. Wm Buckland, Oxford geologist 1823: First human fossil ever found. Goat’s hole cave, Gower.


Ochre Pits

Yellow ochre

Natural mineral consisting of silica and clay

colour due to an iron oxyhydroxide mineral, goethite.

Found throughout the world, many shades, in hues from yellow to brown

Iron oxyhydroxide **FeO(OH)**

Lascaux:

Upper Paleolithic art. These paintings are est. 17,300 years old

Carbon black

The Chauvet-Pont-d'Arc Cave, discovered 1994 Ardèche S. France Contains the earliest known cave paintings (30,000 BCE)

artists used techniques rarely seen in other cave art

Walls scraped clean and smooth light background.

3 dimensional effect by incision

Carbon blacks are made by heating wood, in restricted air.

Sticks of charcoal have been used for sketching by artists of all periods, and traces of their work may be found on the ground layer of paintings.

Used both in oil and watercolour.

Modern use photocopier and laser printer

Were Ancient Greeks colour blind?

William Gladstone (1858),

Homeric scholar: lack of colour terminology in Homeric Greek literature, Greeks could probably not see color as we can today.

" ... that the organ of color and its impressions were but partially developed among the Greeks of the heroic age.

Ancient written languages did not name colours as precisely and consistently as modern European languages.

Proposal of evolutionary sequence in which colour vocabulary evolves along with biological evolution of the color sense".

Pebble mosaic floor, griffins eating a horse.
earliest surviving Greek mosaics, ca. 400 BC. Corinth

Greek Colour Use

Pliny: Best painters used a restricted palatte

White from Milos

Attic yellow

Red from Sinope (Black Sea)

Black

Use attributed to Apelles (b370BC), Aetion, Melanthius & Nikomachus.

Mummy paintings

Encaustic painting

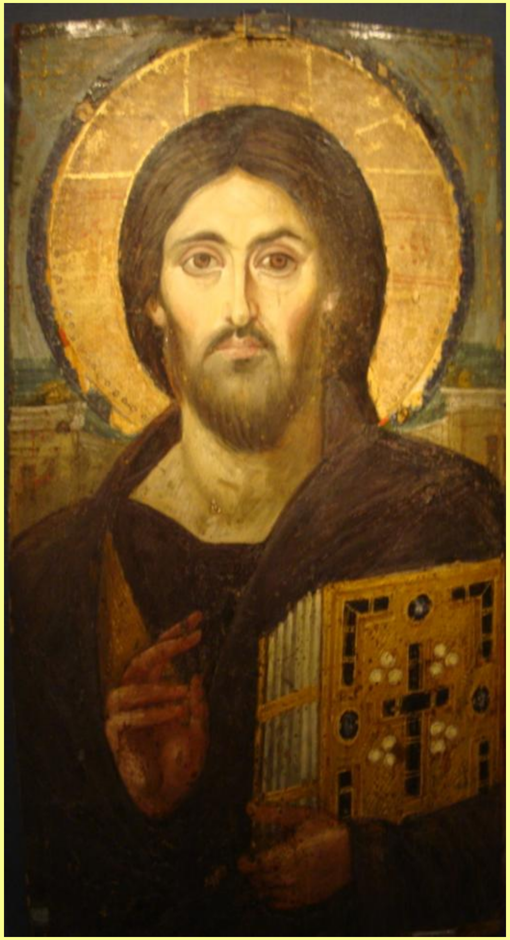
technique was used widely in Greece and Rome for easel pictures.

the binder for the pigment is wax or wax and resin.

tomb portraits from Roman Egypt durability of the medium, which is thought to have been widely used in ancient times.

Flesh tones: Red ochre and hatching or glazing.

Wax allowed blending like later oil paints.



Use of blue in ancient Greece

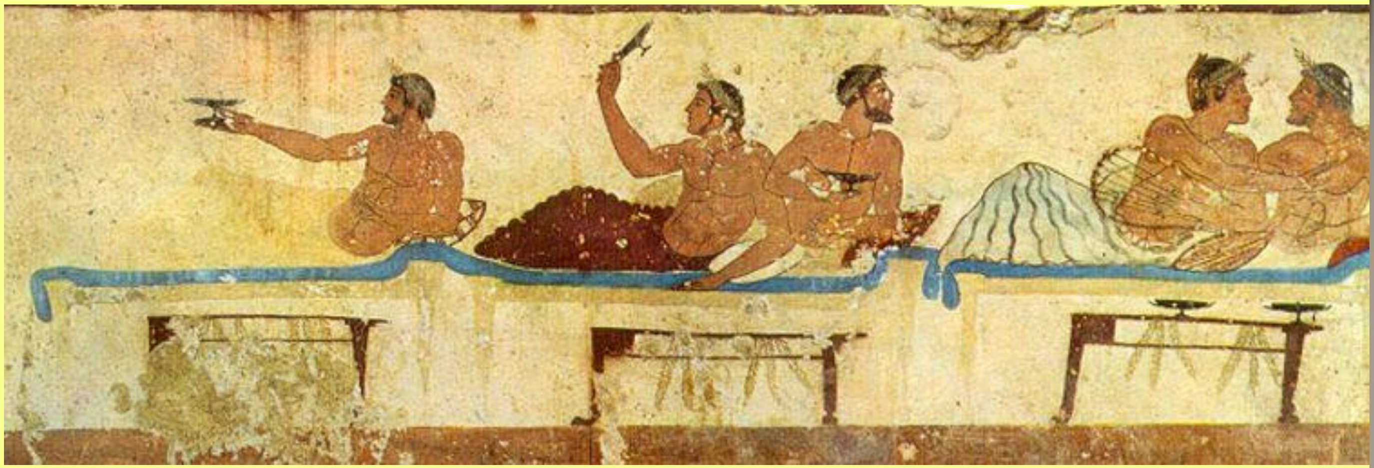
Shades of blue from the limited palatte using Atramentum, the dark varnish

Also used Egyptian Blue.

Zeuxis b Heraclea c464 BC .

”I have deceived the birds, but Parrhasius has deceived Zeuxis

Tomb of the Diver, 470 BC, Paestum: welcoming symposium for owner of the tomb. similar Frescoes in Etruscan tombs of the period.



Egypt

Use of colour highly symbolic and strictly regulated. relied on six colour palette:

red, **green**, **blue**, **yellow**, white, and **black**.

Iron oxide (red ochre, yellow ochre and umber) basic palette. Tutankhamen's tomb small paint box. contain powders of orpiment, red ochre, and malachite.

4000 BC, colour manufacturing, washing of pigments to increase purity.

Egyptian blue: calcium copper silicate- first artificial pigment made around 3000 BC.

Also used azurite and realgar.

Vegetable dyes: **Madder and Indigo** principal use textile dyes, but also inks

First to fix dyes onto a transparent-white powder; lake making (madder lake, carmine lake). Solutions of organic dyes extracted from parts of plants were mixed with hydrated clay or tannin to form an insoluble pigment.

The Old Masters used chalk or alum

The Ivory Palette a gift from Princess Merytaten to Tutankhamen: found in the Treasury between the paws of the jackal mounted on a shrine.

Early Fresco painting

Egyptian:

limestone walls of tombs plastered, then painted.

earth pigments unaffected by alkalis.

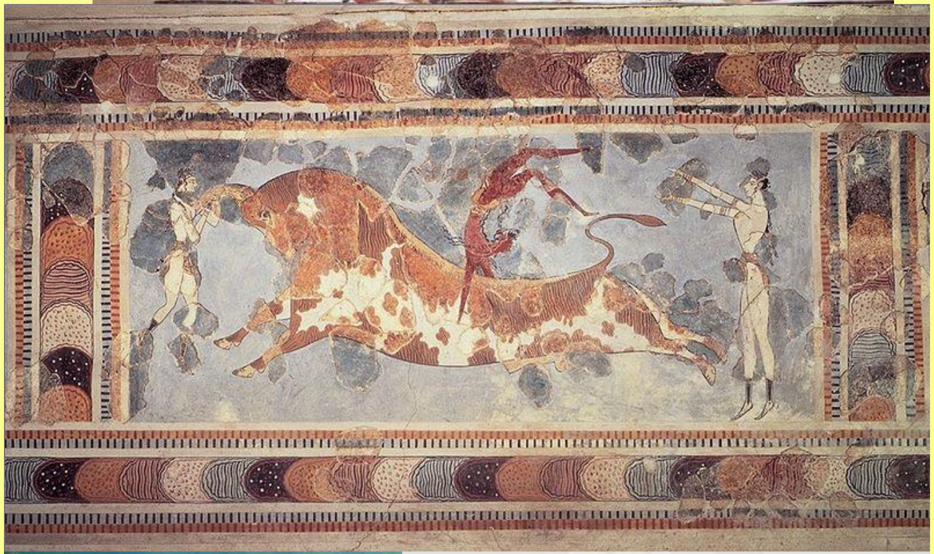
black, red, yellow, brown, blue, and green pigments.

Minoan:

Bull-Leaping Fresco is a 78.2 cm high stucco fresco of bull-leaping from the Middle Minoan III to Late Minoan B period (17th-15th centuries BC)

Egyptian blue: background, bull, pink-red ochre, lime and brown, yellow ochre with charcoal

Paints were made by using the ground pigment with gum.

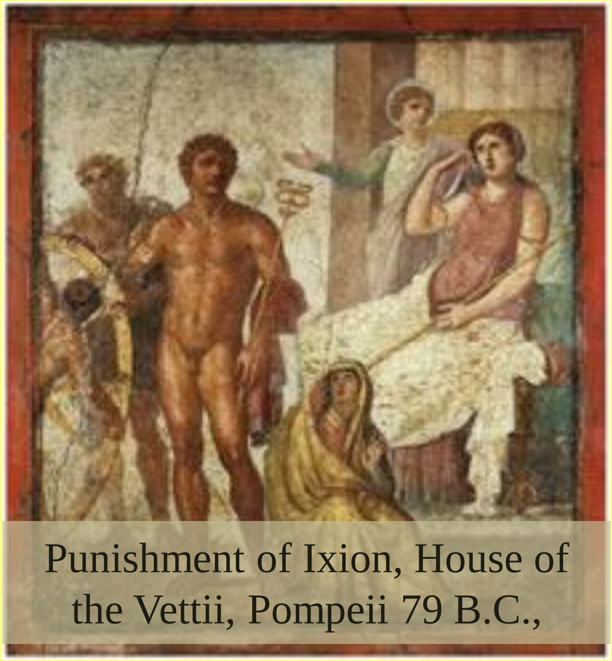


Roman

The Romans made use of the pigments developed by the Egyptians and Greeks.

Mural artists used wax, wax emulsion or Punic wax.

Pliny: boiling beeswax with salt water and potassium carbonate, bleaching in the sun, to a paste consistency



Punishment of Ixion, House of the Vettii, Pompeii 79 B.C.,

Vermillion was mined Almaden Spain.

Used in wall decorations;

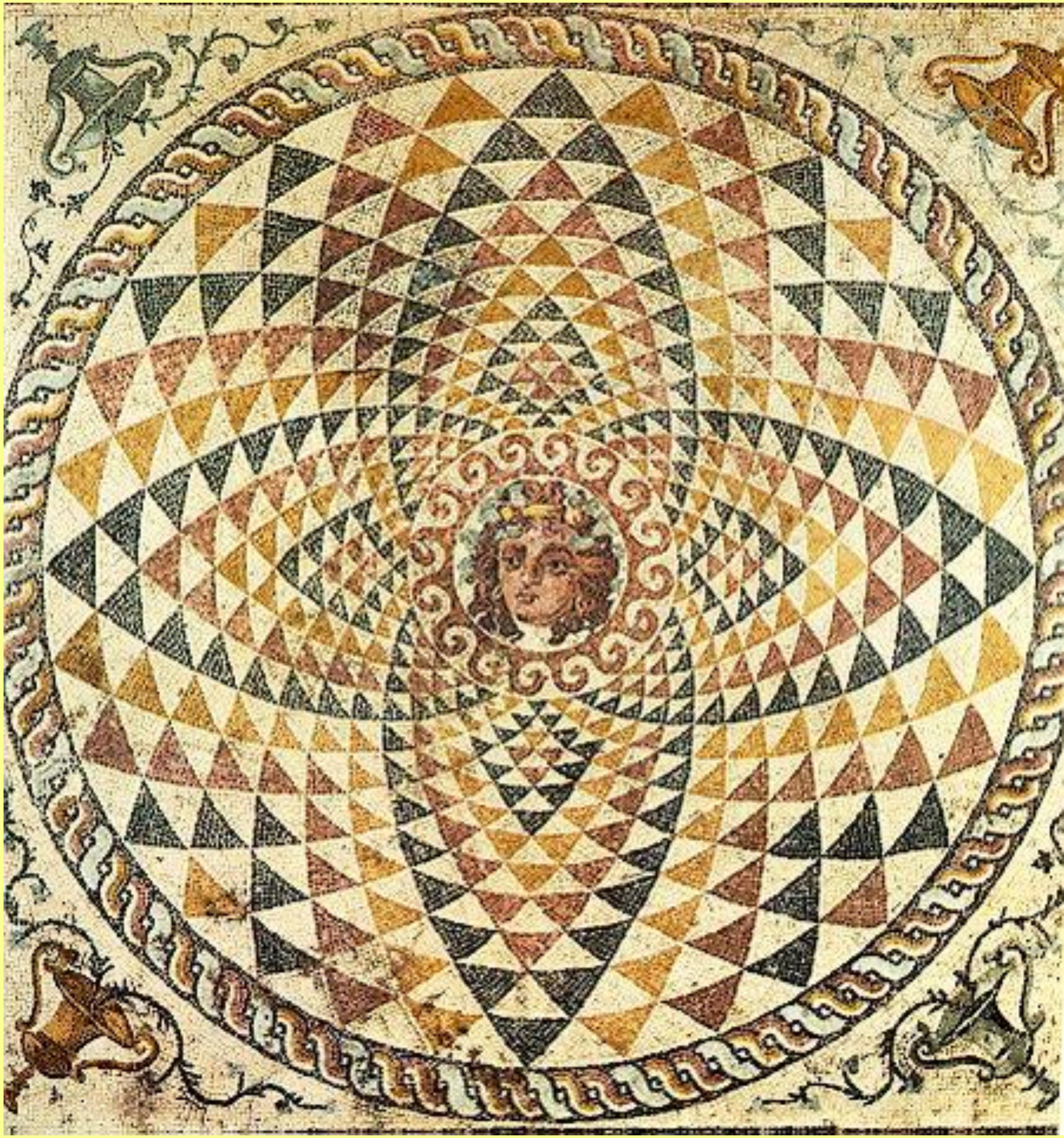
gladiators and statues were painted

worn by Roman women as lipstick.

used into the 19th century.

Mosaic floor:

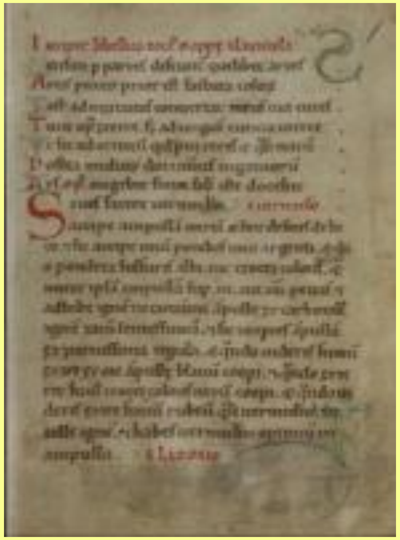
head of Dionysis. 2nd century A.D



Medieval art technology

July 31st 1437: In the prison known as the stink, a prisoner of the Pope wrote on the last page of his manuscript “ex stincharum, ecc”

The book was Ill Libro dell’Arte, the author Cennino d’Andrea Cennini. The writer a prisoner, copying.



Schedula diversarum artium: Theophilus C12th

Compositiones variae 787-816

Mappae Clavicula: Reichenau catalogue 821. Oldest existing Lucca. 300 recipes for pigments and metal processing.

Heraclius: (De coloribus artibus et Romanorum)

Early Mediaeval Colour

Palette:

*Mineral pigments (*red ochre, yellow ochre, umber, lime white). Dug and shaped into sticks with knives, chalks ready for drawing.

Natural red chalks, popular from about 1500 to 1900. Such artists as Michelangelo, Rembrandt.

green earth for under painting flesh tones.

Malachite and verdigris were also used as greens. Orpiment continued to be used for yellow together with yellow ochre.

azurite,

ultramarine. blue was associated with purity, used in paintings of the Virgin Mary, where she was almost invariably depicted wearing ultramarine blue garments. The high price of the pigment, sourced in Afghanistan, also meant that its use was appropriate in the case of a noble subject such as the mother of Christ.

pigment was mixed with water and egg before application, was well established by the 13th century. The dried protein remaining after the water evaporated bound the pigment to the substrate. The tendency of a thick layer of such paint to crack meant that it was essential to apply the paint in thin layers or glazes, and is the reason for the highly finished appearance of medieval paintings.

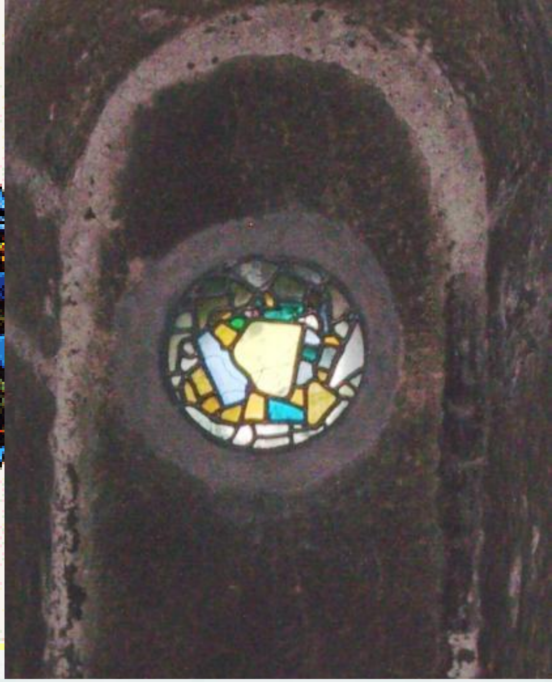
Nativity, chapel of the Appiano castle (Italy), XII century.The interior walls of the Castle Chapel, a small hall church of Castel Appiano in the north of Italy, are entirely covered with paintings. The paintings reflect the predominant Veneto-Byzantine influence on the High Romanesque style. Ultramarine was used by the artist for painting the Virgin’s cloak.

Importance of colour in Medieval art

Bede AD 674: Benedict Biscop imported French craftsmen to produce glass windows for St.Peter's monastery at Monkwearmouth. First recorded use of stained glass in Britain. The local monks learnt their glassmaking skills: tradition at the monastery

The oldest stained glass in the world in situ to date is at St. Paul's church in Jarrow.

The fragments of glass dated C7th. Central window original slab small circular light only 7" in diameter. Unique; contains fragments of Saxon glass



Pseudodionysian light metaphysics

Abbot Suger, friend of Louis VI and Regent to his son, reconstructed the choir of St. Denis, Benedictine Priory. 1140-44. Glazed the upper Choir “Nova Lux”

Used stained glass with much expensive blue.

The primary light Lux is substance distinguished from light of heavenly bodies Lumen which flows from it

Lux = Divinity:

Pseudo-Dionysius (Denys) C5th anonymous theologian. Ascribed to Athenian Convert of St. Paul Acts 17:34 D. the Areopagite

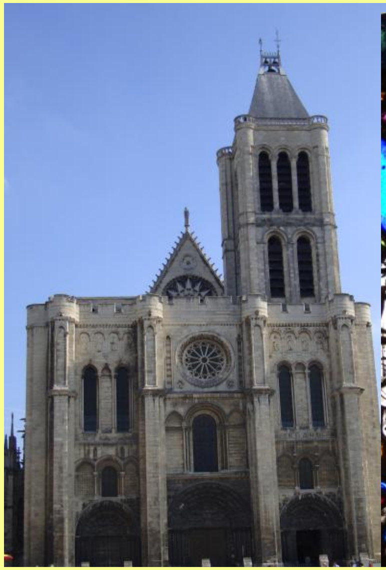
Comes to West as gift of Byzantine Michael the stammerer to Louis the Pious at Compeigne 827

Charles the Bald comissions John Scotus to translate

“Quid Distante inter Sottum et Scottum”

Suger presenting glass window

Suger at foot of Virgin in infant of Christ window



monks gaze heavenwards to the path created by St Benedict.





Romanesque glass was more colourful than later. The colours were not just taste.

Material itself valuable

Liber de Lapidibus- gem lore Saphires protect from harm and reconcile with God.

Theophilus describes melting of ancient mosaic blue to make the semi-transparent precious glass.

Art judged by its physical as well as the metaphysical aspects of the raw materials.

Suger quotes Ovid

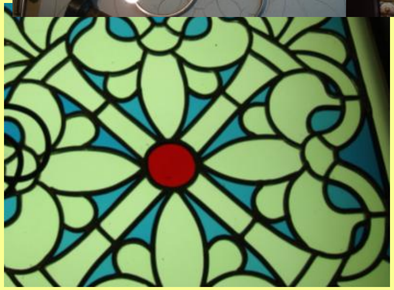
Materium superbat opus

The workmanship surpassed the material

Neoplatonic early medieval: Light a direct emanation from the divine

St Bonaventure (head Franscican) permits more coloured glass than Cistercians. Ash to glass reveals presence of light in even most despised materials

C14th: Light reveals the optical properties of surfaces.



Renaissance techniques for handling colour

C15th, egg replaced by walnut or linseed oil. dried more slowly than tempera more versatile. oils and canvas , a greater understanding of perspective.

Natural chalks made from mineral pigments for drawing. shaped into crayons with knives, ready for use.

Renaissance palette similar to Medieval.

3 new pigments: Naples yellow, smalt and carmine lake (cochineal).

Red: vermilion and madder lake, which brought to Europe by crusaders in the 12th century.

Realgar

blues: azurite, ultramarine and indigo.

Greens: were verdigris, green earth and malachite; yellows: were Naples yellow, orpiment, and lead-tin yellow.

Browns: derived from umber.

Whites: lead white, gypsum and lime white,

Black: carbon black and bone black.

Tintoretto, Miracle of the slave, 1548, Gallerie dell'Accademia
son of a master dyer, used carmine.
the legend of a Christian slave who was to be tortured as punishment for acts of devotion to the evangelist, saved by the miraculous intervention of St. John, smashing the torture implements

Bone Black

Bone black is blue-black in color and smooth in texture and also denser than lamp black.

made from burnt bones or ivory.

10% carbon, 84% calcium phosphate and 6 % calcium carbonate.

used from prehistory and it is in use until today.

Ivory Black is least pure form of carbon black, containing a high percentage of calcium phosphate.

Rembrandt, portrait of Phillips Lucasz, National Gallery, London.
Rembrandt used bone black as a wash for initial sketch; here unmixed bone black used for clothing

Crimson

Fr carmin (C12th), Medieval Latin carminium, from Arabic qirmiz "crimson", Sanskrit krimiga "insect-produced", from krmi "worm, insect"

Crimson: dried bodies of kermes insect, Mediterranean live on the Kermes oak

used in burial shrouds by the Anglo-Scandinavian c866**.**

Middle Ages, rich crimson in new silk-weaving centers of Italy and Sicily exceeded the legendary Tyrian purple "in status and desirability".

Dried product resembled grains of wheat; textiles dyed with kermes were described as *dyed in the grain.*

Woollens often dyed blue with woad before spinning and weaving, then piece-dyed in kermes, producing a wide range colours

C14th: brilliant pure kermes scarlet was "by far the most esteemed, most regal" color for luxury woollen textiles in the Low Countries, England, France, Spain and Italy

The Coronation Mantle of Roger II of Sicily, silk dyed with kermes and embroidered with gold thread and pearls. Royal Workshop, Palermo, Sicily, 1133–34. Kunsthistorisches Museum, Vienna.

Crimson Lake

The Virgin and Child (1500-10).

Workshop of Albrecht Durer, National Gallery, London.

artists used translucency of crimson lake by using it as glazing pigments.

Lake pigments frequently applied in oil, or oil –resin to enhance the translucency.

upper layer of kermes lake from the shadow of the Virgin's robe

Carmine

Carminic acid ($C_{22}H_{20}O_{13}$) red glucosidal hydroxyanthrapurin some scale insects, produce the acid as a deterrent to predators.

Polish cochineal (*Porphyrophora polonica)*, Polish carmine scales.

used to produce a red dye , "Saint John's blood". Harvested in June 24th

The larvae are parasites on the roots herbs growing on the sandy soils

Larvae killed with boiling water sun-dried , ground, and dissolved in rye beer, kvass to remove fat. Extract used for dyeing: 1 Llb/20 Llb of wool.

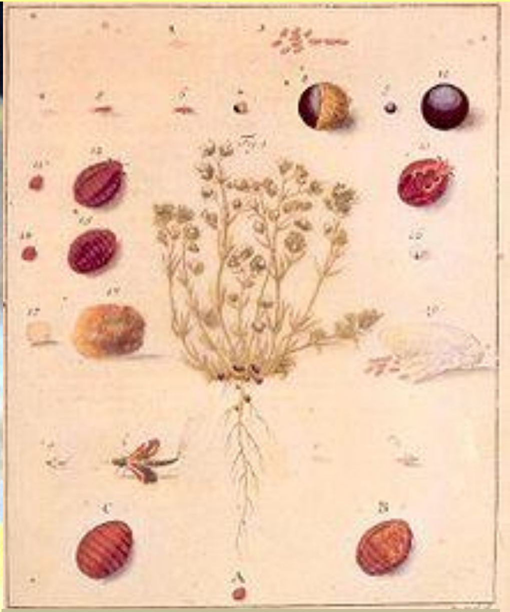
Lucrative buisness. 1Llb cost £5 venetian: Peaked in 1500’s 30 metric tonnes sold in Poznań 1534.

Slump in trade as cheaper Mexican cochineal.

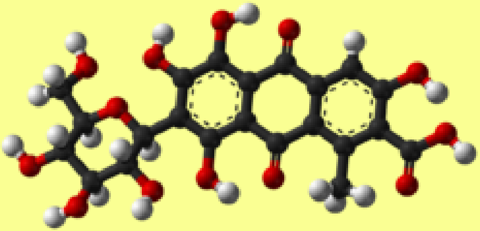
Now used as a colourant for medicine, vodka and horses tails.

Carmine superseded crimson, 10X fewer cochineals than Kermes insects to produce the same amount of acceptable red dye; a lot less insect to find and crush.

Brodero Mathisen
Portrait of Stefan Czarniecki, Field Hetman of the Crown. 1659



Larvae, shed exoskeletons legs and antennae, form red cysts within the root tissues



Carmine

11 cities conquered by Moctezuma in the C15th paid a yearly tribute of 2000 decorated cotton blankets and 40 bags of cochineal dye each.

conquest of Mexico by Hernán Cortés, 'carmine' is derived from the Spanish word for crimson.

first described by Mathioli 1549. Also called cochineal after the insect.

cochineal became Mexico's second most valued export after silver.

one of the few water-soluble colorants that resist degradation with time

Alizarin replaced it causing collapse.

Recently introduced as a non-carcinogenic alternative for foodstuffs.

Vermilion

An orangish-red pigment

mercury sulfide mineral (cinnabar) used from antiquity through to the present

Made artificially from the 8th century, it was the principle red in painting until the manufacture of its synthetic equivalent, cadmium red.

Titian, Assumption of Mary, 1516-1518, Santa Maria gloriosa dei Frari, Venice

Green Earth
Verona Green

Natural green pigment: minerals celadonite and glauconite

bluish greens to yellow and olive. Used since antiquity, medieval Italian painters used green earth for under-painting flesh tones.

Neutralises effect of the pinks and reds of the flesh colours. Painting pinks odirectly onto the white gesso gives "sunburn" effect. The red pigment layer eventually fades

Glauconite formed in ancient submarine continental shelves in sedimentary rocks. *glaucos (γλαυκος)* meaning 'gleaming' or 'silvery', to describe the appearance of the blue-green coluor, presumably relating to the sheen and blue-green color of the sea's surface.

The most famous deposit of green earth was found near Verona, mine was active until World War II.

Other mines Baltic states, Bohemia, Cyprus, France, Hungary, Poland, Saxony, Tyrol, and the Mendip hills of England.

Icons, wall paintings

Duccio, The Annunciation, 1311, National Gallery.

Egyptian blue: First synthetic pigment *. It is a copper calcium silicate that was* mixture of silica, lime, copper, and alkali

Egypt during the 3rd millennium BC until the end of the Greco-Roman period (332 BC–395 AD)

Many specimens, well over 3000 years old, appear to be little changed by the time. Egyptian blue

Azurite

Azurite is composed of mineral basic carbonate of copper, found in many parts of the world in the upper oxidized portions of copper ore deposits. Azurite mineral is usually associated in nature with malachite, the green basic carbonate of copper that is far more abundant. Occasional use began with Egyptians, but it was uncommon until the Middle Ages when the manufacture of the ancient synthetic pigment "Egyptian blue" was forgotten. Produced artificially from the 17th century, it was replaced when "Prussian blue" is discovered in the 18th centur important b painting thr and Renais

Raphael, Madonna and Child Enthroned with Saints, The Metropolitan Museum of ArtThe azurite blue of the Virgin's mantle has darkened due to its degradation into green malachite and now this mantle looks greenish. Also to be noted in this painting is that the children are not naked. Indeed, this important early altarpiece by Raphael was painted for the small Franciscan convent of Sant'Antonio in Perugia and hung in a part of the church reserved for nuns. According to Vasari, it was the nuns who asked Raphael to depict the Christ Child and infant Saint John the Baptist fully clothed. Their patronage may also account for the painting's conservative style and the emphasis given to gold decoration.

The Language of Colour

Aulus Gellius C2nd Attic Nights: Favorinus, member of the Antonine smart set "Eye sees more colours than language can distinguish" Greek was more discriminating than Latin. Rufus described purple to gold, wheras Greek had 4 terms xanthos (used for hair, honey, wine and parched grass), ereuthros, purros and kirros.

Marcus Fronto responded by listing 7 Latin terms for red.

Purpura was a silk in spain that could be white, yellow, blue or black!

Friedrich von Humboldt (1767–1835), diplomat, linguist friend of Goethe, designer of the Prussian education system. "The character and structure of a language expresses the inner life and knowledge of its speakers"

Each culture develops a unique world view because of how its language categorises reality.

"Linguistic relativity"

Edward Sapir (1884-1939) student **Benjamin Whorf:** the way language codes things, affects thought, speakers of different languages think and behave differently because of it. What we can think about is determined by what we have language for. (linguistic categories limit and determine cognitive categories).

Basic colour words should not be translatable across languages.

This idea was challenged when Berlin and Kay discovered that there was a limited way in which languages could describe colours.

Colour blindness, evolution C19th and ancient language

1858: William Gladstone, ***Studies on Homer and the Homeric Age***. Final chapter, "Homer's Perception and Use of Color,"

Why, were there so few references to colour in the Iliad and the Odyssey? The predominant colours mentioned black and white.

Sea is described as "wine-dark"; also used for sheep and oxen.

Κλοροσ described faces pale with fear, olive-wood clubs and honey

Sky described as "starry, or broad, or great, or iron, or copper; but never blue"

Conclusion: Ancient Greeks were colour-blind.

Lazarus Geiger, studied colour words in Old Testament, the Indian Vedas, Icelandic sagas and the Koran. These ancient texts also deficient in colour terms.

Mans perception of colour, increased 'according to the schema of the color spectrum': first sensitivity to red, then to yellow, then to green, and only finally to blue and violet. this sequence seems to have occurred in the same order in different cultures all over the world."

supported Gladstone; that the colour sense among the ancients was unevolved.

Distinguishing blue and green

The English language distinguishes blue and green, but not other languages.

Some, mostly in Africa, do not even distinguish blue from black.

The overall term is called Grue in Linguistics. Can be sky grue, or leaf grue to distinguish.

青天 qing tian **blue sky**

青菜 qing cai **green vegetables**

Modern

蓝/ 藍 *lán for blue*

绿 / 綠 lǜ for green

What do I mean by a name?

Colour identification

physiological (most humans can naturally "see" the full spectrum)

cultural / linguistic (individual colours are given specific terms that apply to an imprecise narrow range of the spectrum. Whole regions can only be described vaguely as "greeny-blue" or qualified as "darkish blue-green."

Infinite number of colours in the spectrum impossible to have an infinite number of words for them.

Michael Minnich: "It's not simply cultural and it's not simply observational. It seems to have some relationship to language itself, something like grammatical gender or case marking."

We have only **11 unambiguous colour terms** in English: White, Black, Grey, Yellow, Red, Blue, Green, Brown, Pink, Orange, Purple.

What do I mean by terracotta

Distinguishing colours often use names based on nature, eg Lilac. Each of these coloured sheets described as terracotta, but when we see them together we have difficulty expressing the difference in words.

Colour names

Berlin and Kay (1969) 'Basic Color Terms, their Universality and Evolution'

98 languages finding that words for basic colours occurred in different languages in a defined order

• all languages with only two basic colour words have words for black and white; • languages with three basic colour words have words for black, white and red

interpreted this as a demonstration of language evolution.

A set of 11 basic colour words in all the languages of the world. **a semantic universal. Basic colour words *are translatable.***

Stage I : WHITE BLACK

9 languages: 7 New Guinea 1 Congo 1 South India

Dark-cool and light-warm (a larger set of colours)

Stage II: WHITE BLACK RED

21 languages: 2 Amerindian 16 African 1 Pacific 1 Australian Aboriginal 1 South India

Stage IIIa: WHITE BLACK RED GREEN

8 languages: 6 African 1 Philippine 1 New Guinea

Stage IIIb: WHITE BLACK RED YELLOW

9: 2 Australian Aboriginal 1 Philippine 3 Polynesian 1 Greek (Homeric) 2 African

Stage IV: WHITE BLACK RED GREEN YELLOW

18: 12 Amerindian 1 Sumatra 4 African 1 Eskimo

Stage V: WHITE BLACK RED GREEN YELLOW BLUE

8: 5 African 1 Chinese 1 Philippine 1 South India

Stage VI: WHITE BLACK RED GREEN YELLOW BLUE BROWN

5: 2 African 1 Sumatra 1 South India 1 Amerindian

COMPLETE ARRAY OF COLOURS: Stage VII

20 languages: 1 Arabic 2 Malayan 6 European 1 Chinese 1 Indian 2 African 1 Hebrew 1 Japanese 1 Korean 2 South East Asian 1 Amerindian 1 Philippine

Critique of Berlin and Kaye

Barbara Saunders: "Revisiting Basic Color Terms" Berlin and Kaye's work is fundamentally flawed

There were labeling, transcription and factual errors, empirical deficiencies in the experiments, a language sample that was not random, and a bilingual and colonial factor that was ignored.

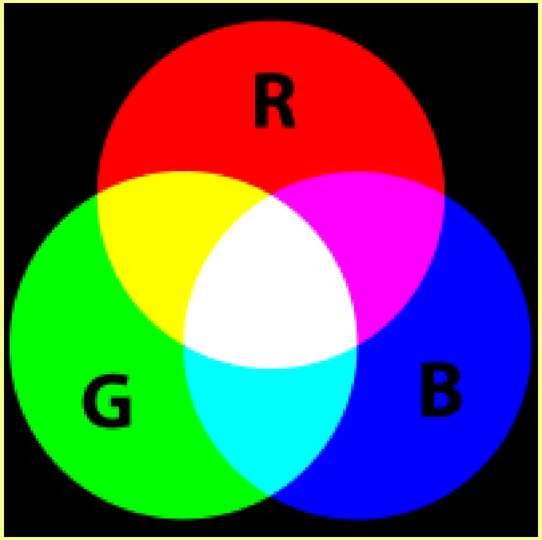
15/20 mapped languages at Evolutionary Stage VII, hardest datum - the universal clustering of foci - was a foregone conclusion."

The 11 basic colour terms aren't universal; not even within the 98 languages.

red is 'hong se' **pink** is 'fen hong se'. 'fen' is diminutive. so 'Chinese' does not in fact fit into the European 11-color system.

Theories of Colour vision

Two complementary theories of color vision are the **trichromatic theory** and the **opponent process theory**. describing different stages in visual physiology



The trichromatic/ Young–Helmholtz/RGB theory

three types light receptor preferentially sensitive to blue (S), green (M) or red (L).

proposed in the 19th century by **Thomas Young** developed by **Hermann von Helmholtz**

Opponent process theory

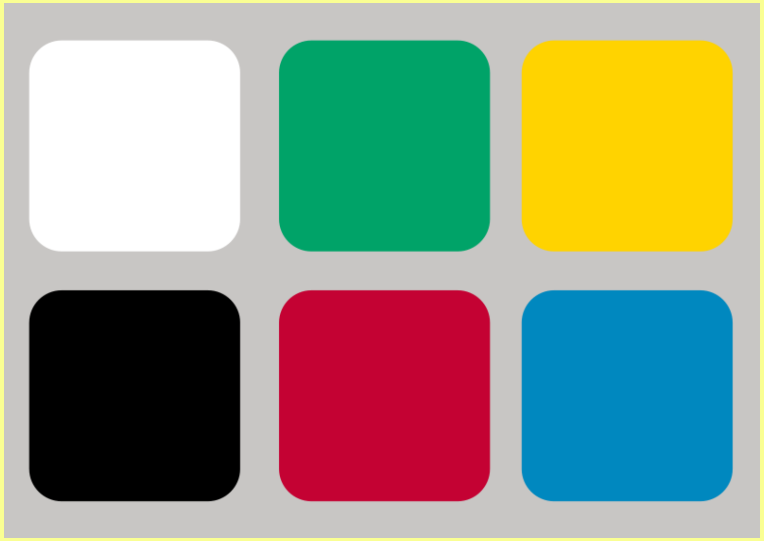
1872 **Ewald Hering**:

overlap in the wavelengths of light to which they respond, so it is more efficient for the visual system to record differences between the responses of cones

red vs. green,

blue vs. yellow,

black vs. white. (luminance channel)



Thomas Young (1773 – 1829)

Genius and polymath, admired by Einstein.

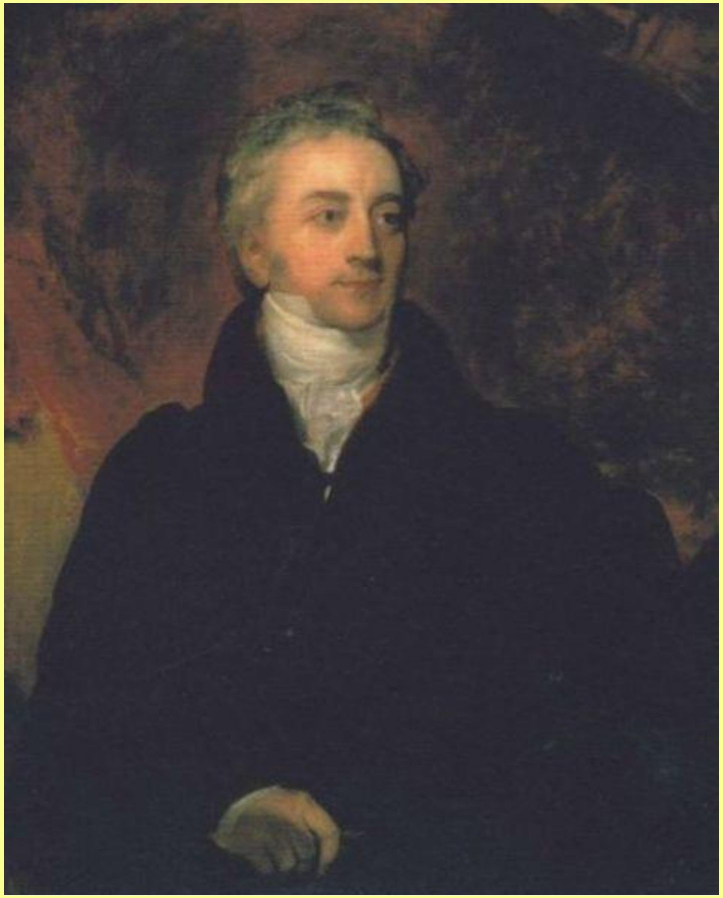
Contributions to the fields of vision, light, solid mechanics, energy, physiology, language, musical harmony and Egyptology.

Partly deciphered Egyptian hieroglyphs (specifically the Rosetta Stone) before Jean-Francois Champollion.

1802: postulated the existence of three types of photoreceptors (now called cone cells) in the eye, each of which was sensitive to a particular range of visible light.

"As it is almost impossible to conceive each sensitive point of the retina to contain infinite number of particles, each capable of vibrating in perfect unison with every possible undulation. It becomes necessary to suppose the number limited, for instance to three principle colours, red, yellow and blue."

Young's brilliant idea, thrown off casually in the course of a lecture, was forgotten, or lay dormant for fifty years, until Hermann von Helmholtz, in the course of his own investigation of vision, resurrected it



Thomas Young c1822: Sir Thomas Lawrence

Colour opponency

Ewald Hering Hering proposed colour opponency 1892.

red, yellow, green, and blue are special in that any other color can be described as a mix of them, and that they exist in opposite pairs.

either red or green is perceived and never greenish-red

six primary colour receptors

coupled as three pairs: red-green, yellow-blue and white-black.

Any receptor turned off by one of these colours, was excited by its coupled colour.

explained afterimages.

Karl Ewald Konstantin Hering (August 5, 1834 – January 26, 1918)

Cones, detect light,

3 types of cones: **L**, **M**, **S**

1956 **Gunnar Svaetichin**: fish retina opponent response in red-green and yellow-blue potentials.

Opponency requires bipolar cells, and ganglion cells. Information from the cones is passed to the bipolar cells. The information is then passed to ganglion cells,

Parvocellular P cells: handle the majority of information about color,

one type processes information about differences between firing of **L** and **M** cones, processes red-green differences

Second type processes differences between **S** cones and a combined signal from both **L** and **M** cones. **B-Y** channel

P cells also transmit information about relative intensity of light (how much of it there is) over their receptive fields.

150 years ago the World's first colour photograph

First colour system based on psychophysical measurements.

Thomas Young; no more than 3 colours required in order to bring all others into being.

"I witnessed in 1849; that **blue** and **yellow** do not make **green**, but a **pinkish tint**, when neither prevails in the combination". Vermilion (**V**), emerald (**EG**), and ultramarine (**U**) A scale around the rim measure the ratios of the primaries.

Matched observed colour on the spinning top with coloured papers. Snow white (SW) and ivory black (**BK**), in an inner circle, creating shades of gray. Adjusting ratio of primaries, matched the observed gray of the inner wheel,

$0.37V + 0.27U + 0.36EG = 0.28SW + 0.72BK$

each of the 3 colours allocated to a corner of a **triangle.** Basis of future systems of quantitative colour measurement (Colourimetry) eg CIE

1861: Royal Institution lecture. Thos Sutton, inventor of SLR camera, photographs a tartan ribbon thrice, with a different colour filter over the lens. The 3 images developed as separate transparencies, 3 projectors, with the same colour filter used to take its image; formed a colour image. (Kings College Old Anatomy Room May 19th)

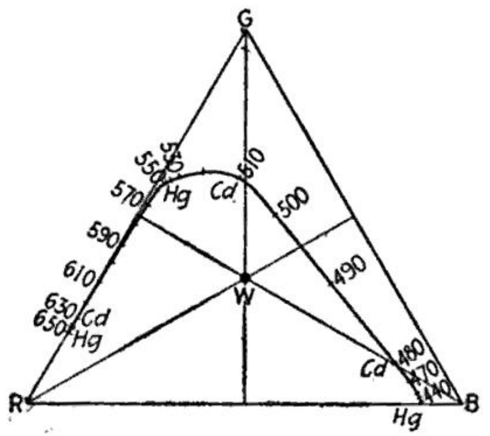
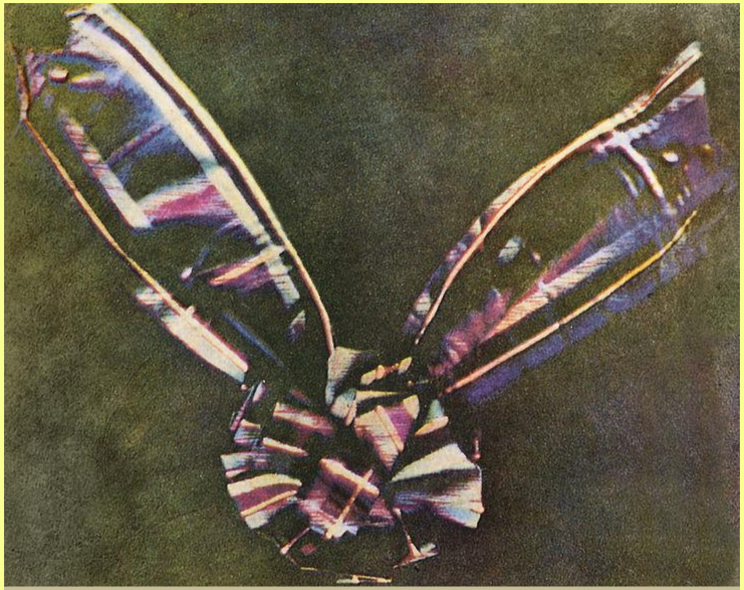


Fig. 31.—The Maxwell color-triangle.

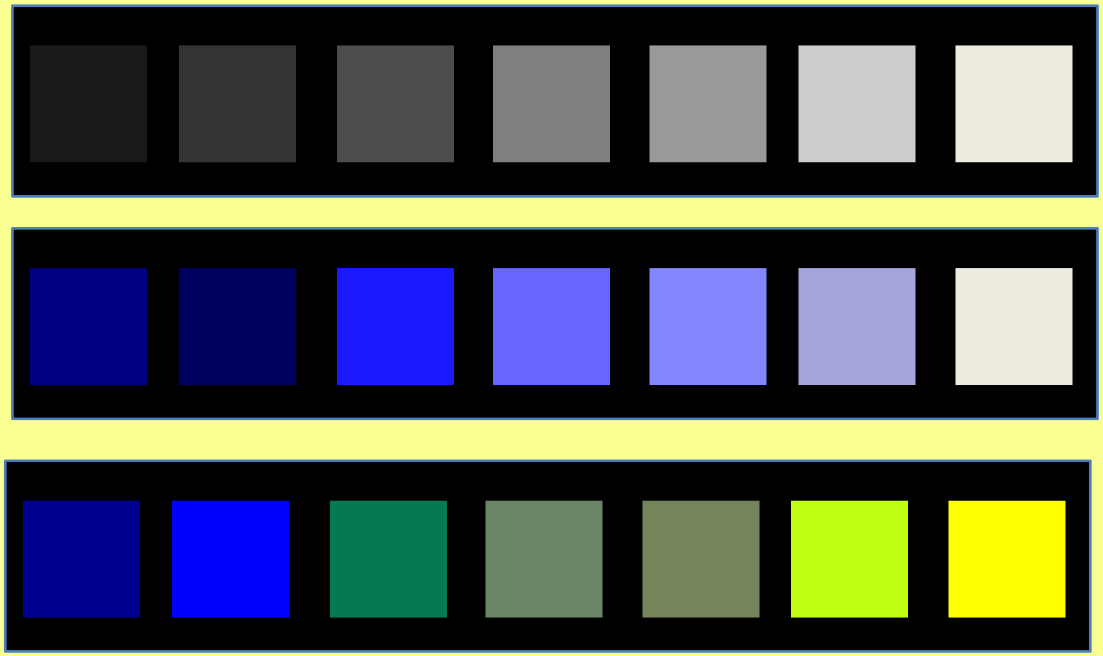
James Clerk Maxwell (1831 – 1879



The first permanent color photograph, Maxwell in 1861 using three red, green, and violet-blue filters.

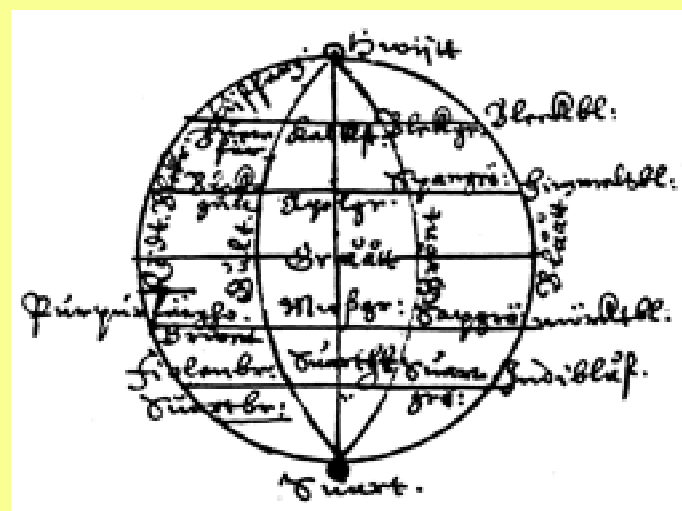
Colour scales

Theophilus



The idea of using a three-dimensional color solid to represent all colors was developed during the 18th and 19th centuries.

In 1611 A.S. Forsius published the first embryo for the Natural Colour System in his book ‘Physica’.



Tobias Mayer 1723 – 1762

b. Marbach, Württemberg, self-taught mathematician, studies Moon.

1758: lecture to the Göttingen Academy of Science "De affinitate colorum commentatio" (historical system), tried to identify the exact number of colours which the eye is capable of perceiving.

red, **yellow** and **blue** his basic colours, and vermillion, massicot and azurite as their pigments.

Black and white were considered to be the agents of light and darkness, which either lighten of darken the colours.

very small variations in colour are not noticed by the eye, as basis for calculation, Mayer adopted twelve gradations between any two basic colours, and claimed that mixing of such a twelfth part of a colour into a base colour was essential in order to perceive the new mixture.

cinnabar is characterised by r12 (12 units of red),

massicot by y12 (12 units of yellow),

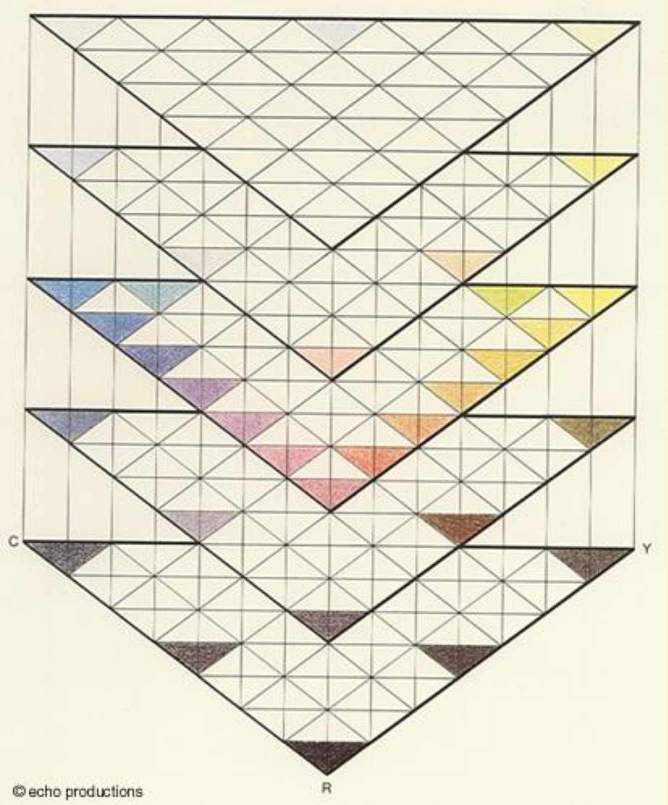
azurite by b12 (12 units of blue).

r6y6 (6 units of red, and 6 units of yellow to give orange),

b6y6 (6 units of blue and 6 units of yellow to give green)

r6b6 (6 units of red and 6 units of blue to give violet).

By placing pure colours r12, b12 and y12 at the corners of a triangle, creates a geometrical figure classifying 91 chromatic colours.



Johann Heinrich Lambert (1728-1777

Lambert's law governing the illumination of a surface by a light source

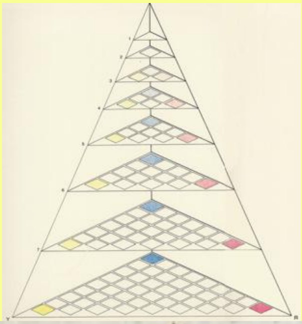
Influenced by Mayer's colour-triangle. His own experiments, suggested a pyramid constructed from a series of triangles to represent all natural colours in one geometrical form.

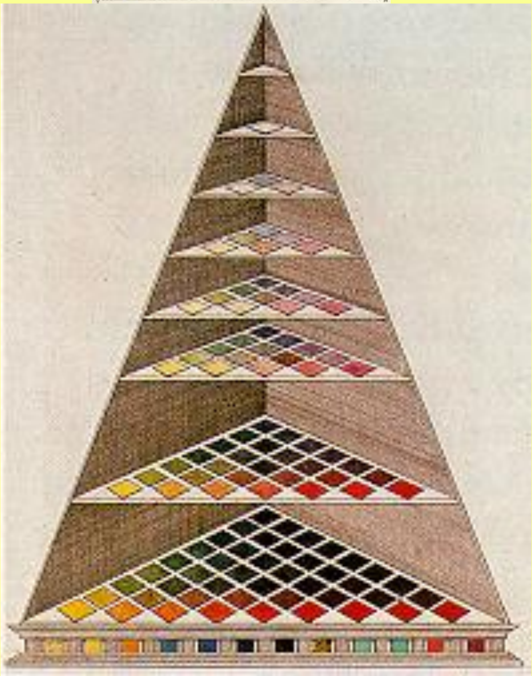
The corners of the base triangle same as Meyer's; King's yellow, cinnabar and azurite. 2 basic colours are mixed in varying proportions to form seven hues along the sides, while on the inside all three basic colours contribute to the colour of each square. 45 hues in the lowest triangle, tapering and becoming brighter as they proceed upwards. In turn, they contain 28, 15, 10, 6, 3 and finally 1 field at the tip which is white.

108 colours. incorporating the various "tertiary colours" into one system, and logically links them with the neutral grey values appearing along its central axis. Black: created by mixing all the colours is at the centre of the base triangle. Lambert believed that textile merchants, using this, would know if they stocked all the colours, and if there were gaps in their range. He also hoped that the dyers and printers of his time would find inspiration for their mixtures.

As a naturalist, Lambert used his pyramid in his efforts to identify and classify all the colours which occur in animals and plants.

Colours in insects or bird wing feathers occur not by pigment mixing but by interference patterns of light waves.





The system attempts to explain the alternating relationships between the colours using a triangular pyramid. The base triangle is black at its centre and carries the basic-colours of cinnibar, King's yellow and azurite out to the corner points. The seven layers of the pyramid gradually increase in brightness to the white tip

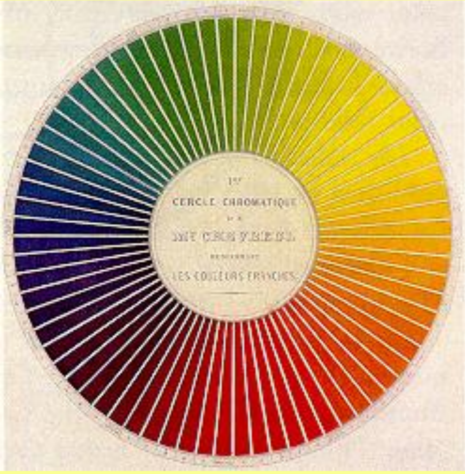
Johann Wolfgang von Goethe

studied the physiological effect of opposed colors in his *Theory of Colours* in 1810.

arranged his color wheel symmetrically, "for the colours diametrically opposed to each other in this diagram are those that reciprocally evoke each other in the eye. Thus, yellow demands violet; orange, blue; red, green; and vice versa: thus... all intermediate gradations reciprocally evoke each other.

Influenced Turner

Michel Eugène Chevreul (1786-1889)



b.Angers, father, grandfather, and a great-uncle, surgeons. Becomes chemist. Discovers margaric acid and soap made from animal fats and salt. professor of chemistry at the Lycée Charlemagne, 1824 director of the Gobelins tapestry works, researches colour contrasts . Dies aged 102.

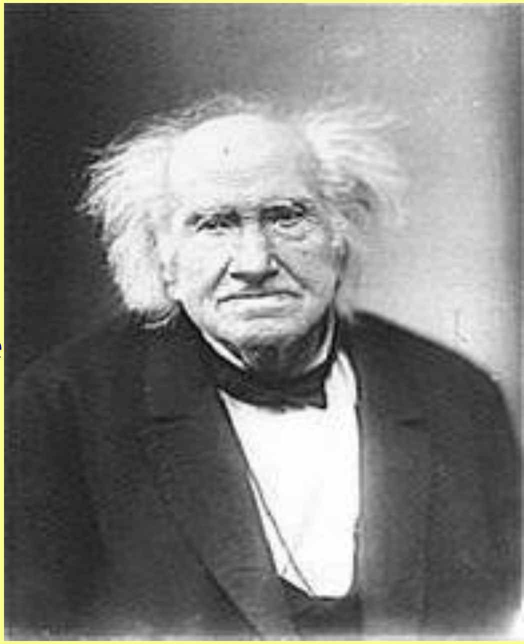
supervised the preparation of dyes. A colour frequently failed to achieve the desired effect. This was not caused by pigments, but by the influence of adjacent colours.

1839: *De la loi du contraste simultané des couleurs*; 1854: transl **“The Principles of Harmony and Contrast of Colors”**.

Simultaneous contrast of colours, Chevreul’s law:

"Two adjacent colours, when seen by the eye, will appear as dissimilar as possible”.

Leonardo da Vinci noticed that adjacent colours influence each other.



Goethe, however, was the first to specifically draw attention to these contrasts. Chevreul’s 72 colour-circle had radii, of three primaries of red, yellow and blue, three secondary mixtures of orange, green and violet and six further secondary mixtures. The resultant sectors were each subdivided into five zones and all radii were separated into 20 segments to accommodate the different brightness levels.

This is the first time that we have been confronted with the active role of the brain in the formation of colours, and we should once more remind ourselves that colours are also effects which are created in the world inside our heads

Influences Impressionism, Neoimpressionism and Orphic Cubism, with Robert Delaunay (1885-1941) using coloured "simultaneous discs" in his paintings. also influenced the views of both Eugène Delacroix (1798-1863) and Georges Seurat (1859-1891) with regard to colours and the way in which they used them.

Philipp Otto Runge 1777-1812

b. 9th of 11 children, Western Pomerania; under Swedish rule. Sickly child, trains in Copenhagen and Dresden. Mystical, Christian BYR symbolic of the Christian trinity.

B associated with God and the night,

R with morning, evening, and Jesus,

Y with the Holy Spirit.

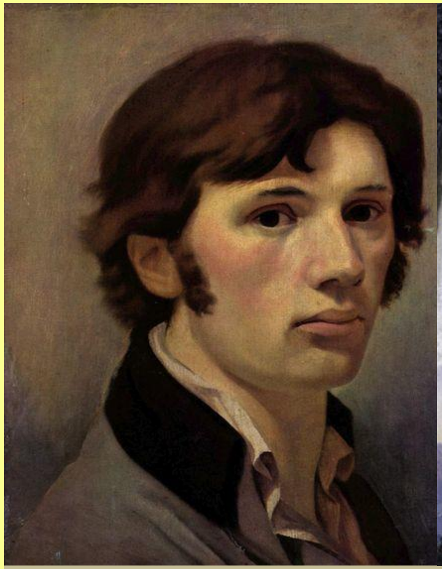
Aims to represent all colours by mixing the 3, and with B&W; which were not just colours since "light is goodness, and darkness is evil".

1806 draws a colour circle in a letter to Goethe " there are only three colors, yellow, red, and blue", arranged within a circle, then three transitional areas of orange, violet and green formed"

The colours terminate in the grey of the centre, which can also be mixed from B&W. 1807 sphere, pure colours equally spaced around the equator, neutral grey at centre; white and black at the poles.

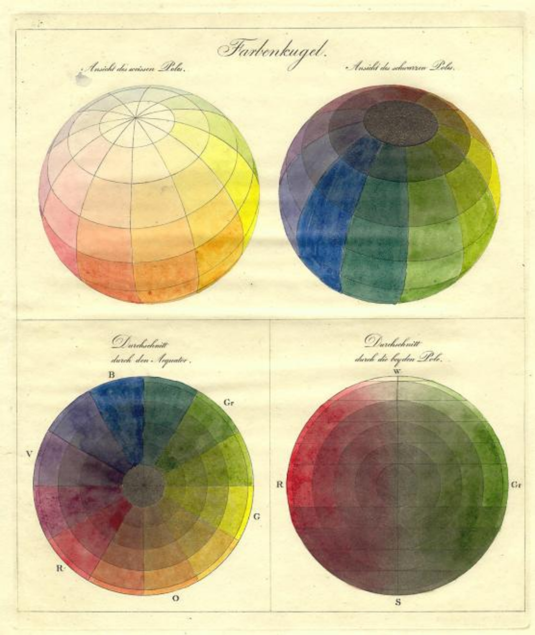
Knew of Lambert's pyramid, but wanted to place the pure colours at the same distance from white and black and therefore used a sphere.

Letter to Goethe: "If we try to think of a blueish orange, a reddish green or a yellowish violet, it is like trying to imagine a southwesterly north wind".



Self Portrait Kunsthalle

The Great Morning 1809 Kunsthalle, Hamburg



Runge's *Farbenkugel (Colour Sphere), 1810*

Munsell

Munsell color system is a color space that specifies colors based on three color dimensions: hue, value (lightness), and chroma (color purity).

Albert Munsell was a art teacher and artist who published a simple color system in 1905 and an atlas of colors in 1915. His book was successful at creating a standardized set of colors that continues to be used by artists and publishers. to this day. The Munsell standardized colors make it easy for people to communicate in the language of color. Although other tools exist to define colors, most notably the CIE 1931, they are slightly more difficult to work with in comparison to the Munsell system

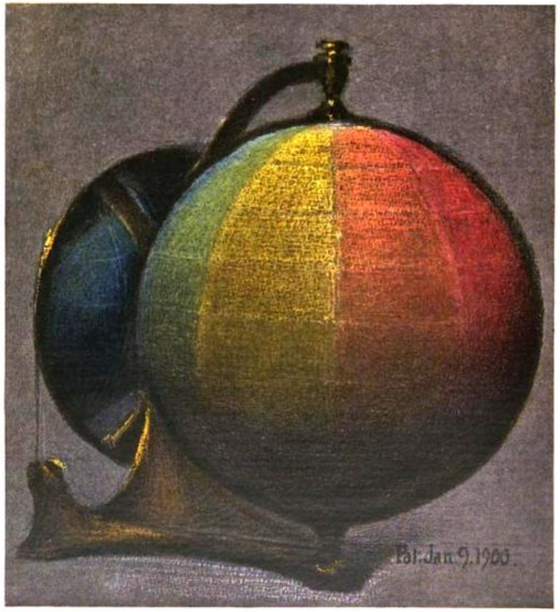
Hue ranges from 1 to 100 around a circle.

Value ranges from 0 to 10, and

Chroma, or the saturation level of a color ranges from 0 to 10.

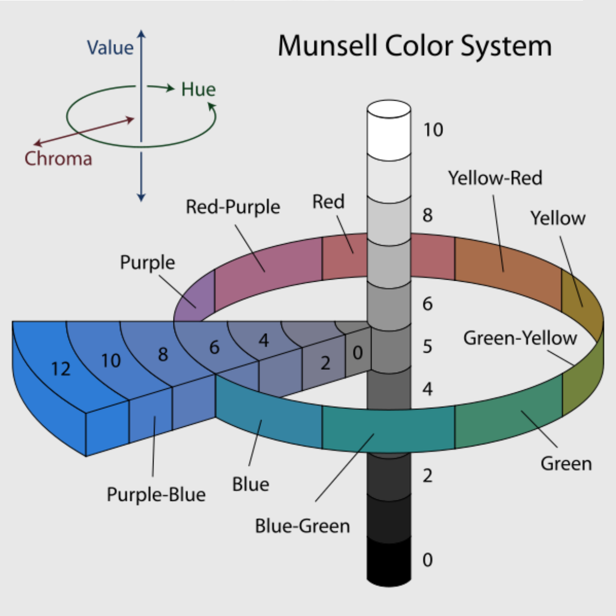
Adopted by the USDA as the official color system for soil research in the 1930s.

Several earlier color order systems had placed colors into a three dimensional color solid of one form or another, but Munsell was the first to separate hue, value, and chroma into perceptually uniform and independent dimensions, and was the first to systematically illustrate the colors in three dimensional space



A BALANCED COLOR SPHERE

A color sphere; the color frontispiece from Albert Henry Munsell's 1905 pamphlet *A Color Notation.* **1905** Munsell's color sphere, 1900. Later, Munsell discovered that if hue, value, and chroma were to be kept perceptually uniform, achievable surface colors could not be forced into a spherical shape.



The Munsell color system, showing: a circle of hues at value 5 chroma 6; the neutral values from 0 to 10; and the chromas of purple-blue (5PB) at value 5.

Colour scales

Bauhaus

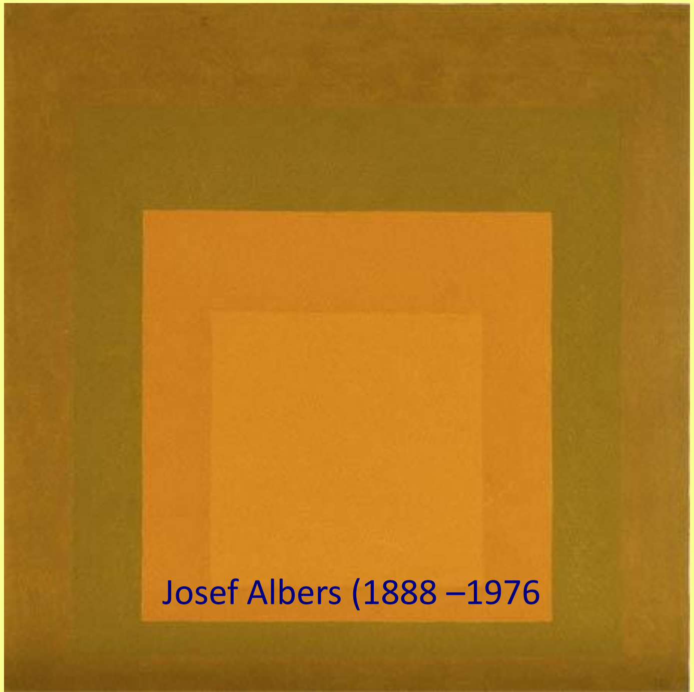
Johannes Itten (11888 – 1967) Swiss expressionist painter, designer, teacher, writer and theorist associated with the Bauhaus

follower of Mazdaznan, a fire cult derived from Zoroastrianism. strict vegetarian diet, meditation to develop inner understanding. mysticism and popularity with students distanced him from the other leading figures of the Bauhaus

The Art of Color, development of Adolf Hölzel's color wheel. Itten's "color sphere” 12 colors

Josef Albers: Interaction of Color. 1963.

Farbkreis by Johannes Itten (1961)



Josef Albers (1888 –1976

Subtractive colour

Subtractive color mixing occurs when light is reflected off a surface or is filtered through a translucent object.

Thus **red pigment** absorbs (subtracts) all of the light that is not red and only reflects red.

As a consequence mixing pigments and dyes, gives a different result from combining coloured lights; any colour can be made from RGB lights,

what happens with mixing of red, green and blue pigments?

It doesn't work.

red pigment absorbs green and blue, the

blue pigment absorbs red and green,

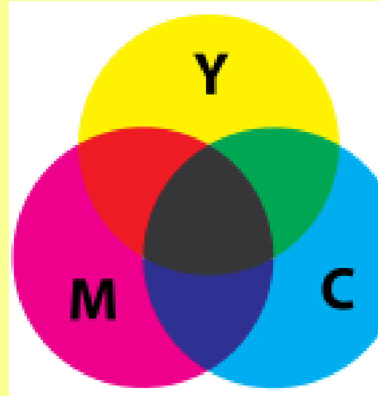
green pigment absorbs red and blue.

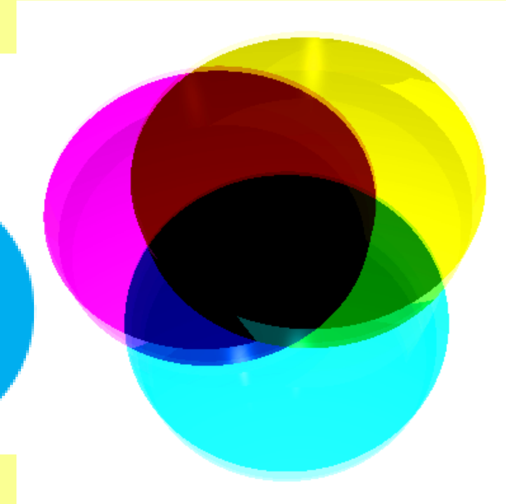
In order to print something that is red, we need to absorb both blue and green. To absorb the blue, use yellow ink. To absorb green, use magenta. So, by combining both yellow and magenta pigments, we're left with red!

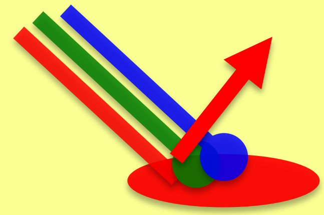
Blackness of Black

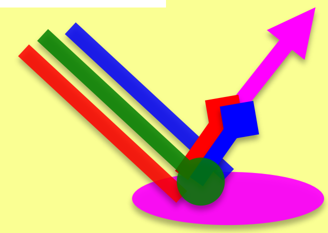
combining all three subtractive pigments yields black. In practice not a true black color as printing with black ink, so most colour printing is done with four inks, cyan, magenta, yellow and black, or CMYK. ("K" not "B" avoids confusion with blue).

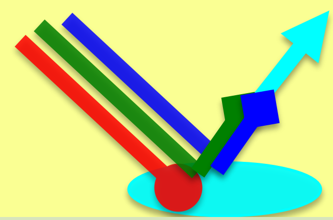
With ink jet printers, much cheaper to print with black ink











Combination	**Absorbs**	**creates**
Cyan + Magenta	Red + Green	**Blue**
Cyan + Yellow	Red + Blue	**Green**
Magenta + Yellow	Green + Blue	**Red**
Cyan + Magenta + Yellow	Red + Green + Blue	**Black**

Colour space

x, y, and z axes the stimuli for the long-wavelength (L), medium-wavelength (M), and short-wavelength (S) receptors.

The origin, (S,M,L) = (0,0,0), corresponds to black.

White has no definite position in this diagram; rather it is defined according to the white balance as available from ambient lighting.

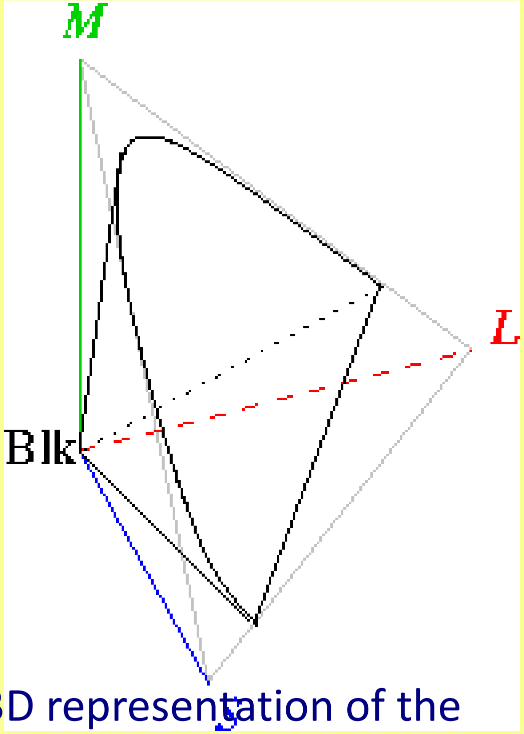
Human color space is a horse-shoe-shaped. receptors will be damaged at extremely-high light intensities.

The most saturated colours around outer rim of the region, with brighter colors farther removed from the origin.

For receptors, no such thing as "brown" or "grey" light.

overhead projector black lettering. The "black" areas have not actually become darker but appear "black" relative to the higher intensity "white" projected onto the screen around it. Like Moon.

The human tristimulus space has the property that additive mixing of colours corresponds to the adding of vectors in this space. This makes it easy to, for example, describe the possible colours (gamut) that can be constructed from the red, green, and blue primaries in a computer display.



3D representation of the human color space.

CIE Commission internationale de l'éclairage

The eye is more sensitive to the green-yellow part of the spectrum. Light of other wavelengths with same radiant intensity appears dimmer (power luminous intensity).

1920's: **W. David Wright and John Guild**:

Investigated how people perceive color.

Subjects looked at two colored dots from light beams. 2° circular split field: One was a fixed color the other could be changed by manipulating knobs to combine the three primary light colors of red, green and blue, to match the fixed color.

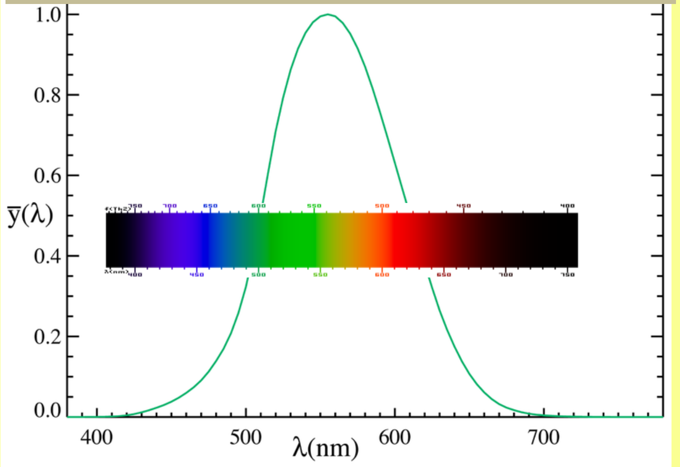
The same color could be created by many different combinations of three colors.

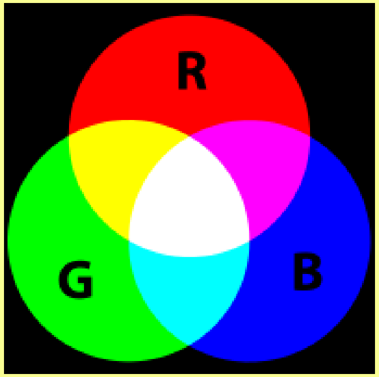
primaries at 435.8 nm, 546.1nm, and 700 nm.

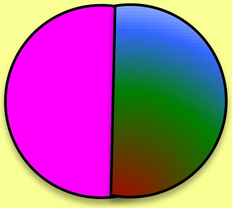
plot of the relative intensities of the RGB primaries that matched monochromatic stimulus at each wavelength. minus value means that one of the primary colors had to be added to make the match.

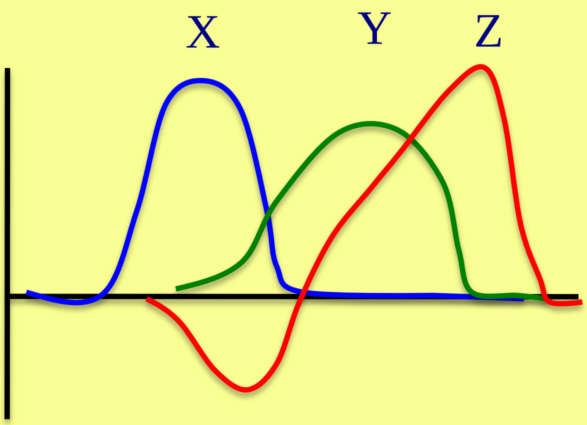
Their results were combined to create the **Standard Observer**

The response of a typical human eye to light, as standardized by the CIE in 1924









CIE Commission internationale de l'éclairage

In 1931, the International Commission on Illumination using Wright & Guild's data established the first system for scientifically defining light colors or additive colors. widely accepted, internationally; still the "gold standard"

Each colour can be given a value based on the relative stimulation of each of the 3 channels, based on sensitivities of cones to S M and L wavelengths.

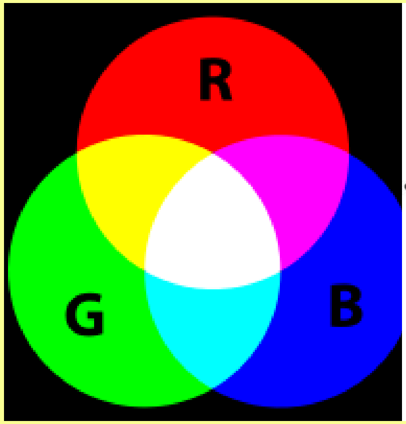
Colour can be defined by an xyz triplet which are normalised versions of XYZ:

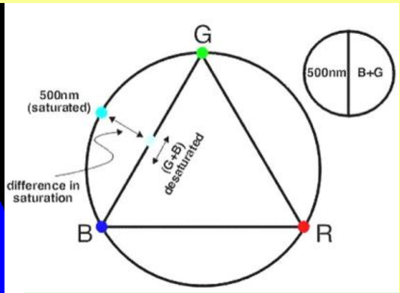
$$x = \frac{X}{X+Y+Z} \qquad y = \frac{Y}{X+Y+Z} \qquad z = \frac{Z}{X+Y+Z}$$

x+y+z =1 so only need 2 co-ordinates

CIE 1931 Color Space or CIE XYZ: a full plot of all visible colors is a three-dimensional figure. However, the concept of color can be divided into two parts: brightness and chromaticity.

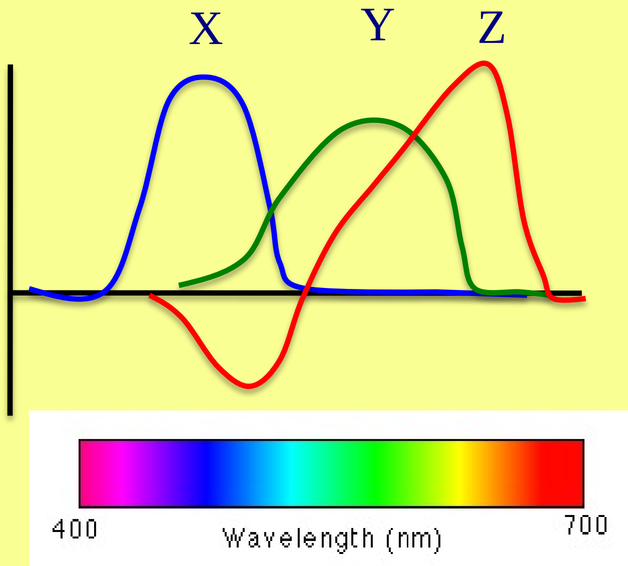
white is a bright color, while the color grey is considered to be a less bright version of that same white. In other words, the chromaticity of white and grey are the same while their brightness differs





500 nm (S)

° G + **B** - **R**

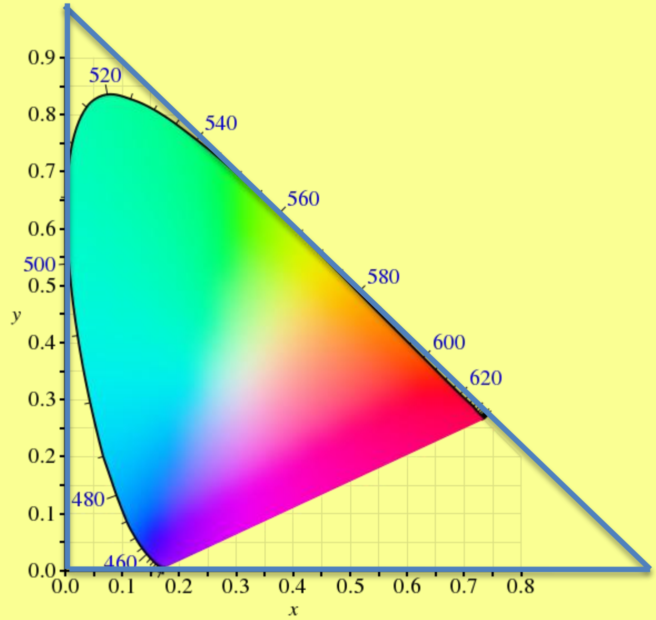


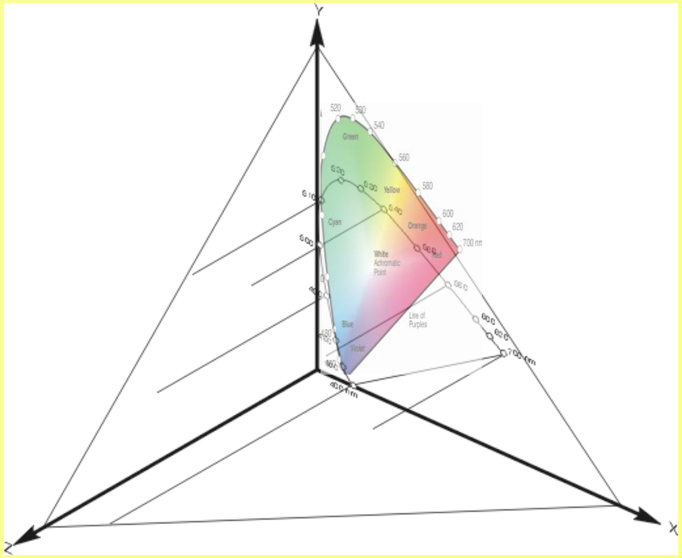
CIE

Chromaticity, ie the color we see, determined by the dominant wave length . All the chromaticities are the gamut of human vision.
The CIE gamut chart displays all the chromaticities which an average person can see. Plotted in 2D, forms an ellipsoid.
Different technologies (computer monitor, TV, LEDs, plasma screen, inkjet printer) have different colour gamuts.

CIE 1931 color space, reflects only hue and saturation, which make up together **chromaticity.**
The third dimension – lightness – is not shown in the diagram. 2 co-ordinates will find a colour (although 3 needed to define a colour) distorted like a map of the globe, (where we use lat/longitude to define position how high up not accounted for)
the curved edge is the spectal locus. Shows the wavelength of the single un-mixed colours.
Colours less saturated toward the centre. **White**, (point of equal frequency energy distribution), located at intersect of 1/3 x and 1/3 y
Lower border; the line of purples, these colors have no monochromatic definition. Only formed by mixing different proportions of the two colours at the bottom corners. This line connects the endpoints of the visible spectrum.

The colour of any light-emitter (bulb, flame, spark,, LED, backlit-LCD, etc.) can be defined by a CIE x,y coordinate.
However the colour of reflective, non-emissive material (paint, paper, fabrics, skin, fur, leaf, petal.) can only be defined by a CIE x,y coordinate illuminated by a given source of illumination





The Natural Colour System

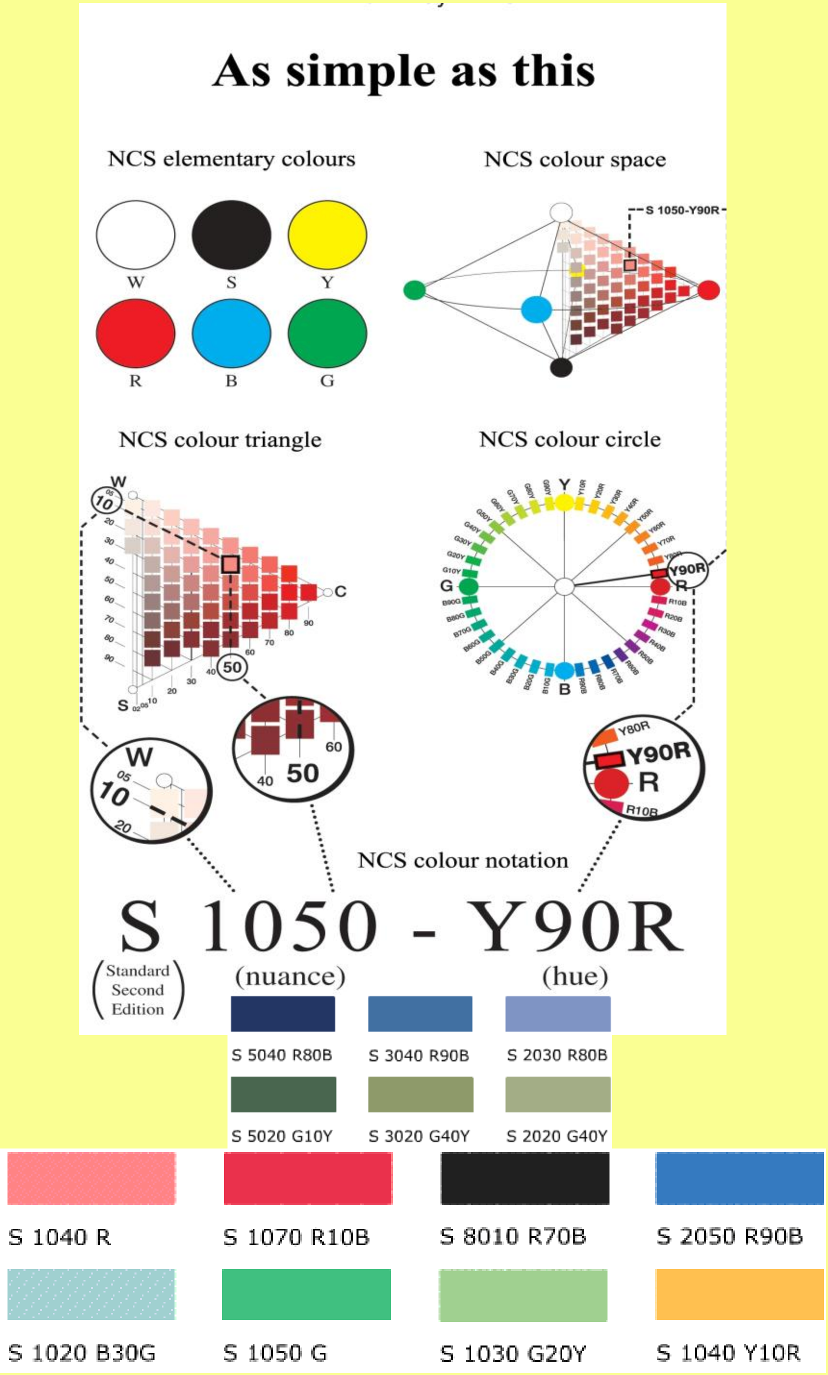
Based on how our eyes and brains register these light wavelengths and perceive colour.

people involved in the development of NCS: Tryggve Johansson, Sven Hesselgren and Anders Hård.

NCS is based around six elementary colours, which can only be perceived and described as 'themselves'. White, black,yellow, red, blue and green. In their purest form there is no other way to describe their appearance.

Modern education will have taught most of us that yellow, red and blue are primary colours. This, while being true, is not entirely the best way to consider colours as it is knowledge based upon how to mix or produce colours. The drawback with primary colours being mixed is that yellow and blue do not produce a clear, chromatic green. We now know that, in modern tinting, there can be as many as 16 different colourants used to reach a reasonably large colour gamut.

It is for this reason that NCS as a colour system incorporates green as one of its elementary colours. It is also one of the small considerations which contributes to NCS being the most widely used colour system today.



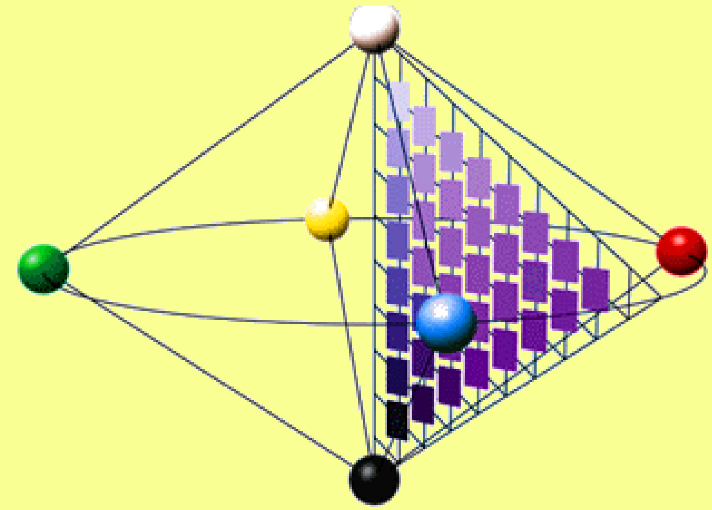
Talking about colour

The Natural Colour System is a user friendly colour language. It is the only colour system which describes colour exactly as we see it. NCS is used by professionals as a tool for precise colour communication, selection and specification.

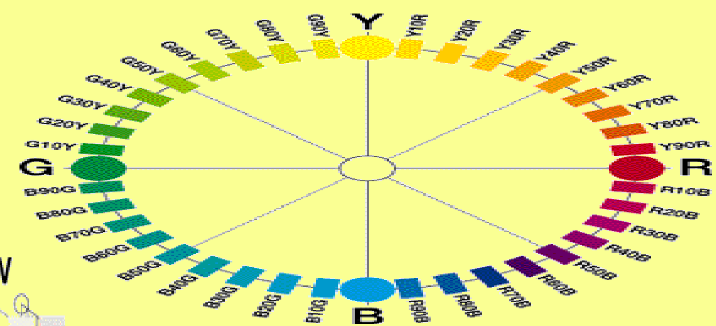
In order to accurately communicate the colours we see, we need a reference or notation system with the ability to pinpoint precise colour.

Six Elementary Colours. White, Black, Yellow, Red, Blue and Green.

The colours plotted on 3D model NCS Colour Solid. Every colour in the Natural Colour System is contained within the NCS Colour Solid, and can be described in terms of the six Elementary Colours.

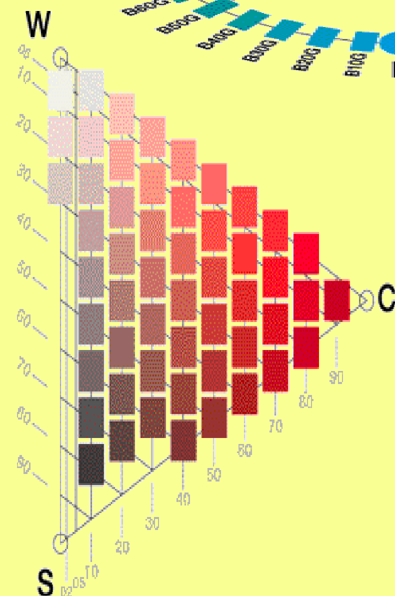


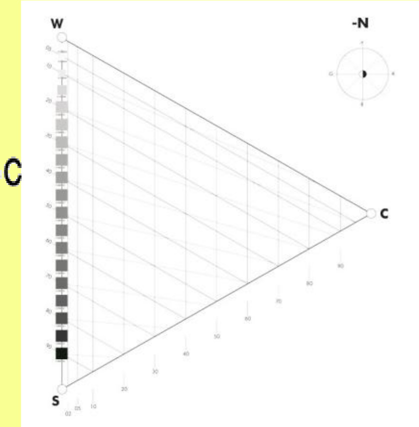
The NCS Colour Circle is a horizontal slice through the NCS Colour Solid, and viewed from above; is a progression from Yellow to Red to Blue to Green and back round to Yellow in 100 steps (hues); shown in 10% steps.



The NCS triangle is a vertical section through the NCS model at one of the steps. Each of the steps (hues) indicated on the colour circle corresponds to a vertical slice which can be visualised in an NCS colour triangle.

At the vertical base of the colour triangle is the grayscale from white to black and at the apex of the triangle is the point of most chromaticness (colour strength). Within each triangle you can plot the nuances for the colours in this step according to blackness, chromaticness and whiteness, all colours sharing the same hue will be found in a single triangle (a single colour family).





Y90R section, which shows all the colours on the Atlas page for the hue Y90R between White, Black and the full chromatic colour ('C').

NCS colour notations are based on how much a given colour seems to resemble these six elementary colours.

S 1050-Y90R

S shows that it is one of the 1,950 NCS standardised colours (Second edition).

The next two numbers show the colour's percentage of blackness

The following two show the percentage of chromaticness. The 4 numbers are the colour's nuance. ie the degree of resemblance to black, which is 10% and to the maximum chromaticness which is 50%.

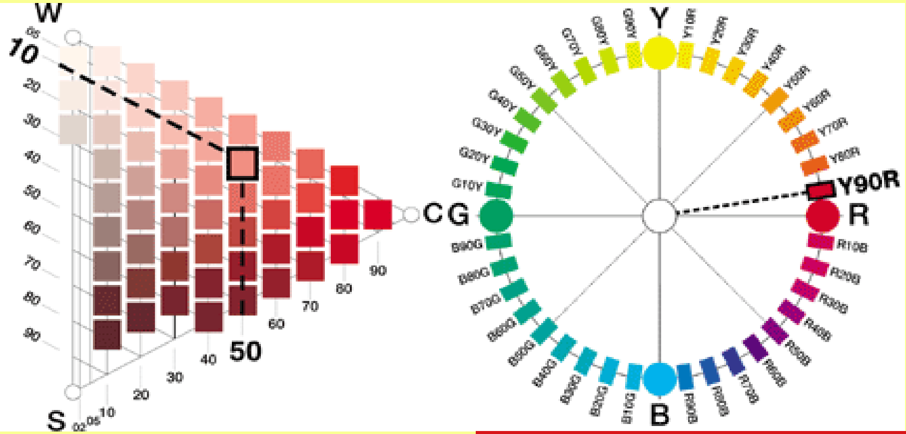
The next part of the NCS notation denotes which colour family this notation belongs (The hue of the colour). The first letter, Y, denoting this colour is a Yellow, but has 90% of R (Red). Thus it's a yellow (10%) with 90% red.

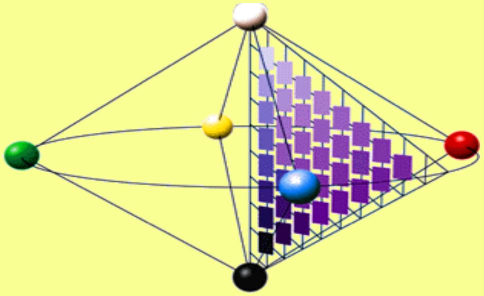
S2030-Y90R

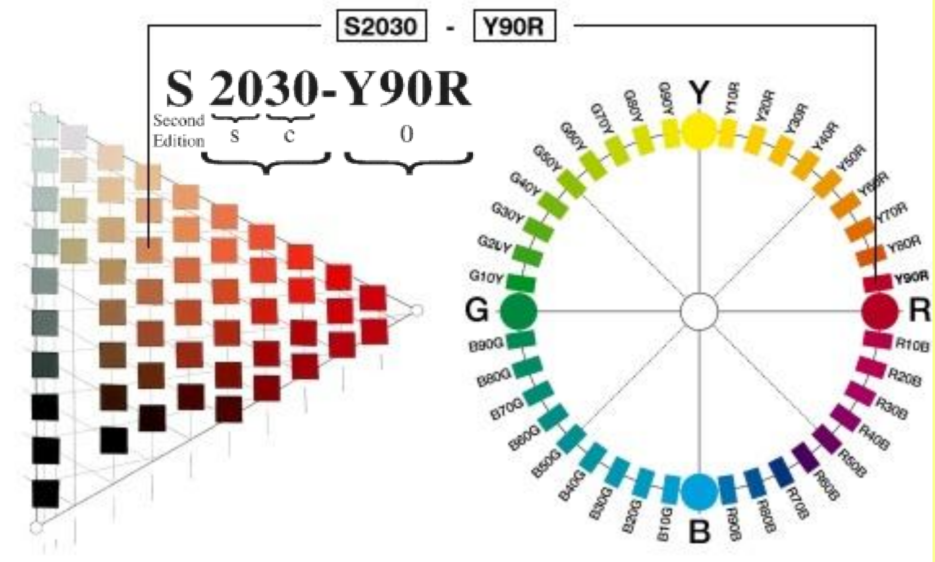
The hue Y90R describes the degree of resemblance between yellow and red (Y and R). Y90R describes a yellow with 90% redness and 10% yellowness.

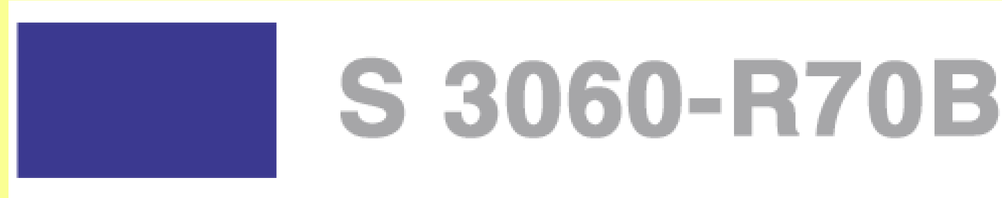
The nuance is 20% black 30% chromaticity

Achromatic colours (Black, White and Grey) lack Hue and are only given Nuance notations, followed by -N for neutral. S 0500-N is White and is followed by S 1000-N, S 1500-N, S 2000-N and so on to S 9000-N, which is Black.









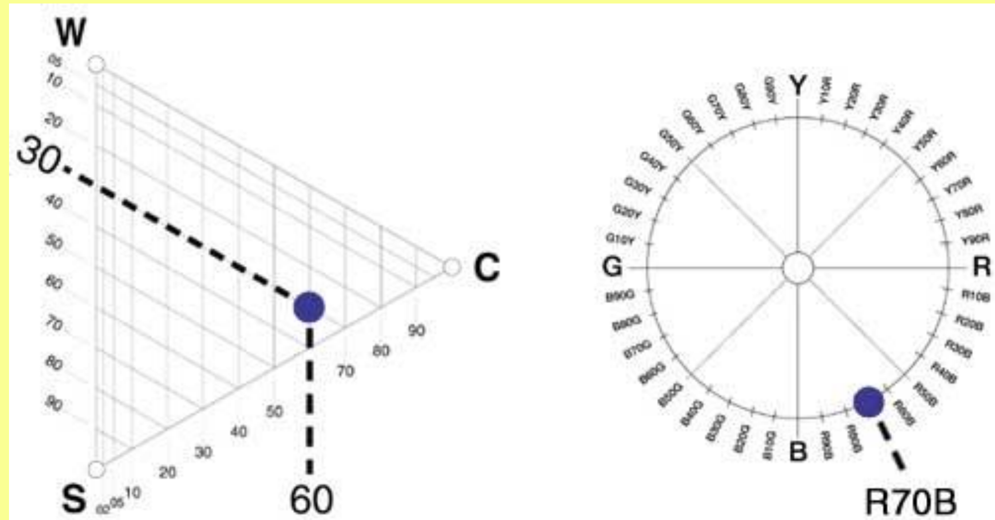
The **NCS Atlas**

shows the full range of 1950 colours on 40 hue pages with a page of neutral and tinted greys, making colour reference and selection quick and easy

The human can see approximately 10 million different colours. Obviously how we react to them is subjective and our clarity of vision can vary but the basic fact remains - we all see and visually process colours the same way.

To insert or produce all of the 10 million colours in the Colour Space or its constitute parts is needless, would be very confusing, incredibly expensive for the user and have a big impact on our environment. Instead, a range of 1,950 standard colours has been selected to represent the best possible distribution of colours.

Selecting hues at every tenth step of the colour space gives a very good, workable spread of colours from across the visual spectrum.



Characteristics of colours

Chromatic means that a colour corresponds to a hue.

Hue describes the relative amount of the two nearest chromatic elementary colours (yellow, red, blue and green) that the colour is perceived to contain.

Achromatic colours - black, white and the greys **-** are colours that are devoid of any chromaticness

Lightness: measured by light reflectance value, or by comparison with samples having known lightness values, e.g. the NCS Lightness Meter, grey scale. Colours with the same lightness are found along the straight lines of the diagram. The positioning of these lines will vary for different hues.

Nuance: a colour's relationship to black and to maximum colour intensity or chromaticness. Colours that have the same nuance but a different hue will be found in exactly the same location of the NCS Colour Triangle.

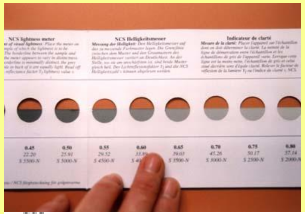
Saturation is the term used to describe the strength of a hue, or the purity of a colour. Colours with the same saturation are found along a straight line throught the black point (S) on the NCS Colour Triangle.

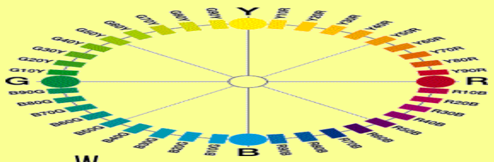
Chromaticness corresponds to the hue and saturation of a colour. The higher the chromaticness the more saturated the colour is. S1050-Y10R has a chromaticness value of 50. Colours with the same chromaticness can be found along lines parallel to greyscale W-S.

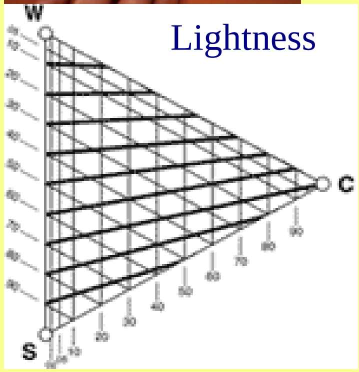
Blackness describes the perceived amount of black in the colour relative to pure black. A colour with the notation S 2060-Y10R has a blackness value of 20. Colours with the same blackness are found along the straight lines parallel to the side W-C on the NCS Colour Triangle.

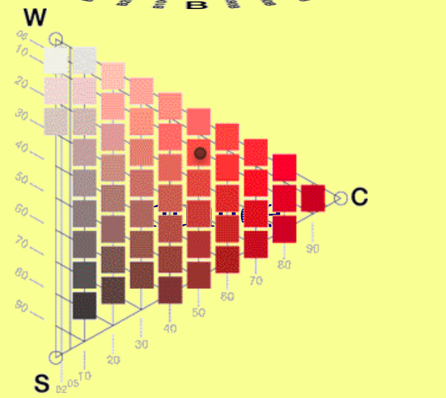
Whiteness = 100 - (Blackness + Chromaticness)

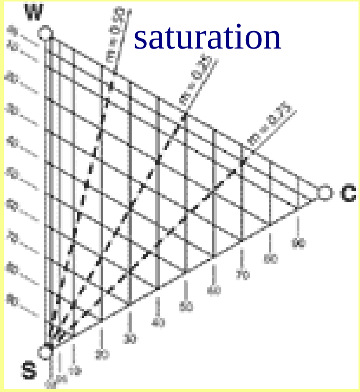
For example, a colour with the notation S 2060-Y10R has a whiteness value of 20. Whiteness = 100-(20+60). Colours with the same whitenes are found along any straight line parallel to the side S-C on the NCS Colour Triangle

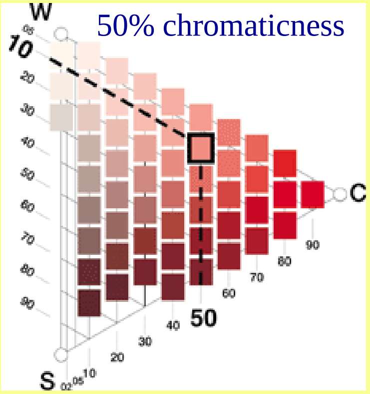


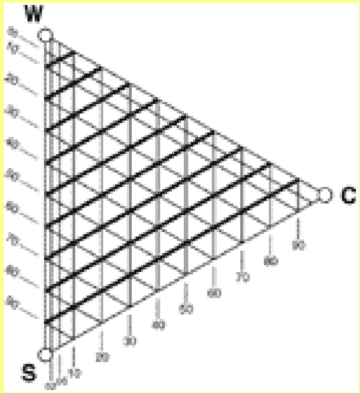


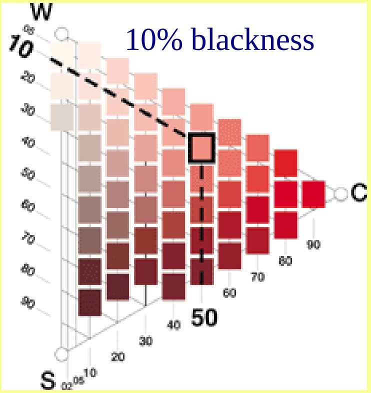




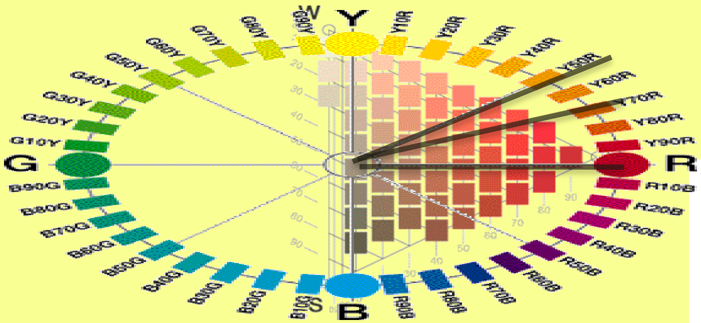


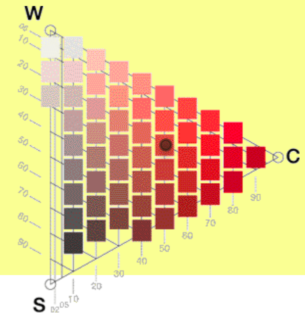






Colour planning



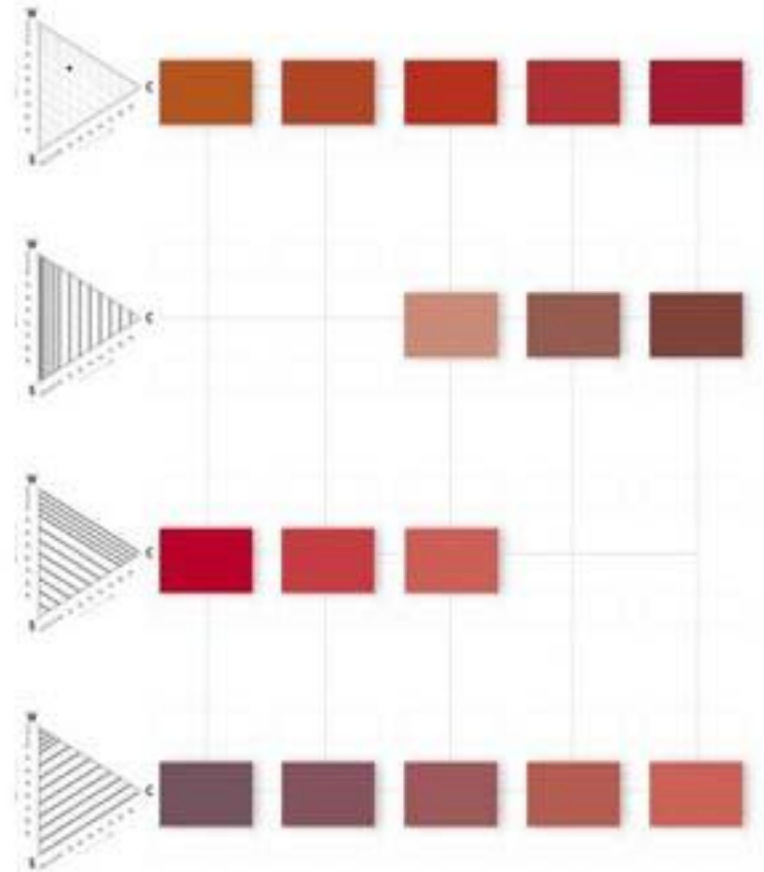


By Nuance

By chromaticness

By blackness

By whiteness.



Colour constancy

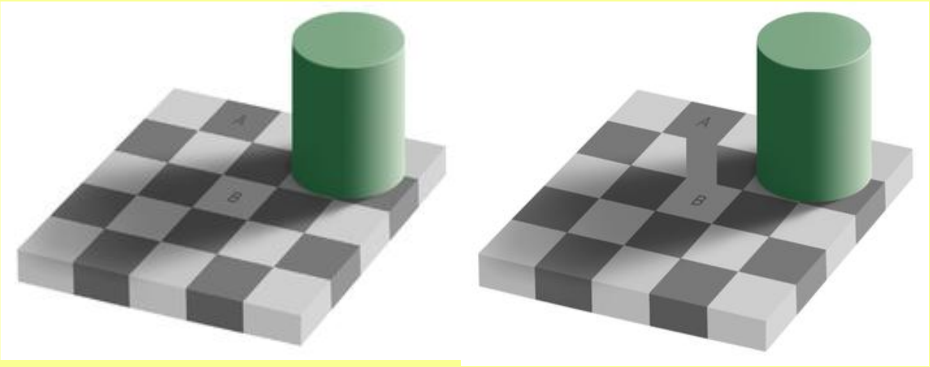
Color constancy is an example of subjective constancy

ensures that the perceived color of objects remains relatively constant under varying illumination conditions.

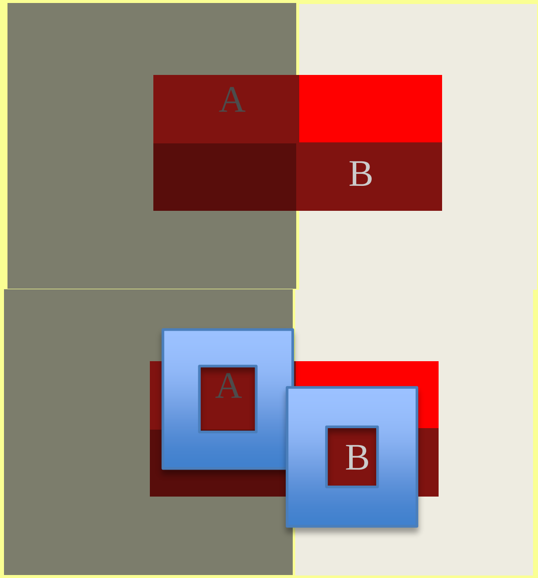
A green apple for instance looks green to us at midday, when the main illumination is white sunlight, and also at sunset, when the main illumination is red. This helps us identify objects.

The physiological basis for color constancy is thought to involve specialized neurons in the primary visual cortex that compute local ratios of cone activity

Color constancy works only if the incident illumination contains a range of wavelengths. The different cone cells of the eye register different ranges of wavelengths of the light reflected by every object in the scene. From this information, the visual system attempts to determine the approximate composition of the illuminating light. This illumination is then *discounted in order to obtain the object's "true color" or reflectance: the wavelengths of light the object reflects. This reflectance then largely determines the perceived color.*



Constancy makes square A appear darker than square B, when in fact they are both exactly the same shade of grey



His theory was rehabilitated in the 1970s when Edwin Land developed the Retinex theory that stated that whereas Helmholtz's colors hold for the eye, in the brain the three colors are translated into six.

The word "retinex" is a portmanteau formed from "retina" and "cortex", suggesting that both the eye and the brain are involved in the processing.The effect can be experimentally demonstrated as follows. A display called a "Mondrian" (after Piet Mondrian whose paintings are similar) consisting of numerous colored patches is shown to a person. The display is illuminated by three white lights, one projected through a red filter, one projected through a green filter, and one projected through a blue filter. The person is asked to adjust the intensity of the lights so that a particular patch in the display appears white. The experimenter then measures the intensities of red, green, and blue light reflected from this white-appearing patch. Then the experimenter asks the person to identify the color of a neighboring patch, which, for example, appears green. Then the experimenter adjusts the lights so that the intensities of red, blue, and green light reflected from the green patch are the same as were originally measured from the white patch. The person shows color constancy in that the green patch continues to appear green, the white patch continues to appear white, and all the remaining patches continue to have their original colors.

The second card from the left seems to be a stronger shade of pink in the top picture. In fact they are the same color, but the brain changes its assumption about color due to the color cast of the surrounding photo.

THANK YOU