COLOUR : THE BASICS IN ESTHETICS...

AN AGE IS CALLED DARK, NOT BECAUSE THE LIGHT FAILS TO SHINE, BUT BECAUSE PEOPLE REFUSE TO SEE IT...

JAMES MICHENER.

APPEARANCE CANNOT BE DESCRIBED BY ANY DEVICE BECAUSE IT'S ESSENTIALLY A SUBJECTIVE SENSATION. IT CAN BE DESCRIBED IN IDEALIZED AND STANDARDIZED TERMS, USUALLY FACTORS WITH NUMBERS THAT CORRELATE WITH WHAT IS PERCIEVED. THERE ARE 2 TYPES OF APPEARANCES: CHROMATIC AND GEOMETRIC. CHROMATIC ATTRIBUTES ARE ASSOCIATED WITH COLOUR WHILE GEOMETRIC ATTRIBUTES ARE ASSOCIATED WITH SURFACE PROPERTIES.

AppeArAnce Attributes:

- Colour
  - Hue – actual colour of object
  - Value – lightness and/or darkness of colour
  - Chroma – intensity of colour

  (Hue, value and cHroma will be discussed in detail in article of shade selection)
- translucency
- Opacity
- Gloss
- Surface roughneSS
- Opalescence
- IrIdescence
- Fluorescence
- PhosPhorescence

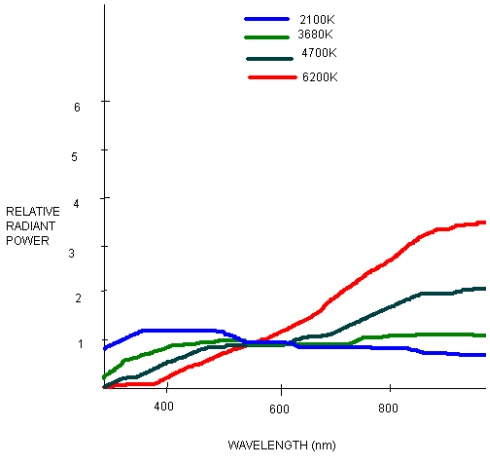
COLOUR IS A PHYSIOLOGICAL SENSATION THAT RESULTS WHEN HUMAN VISUAL SYSTEM RESPONDS TO THE LIGHT REFLECTED FROM OBJECTS IN A SCENE. THE LIGHT THAT REACHES THE EYES FROM EACH POINT IN A SCENE IS THE PRODUCT AT EACH WAVELENGTH OF THE SPECTRAL REFLECTANCE OF THE OBJECTS IN THE SCENE AND THE SPECTRAL POWER OF THE ILLUMINATING LIGHT SOURCE. THE SPECTRAL COLOUR SIGNAL IS FOCUSED BY THE LENS AND THEN SAMPLED BY A MOSAIC OF PHOTORECEPTORS IN THE RETINA THAT LINES THE EYEBALL. COLOUR IS ONE ATTRIBUTE OF THE SENSATION OF VISION. COLOUR VISION DERIVES FROM THE FACT THAT THE RETINA CONTAINS THREE CLASSES OF PHOTORECEPTORS, WHICH HAVE DIFFERENT SENSITIVITIES TO WAVELENGTH OF LIGHT.

THE NATURE OF LIGHT:

LIGHT IS A FORM OF ENERGY. SPECIFICALLY IT IS THAT PART OF THE SPECTRUM OF ELECTROMAGNETIC RADIATION TO WHICH HUMAN EYES ARE SENSITIVE. RADIOWAVES, X-RAYS, ULTRAVIOLET RAYS AND INFRARED RAYS ARE ALL PART OF FAMILY OF ELECTROMAGNETIC RADIATION; BUT THE HUMAN VISUAL SYSTEM IS CAPABLE OF SENSING ONLY A VERY NARROW BAND OF WAVELENGTHS IN THE APPROXIMATE

RANGE OF 360 TO 780 Nm. THE LIGHT FROm ANY SOURCE CAN BE DESCRIBED IN TERmS OF THE RELATIVE POWER EMITTED BY THE SOURCE AT EACH WAVELENGTH IN THE VISIBLE SPECTRUM.

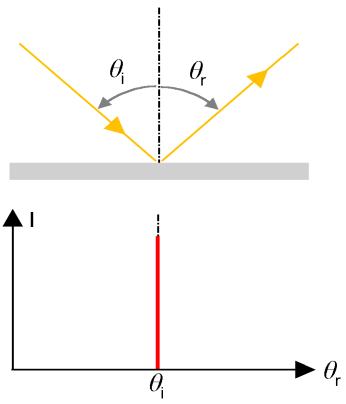
THE SPECTRAL POWER DISTRIBUTION (SPD) OF DAYLIGHT VARIES WITH GEOGRAPHIC POSITION AND WITH THE DAY TIME AND YEAR, BUT THE SET OF DAYLIGHT SPD'S IS VERY SIMILAR TO THAT EMITTED BY A BLACKBODY HEATED AT VARIOUS TEMPERATURES. A BLACKBODY IS A HOLLOW, HEATED CHAMBER WITH A SMALL HOLE; AS THE BLACKBODY IS HEATED, THE SPD OF THE LIGHT EMITTED FROM THE HOLE VARIES. FOR MANY LIGHT SOURCES IT IS USEFUL TO REFER TO THE TEMPERATURE OF THE BLACKBODY WHOSE RADIATION MOST CLOSELY RESEMBLES THAT OF THE LIGHT SOURCE. THE TEMPERATURE IS CALLED THE *CORRELATED COLOUR TEMPERATURE*. THE RADIATION OF NORTH SKY DAYLIGHT ON A CLOUDY DAY HAS A CORRELATED COLOUR TEMPERATURE OF ABOUT 6500K. THE LIGHT FROM A TUNGSTEN FILAMENT BULB HAS RELATIVELY MORE POWER AT THE LONG WAVELENGTHS, WHICH GIVES IT A MUCH LOWER CORRELATED COLOUR TEMPERATURE. IF TWO LIGHT SOURCES HAVE THE SAME CORRELATED COLOUR TEMPERATURES, THIS DOES NOT NECESSARILY MEAN THAT THEY HAVE IDENTICAL SPD'S. ILLUMINANTS D65 AND D55 ARE OFTEN USED TO SPECIFY DAYLIGHT SOURCES; THEY REFER TO A BLACKBODY AT 6500 AND 5500 K RESP.



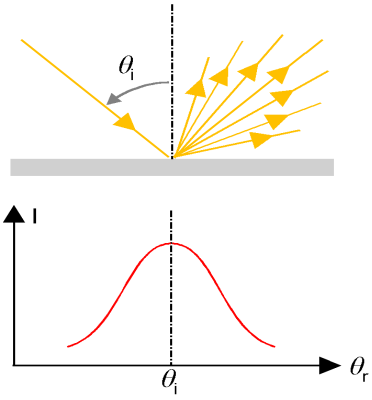
THE SPECTRAL POWER DISTRIBUTION OF VARIOUS PHASES OF DAYLIGHT (NORMALISED AT 560 nm) FOR FOUR DIFFERENT CORRELATED COLOUR TEMPERATURES.

THE PHYSICAL SPECIFICATION OF OBJECT COLOUR:

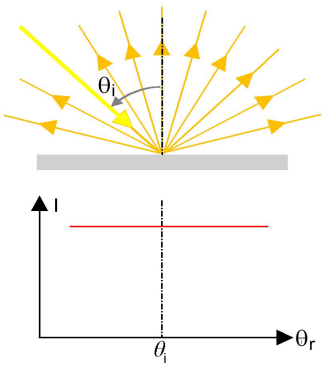
WHEN LIGHT STRIKES AN OBJECT, A RANGE OF INTERACTIONS IS POSSIBLE. THE LIGHT MAY BE REFLECTED, REFRACTED, ABSORBED, SCATTERED, AND/OR TRANSMITTED. SOME LIGHT IS ALWAYS REFLECTED FROM THE SURFACE, AT THE BOUNDARY BETWEEN THE OBJECT AND AIR, BECAUSE OF THE CHANGE IN THE *REFRACTIVE INDEX.* (THE REFRACTIVE INDEX OF THE MATERIAL IS THE RATIO OF THE SPEED OF LIGHT IN A VACUUM TO THE SPEED OF LIGHT IN THE MATERIAL.) THIS REFLECTED LIGHT, WHICH HAS THE SAME SPD AS THE ILLUMINATING SOURCE, IS CALLED *SURFACE REFLECTANCE* AND MAY BE DIFFUSE OR SPECULAR. IN DIFFUSE REFLECTANCE THE LIGHT IS DISPERSED IN MANY DIFFERENT DIRECTIONS, OCCURS WHEN THE SURFACE IS ROUGH; A SMOOTH, GLASS-LIKE SURFACE GIVES RISE TO SPECULAR SURFACE REFLECTANCE, IN WHICH THE ANGLE OF REFLECTION IS EQUAL TO THE ANGLE OF INCIDENCE. THE LIGHT THAT IS NOT REFLECTED AT THE SURFACE ENTERS THE BODY OF THE MATERIAL AND BECOMES SUBJECTED TO FURTHER INTERACTIONS. IF THE MATERIAL IS TRANSPARENT, SOME LIGHT PASSES THROUGH THE MATERIAL AND EMERGES AT THE OTHER SIDE.



SPECULAR REFLECTION

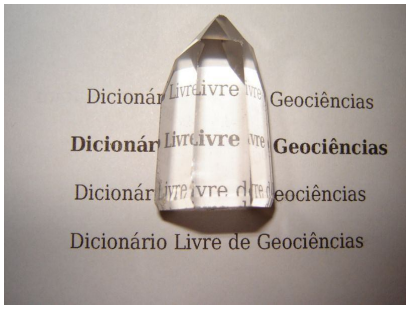


HAZE REFLECTION



LAMBERTIAN REFLECTION

A butterfly (*Greta morGane*) with transparent wings. the body can clearly be seen through the wings



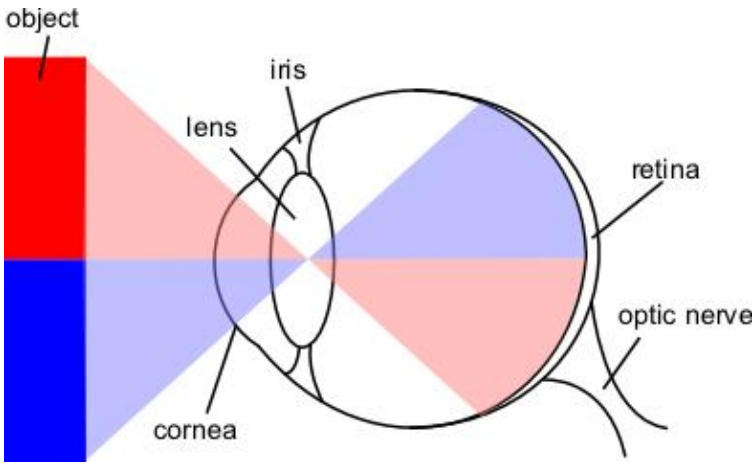
TRANSPARENT OBJECT SHOWING THE BACKGROUND THROUGH IT.

TWO PROCESSES THAT PRIMARILY REDUCE TRANSPARENCY ARE *ABSORPTION* AND *SCATTERING*. ABSORPTION IS A PROCESS WHEREBY PART OF THE INCIDENT LIGHT IS REMOVED BY INTERACTION WITH THE MOLECULES OF THE OBJECT. MOST OBJECTS ARE COLOURED BECAUSE THE ABSORPTION PROCESS IS GREATER AT CERTAIN WAVELENGTHS THAN AT OTHERS, DEPENDING ON THE PROPERTIES OF THE MOLECULES. *SCATTERING* IS A KIND OF REFLECTION THAT OCCURS WHEN PARTICLES OR AIR BUBBLES ARE PRESENT IN THE MATERIAL. THE AMOUNT AND DIRECTIONAL NATURE OF THE SCATTERING DEPEND ON THE SIZE OF THE PARTICLE IN WHICH THEY ARE EMBEDDED. MANY OPAQUE WHITE MATERIALS ARE MANUFACTURED BY ADDING PARTICLES OF WHITE PIGMENTS SUCH AS TITANIUM DIOXIDE OR CALCIUM CARBONATE. *TRANSLUCENCY* IS A VISUAL PHENOMENON THAT CAN GIVE MATERIALS A MILKY OR CLOUDY APPEARANCE; IT OCCURS WHEN THE MATERIAL IS PARTIALLY TRANSPARENT BUT EXHIBITS SCATTERING.

THE HUMAN COLOUR VISION SYSTEM:

THE LIGHT THAT IS REFLECTED BY SURFACES OR EMITTED BY LIGHT SOURCES ENTERS THE EYE, WHERE IT IS ABSORBED BY VISUAL PIGMENTS IN THE PHOTORECEPTORS OF THE RETINA. THE SPECTRAL SENSITIVITIES OF THE PIGMENTS IN THE THREE CONE CLASSES PLAY A ROLE IN THE NATURE OF COLOUR PERCEPTION. IT CAN BE UNDERSTOOD ONLY IF THE PROCESSES THAT TAKE PLACE IN THE NERVOUS SYSTEM TO TRANSMIT THE RETINAL SIGNAL TO THE OCCIPITAL LOBE OF THE BRAIN'S CORTEX ARE STUDIED.

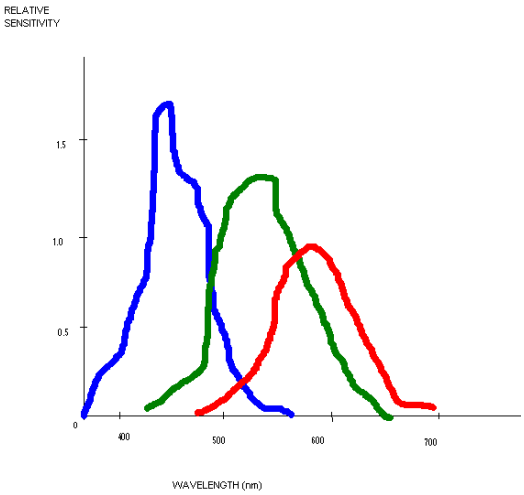
THE HUMAN EYE.



(A) THE RETINAL RESPONSE: THE RODS AND CONES OF THE RETINA CONTAIN PHOTOPIGMENTS THAT UNDERGO A CHEMICAL TRANSFORMATION WHEN LIGHT OF AN APPROPRIATE WAVELENGTH IS ABSORBED. IN THE RODS, THE PHOTOPIGMENT IS BASED ON THE COMPOUND KNOWN AS *RHODOPSIN*. THE EVENTS THAT OCCUR WHEN RHODOPSIN ABSORBS LIGHT ARE STUDIED BY PSYCHOLOGICAL, BIOCHEMICAL, PHYSIOLOGIC AND MOLECULAR TECHNIQUES.THE RODS CANNOT PROVIDE ANY INFORMATION ABOUT COLOUR.

THE COLOUR PROPERTIES OF THE VISUAL SYSTEM RESULT FROM THE FACT THAT THERE ARE THREE CLASSES OF LIGHT-RECEPTIVE CELLS CALLED *CONES*. THE SENSITIVITY FUNCTIONS OF THE THREE TYPES ARE APPROXIMATELY BELL-SHAPED FUNCTIONS OF WAVELENGTH. THEIR PEAK SENSITIVITIES OCCUR AT 420 Nm FOR THE S-CONE CLASS (SHORT WAVE SENSITIVE), 530 Nm FOR THE m-CONE CLASS (MEDIUM WAVE SENSITIVE), AND 560 Nm FOR THE L-CONE CLASS (LONG WAVE SENSITIVE). THE SPECTRAL SENSITIVES OF THE EXTRACTED PIGMENTS ARE MEASURED TO BE AT THE PEAKS WHILE THE EFFECTIVE SENSITIVES OF THE CONE CLASSES ARE MORE ACCURATELY GIVEN AS 440, 545 AND 565 NM; BECAUSE OF ABSORPTION OF THE MACULA PIGMENT IN THE RETINA AND BY THE LENS ITSELF.

ADDITIVE COLOUR MIXING AND THE FACT THAT ANY COLOUR CAN BE MATCHED WITH THREE APPROPRIATE PRIMARIES BOTH RESULT FROM THE FACT THAT THE EYES CONTAIN THREE DIFFERENT CONE TYPES. AT AN EARLY STAGE IN VISUAL PROCESSING, THE CONE SIGNALS ARE COMBINED (BY THE RETINAL GANGLION CELLS) TO PRODUCE A LUMINANCE CHANNEL AND TWO OPPONENT CHANNELS THAT RESPOND TO RED-GREEN AND YELLOW-BLUE SIGNALS.



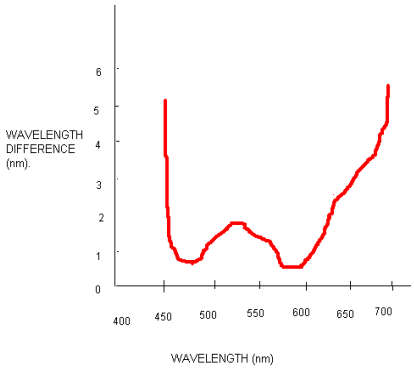
THE SPECTRAL SENSITIVITIES OF THE L-, M-, AND S-CONE CLASSES.

(B) THE CORTICAL RESPONSE: THE RETINAL SIGNALS LEAVE THE RETINA AND PASS ALONG THE OPTIC NERVE AWAY FROM THE EYE INTO THE BRAIN. THE FIBRES FROM THE TWO EYES MEET AND CROSS OVER AT AN ANATOMIC STRUCTURE KNOWN AS THE *CHIASMA.* THE SIGNALS FROM THE LEFT-HAND PART OF THE VISUAL FIELD FROM BOTH EYES PROJECT TO THE RIGHT HEMISPHERE OF THE BRAIN, WHEREAS THOSE FROM THE RIGHT- HAND PART OF THE VISUAL FIELD IN BOTH EYES ARE PROCESSED IN THE LEFT HEMISPHERE. THE RETINAL GANGLION FIBRES TERMINATE AT THE LATERAL GENICULATE NUCLEUS, WHERE A CERTAIN AMOUNT OF FURTHER PROCESSING TAKES PLACE, BEFORE LONG FIBRES KNOWN AS *OPTIC RADIATION* TAKE THE SIGNALS TO AN AREA IN THE LOWER REAR PART OF THE CEREBRAL CORTEX THAT IS CALLED THE *VISUAL CORTEX.*

COLOUR PERCEPTION:

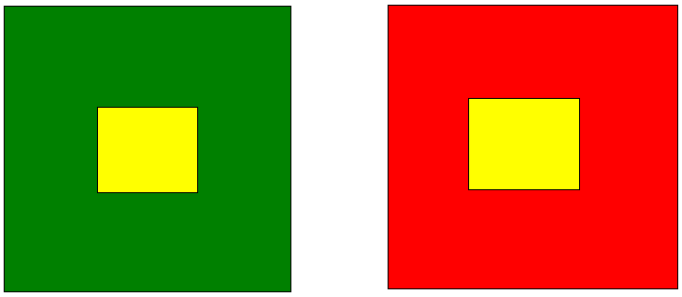
COLOUR PERCEPTION FOR HUMANS IS THREE DIMENSIONAL, A FACT THAT STEMS FROM THE EXISTENCE IN THE RETINA OF THREE DIFFERENT CLASSES OF LIGHT-RECEPTIVE CELLS. HUE, VALUE AND CHROMA ARE NECESSARY AND SUFFICIENT TO DEFINE A COLOUR STIMULUS FOR THE VISUAL SYSTEM UNDER STANDARD CONDITIONS. HUE IS THE EXTENT TO WHICH IT CAN BE DESCRIBED AS BEING RED, GREEN AND BLUE. VALUE DESCRIBES THE BRIGHTNESS OF THE COLOUR. CHROMA DESCRIBES THE INTENSITY OF THE COLOUR. THE COMPLEX NATURE OF THE COLOUR PERCEPTION MEANS THAT IT IS IMPOSSIBLE TO PREDICT EVEN THE APPROXIMATE COLOUR APPEARANCE OF A PATCH IN A SCENE WITHOUT SPECIFYING THE SURROUNDING COLOURS AND THE STATE OF ADAPTATION OF THE EYE.

A) WAVELENGTH DISCRIMINATION: THE EXISTENCE OF THREE CONE PHOTOPIGMENTS ALLOWS HUMANS TO BENEFIT FROM COLOUR VISION; ALTHOUGH EACH ON ITS OWN IS INSUFFICIENT TO ALLOW WAVELENGTH DISCRIMINATION, THE RATIO OF THE THREE RESPONSES IS DIFFERENT FOR EACH MONOCHROMATIC WAVELENGTH. IT'S THE COMBINATION OF CONE SIGNALS PERFORMED BY RETINAL AND CORTICAL PROCESSING THAT PROVIDES A COLOUR VISION SYSTEM. THE HUMAN VISUAL SYSTEM HAS A REMARKABLE ABILITY TO DISCRIMINATE BETWEEN DIFFERENT WAVELENGTHS. THE WAVELENGTH DIFFERENCE NECESSARY TO PRODUCE A JUST NOTICEABLE DIFFERENCE VARIES WITH WAVELENGTH BUT IS ABOUT 5 Nm AT VERY SHORT OR LONG WAVELENGTHS AND LESS THAN 1 Nm AT WAVELENGTHS OF ABOUT 470 Nm OR ABOUT 575 nm.



THE WAVELENGTH SHIFT NECESSARY TO PRODUCE A JUST-NOYICABLE DIFFERENCE BETWEEN TWO COLOUR STIMULI, SHOWN AS A FUNCTION OF WAVELENGTH.

B) COLOUR CONTRAST: THE THREE DIMENSIONAL NATURE OF COLOUR MAY BE EXPLAINED BY TRICHROMACY AND THE EXISTENCE OF THE L-, M-, AND S-CONE TYPES, BUT THE NOTION OF COLOUR CONTRAST IS ESSENTIAL TO A MODERN UNDERSTANDING OF COLOUR PERCEPTION. A YELLOW PATCH VIEWED ON A GREEN BACKGROUND APPEARS RED AND THAT ON A RED BACKGROUND APPEARS GREEN.THE COLOUR APPEARANCE OF A PATCH IN A SCENE IS DEPENDENT ON THE CONTEXT (BOTH SPATIAL AND TEMPORAL) IN WHICH THE STIMULI ARE OBSERVED.



A YELLOW PATCH ON A GREEN BACKGROUND APPEARS REDDISH THAN IT DOES ON A RED BACKGROUND, WHILE THE SAME IN RED BACKGROUND APPEARS GREENISH THAN IT DOES ON A GREEN BACKGROUND.

C) COLOUR CONSTANCY: IT IS ONE OF THE GREAT MYATERIES OF COLOUR VISION. COLOUR PERCEPTION OF SURFACES IN THE WORLD REMAINS APPROXIMATELY CONSTANT AS THE VIEWER MOVES FROM A BRIGHT SCENE TO DIMLY LIT SCENE OR EVEN FROM ONE COLOURED LIGHT SOURCES TO ANOTHER. THE PHENOMENON OF COLOUR CONSTANCY IS A CRITICAL FUNCTIONAL COMPONENT OF COLOUR VISION BECAUSE IT ENABLES HUMANS TO RECOGNIZE OBJECTS IN THE WORLD BY THEIR COLOUR. EG: THE INTENSITY OF LIGHT REFLECTED BY A BLACK OBJECT OUTDOORS ON A SUNNY DAY MAY BE IDENTICAL TO THE INTENSITY OF THE LIGHT REFLECTED BY A WHITE OBJECT IN A DIMLY LIT ROOM, BUT THE OBJECTS APPEAR BLACK AND WHITE RESP. UNDER BOTH ILLUMINATION CONDITIONS. THE PROCESS OF CHROMATIC ADAPTATION MAY PLAY A ROLE IN ENABLING COLOUR CONSTANCY BECAUSE A CONSEQUENCE OF THIS PROCESS IS THAT THE SPATIAL-AVERAGE OUTPUT OF A CONE CLASS IS REGARDLESS OF THE COLOUR OF THE ILLUMINATION. SOME RESEARCHERS ARGUE THAT CHROMATIC ADAPTATION AND COLOUR CONSTANCY ARE TWO DIFFERENT PHENOMENA. CHROMATIC ADAPTATION REQUIRES SEVERAL SECONDS TO OCCUR, WHEREAS COLOUR CONSTANCY TENDS TO TAKE PLACE IMMEDIATELY. CHROMATIC ADAPTATION CAN OCCUR FOR SIMPLE STIMULI WHEREAS COLOUR CONSTANCY WORKS BEST FOR SO CALLED COMPLEX IMAGES IN WHICH THERE ARE MANY DIFFERENT SURFACES IN THE SCENE. MOST SUCCESSFUL APPROACHES TO EXPLAIN THE COLOUR CONSTANCY INCORPORATE THE FACT THAT THE COLOUR APPEARANCE OF A PATCH IN A SCENE IS RELATIVE TO THAT OF OTHER PATCHES IN THE SAME SCENE. COLOUR VISION AND SPATIAL VISION ARE INEXTRICABLY LINKED.

D) COLOUR DEFICIENCY: THERE IS SOME VARIABILITY IN THE COLOUR VISION OF SO CALLED *NORMAL OBSERVERS.* HOWEVER, SOME OBSERVERS HAVE VERY POOR DISCRIMINATION BETWEEN CERTAIN COLOURS (USUALLY REDS AND GREENS) AND ARE LABELLED *COLOUR DEFECTIVES.* HEREDITARY COLOUR DEFICIENCY IS A RECESSIVE DISORDER THAT OCCURS AS A CONSEQUENCE OF AN ABNORMALITY ON THE X-CHROMOSOME; THAT MEANS THAT WOMEN ARE THE CERTAIN CARRIERS, AND IS MAINLY MEN (8%) WHO INHERIT THE COLOUR DEFICIENCY. IT IS EXTREMELY RARE CONDITION TO FIND IT IN FEMALE. COLOUR DEFICIENCY CAN RESULT FROM INJURY OR DISEASE.

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