COLOR CONCEPT AND COLORING IN MAXILLO-FACIAL PROSTHESES

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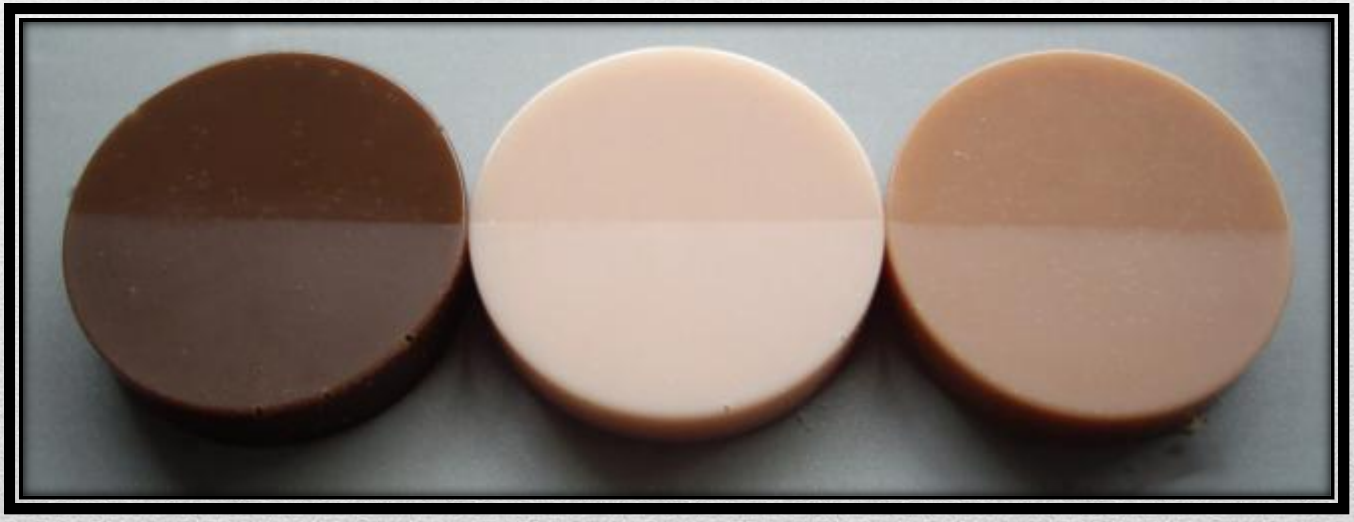
An aesthetic and comfortable maxillofacial prosthesis can make huge differences for the patients with Maxillofacial defects due to cancer, trauma or congenital diseases .

A Maxillofacial defects are located in highly visible body area that is identified with one's own identity ,so accurate representation of skin color in facial prosthesis is essential for achieving successful aesthetic results.

It remains one of the subsequent pigmentation but they are important issues during prosthesis fabrication process.

The ability to match skin tones effectively requires keen eye ,good understanding of color theory & meticulous attention to details.



Materials used in the fabrication of these facial prostheses can be silicones that are tinted externally and internally to match the colour of the surrounding facial structures.

Any small changes in facial appearance will influence the emotion and psyche of these patients who are already hypersensitive to the reactions of others.

Therefore, an important maxillofacial prosthetic service is to fabricate such a prosthesis that restores a pleasant facial appearance where the prosthesis is undetectable.

The ideal colour properties required in a maxillofacial prosthetic material must accept and retain intrinsic and extrinsic coloration, and that the appearance , mechanical strength and other properties of the prosthesis must not be changed by sunlight or other environmental factors.

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An aesthetic and comfortable maxillofacial prosthesis relieves many concerns of the patient and may improve quality of life.

The appearance
of the prosthesis is well known to be a key factor
that determines its final aesthetic result.

Choosing an appropriate color-measuring system is an important issue, and various factors need to be considered.

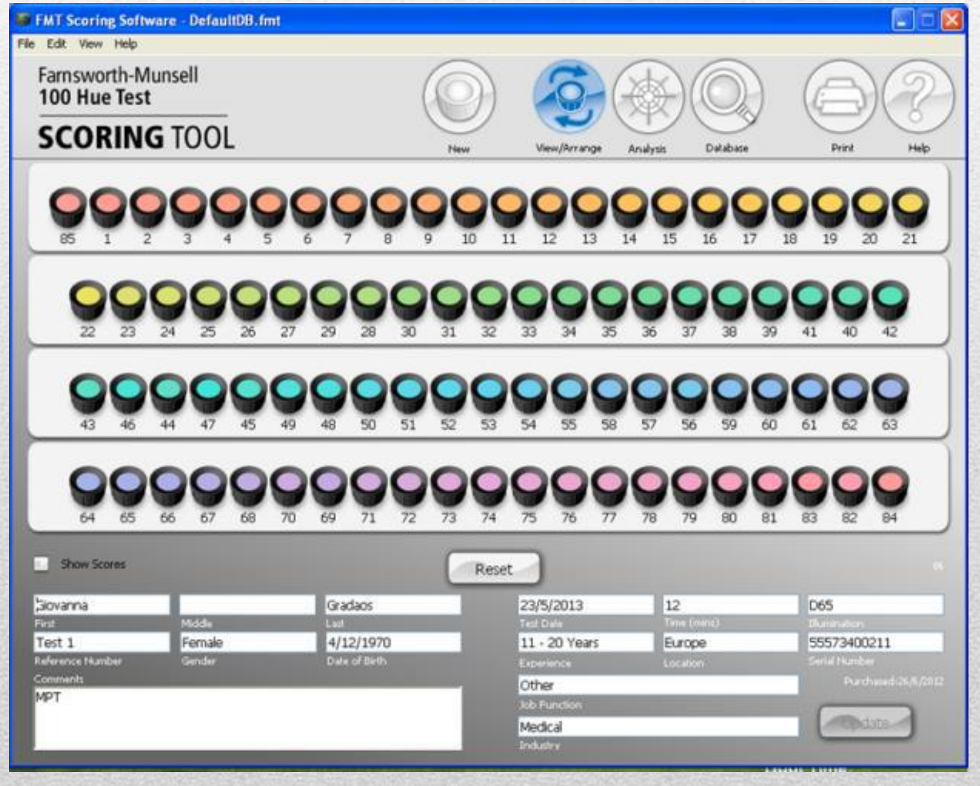
Colorimeters and digital imaging systems have the advantages of fast and larger-area color assessment than traditional methods.

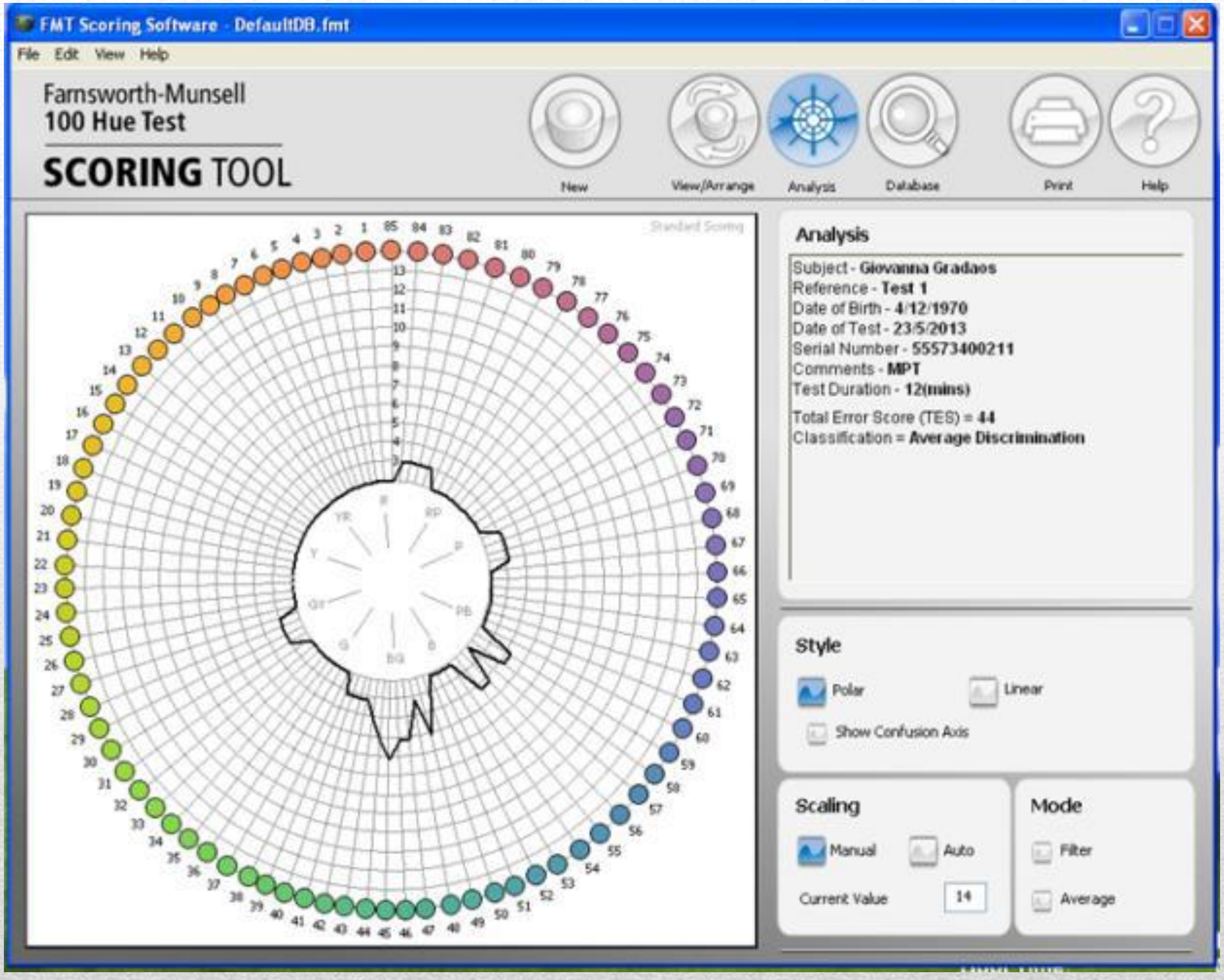
Pigments and dyes play a key role in pigmentation and coloration of maxillofacial prosthetic elastomers and along with this stability of color is also an important issue which cannot be overlooked .

Colour Concepts:

The following terms are commonly used to understand and describe attributes of color and color mixtures.

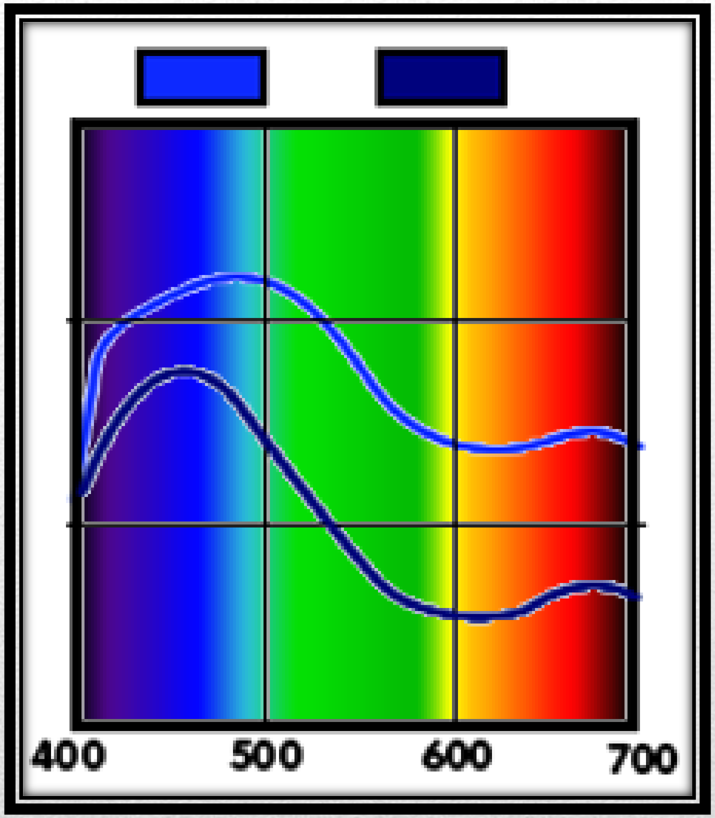
1. Hue:


FMT Scoring Software - DefaultDB.fmt
File Edit View Help
Farnsworth-Munsell
100 Hue Test
SCORING TOOL
New
View/Arrange
Analysis
Database
Print
Help
85 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
22 23 24 25 26 27 29 28 30 31 32 33 34 35 36 37 38 39 41 40 42
43 46 44 47 45 49 48 50 51 52 53 54 55 58 57 56 59 60 61 62 63
64 65 66 67 68 70 69 71 72 73 74 75 76 77 78 79 80 81 83 82 84
Show Scores
Reset
Giovanna
First
Middle
Gradaos
Last
23/5/2013
Test Date
12
D65
Test 1
Reference Number
Female
Gender
4/12/1970
Date of Birth
11 - 20 Years
Experience
Europe
Location
55573400211
Serial Number
Comments
MPT
Other
Job Function
Medical
Industry



Dominant color of an object, for e.g. red green or blue.

2. Value:



Relative lightness or darkness of color.

The
luminous intensity of a color i.e., its degree of lightness is called its value.

3. Chroma:

Chromatic describes the vividness or dullness of a color.

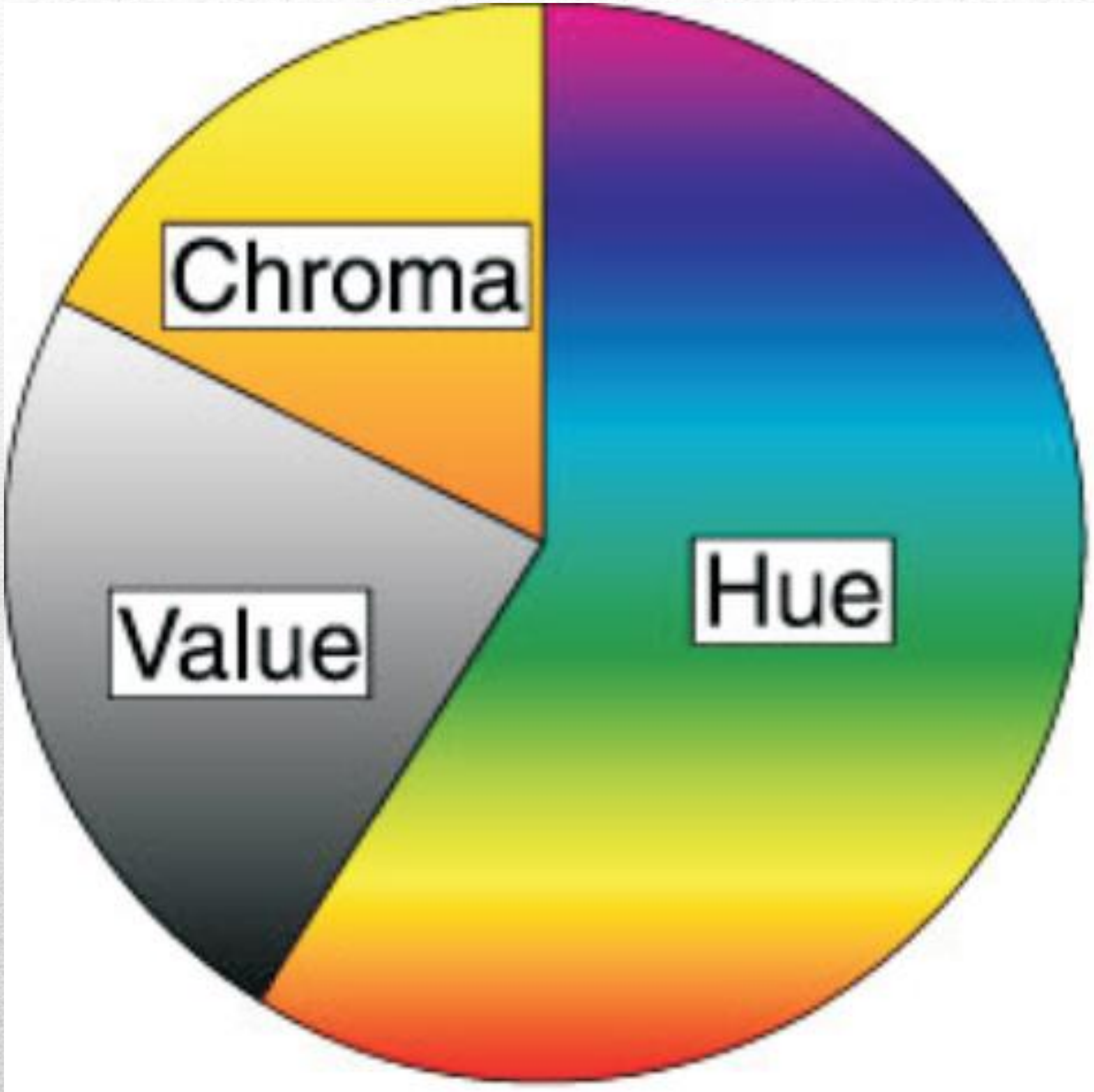

Chroma
Value
Hue

Figure shows how chroma changes as we move from center to the perimeter. Colors in the center are gray (dull) and become more saturated (vivid) as they move toward the perimeter.

Chroma also is known as saturation.

4. Opacity:

The degree to which a sheet film or object obscures a pattern beneath or behind it.

5. Translucency:

The degree to which light can pass through an object.

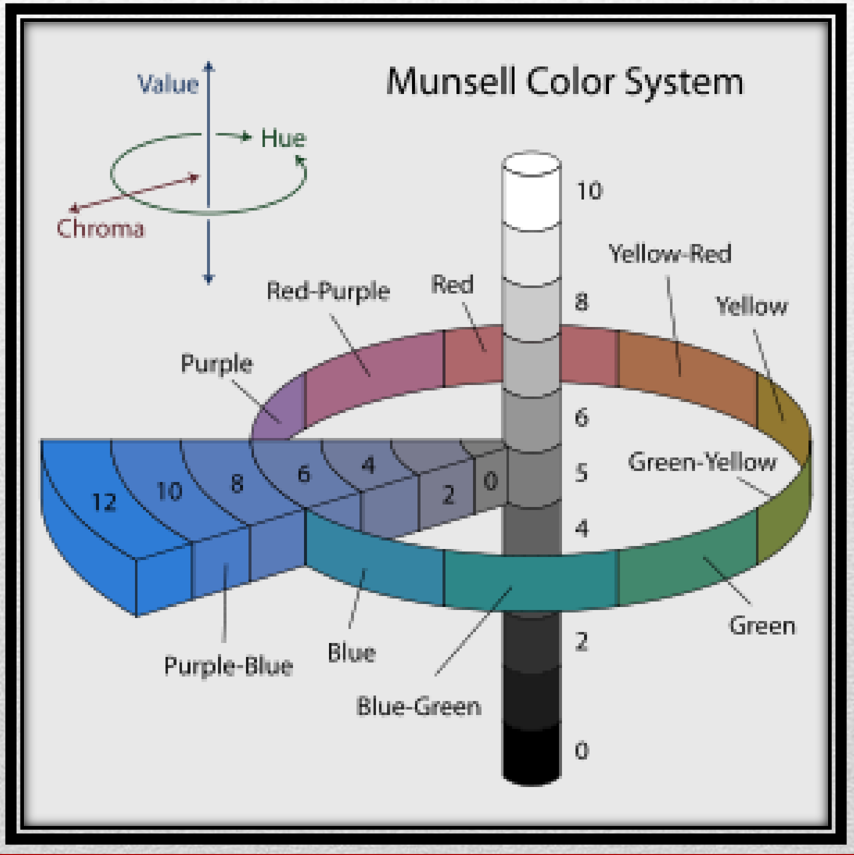
Besides color, it was noted that translucency plays another important role in determining the appearance of esthetic materials.

Matching both color and translucency characteristics of the prosthesis to those of human skin is highly important for an appearance match.

Even when
the shape and texture of the prosthesis do not perfectly duplicate human skin, the prosthesis will still likely remain undetectable if the coloration of the prosthesis produces an acceptable color and translucency match under different lighting conditions.

Scales For Measuring Colour:

1. The Munsell Scale

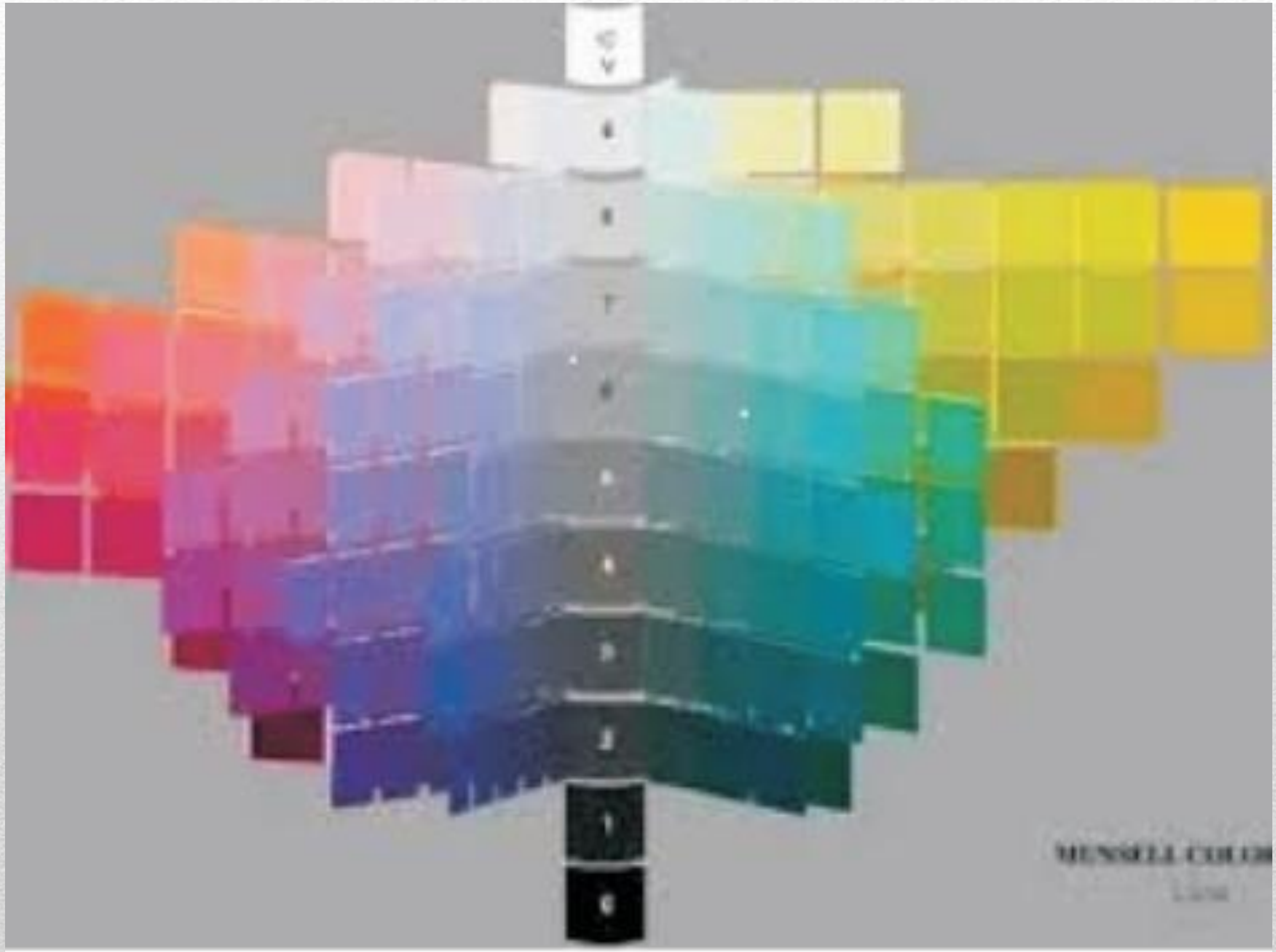


In 1905, artist Albert H.Munsell originated a color ordering system — or color scale which is still used today.

The Munsell System of Color Notation is significant from a historical perspective because it's based on human perception.

The Munsell System assigns numerical values to the three properties of color: hue, value and Chroma.

Adjacent color samples
represent equal intervals of visual perception.



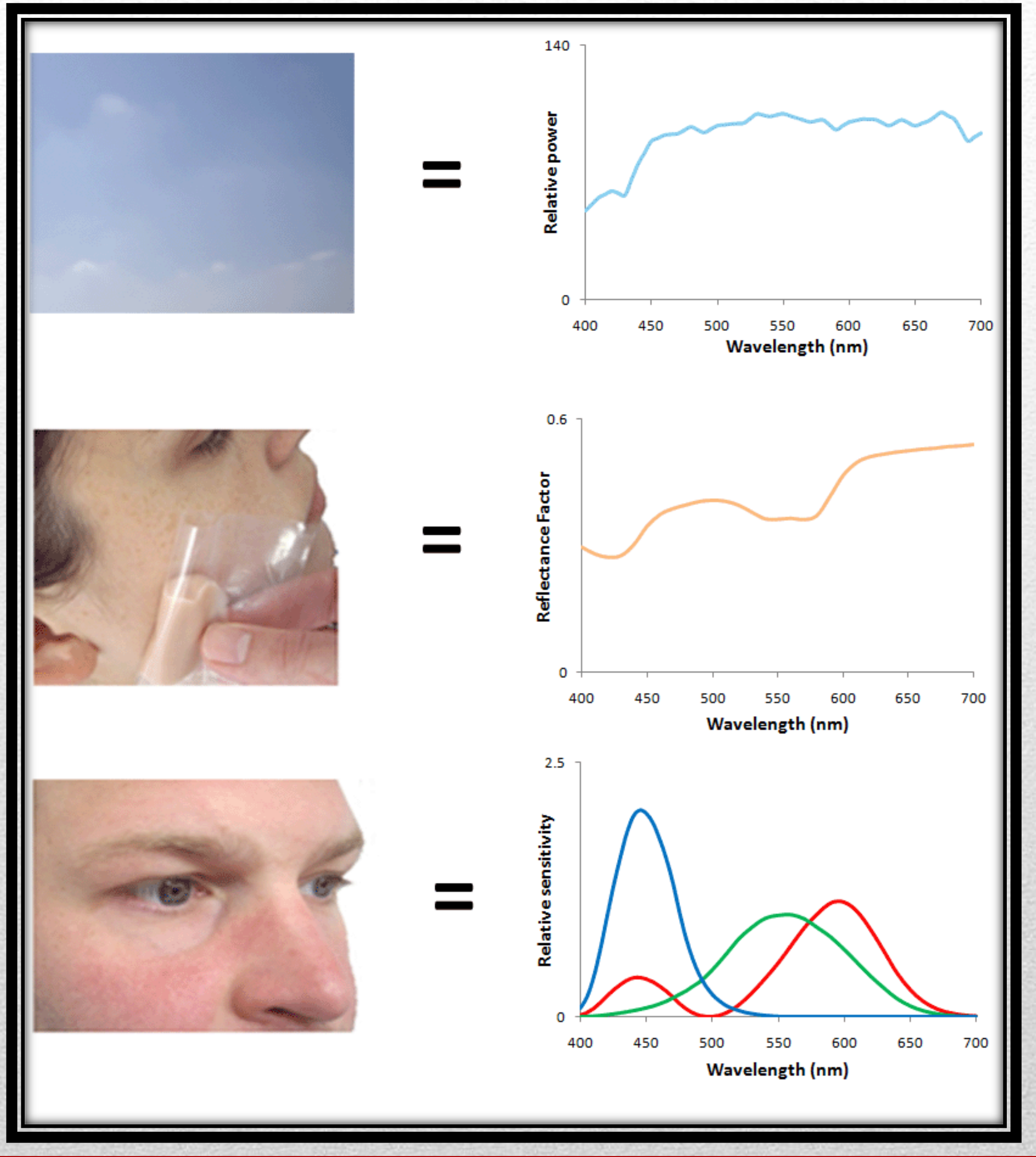
Munsell Color Tree

The model in Figure depicts the Munsell Color Tree, which provides physical samples for judging visual color.

Today's color systems rely on instruments that utilize mathematics to help us judge color.

Three things are necessary to see Color:

1. Alight source (illuminant).
2. An object (sample)
3. An observer/processor.


140
Relative power
0
400 450 500 550 600 650 700
Wavelength (nm)
0.6
Reflectance Factor
0
400 450 500 550 600 650 700
Wavelength (nm)
2.5
Relative sensitivity
0
400 450 500 550 600 650 700
Wavelength (nm)

2. Cie Color Systems

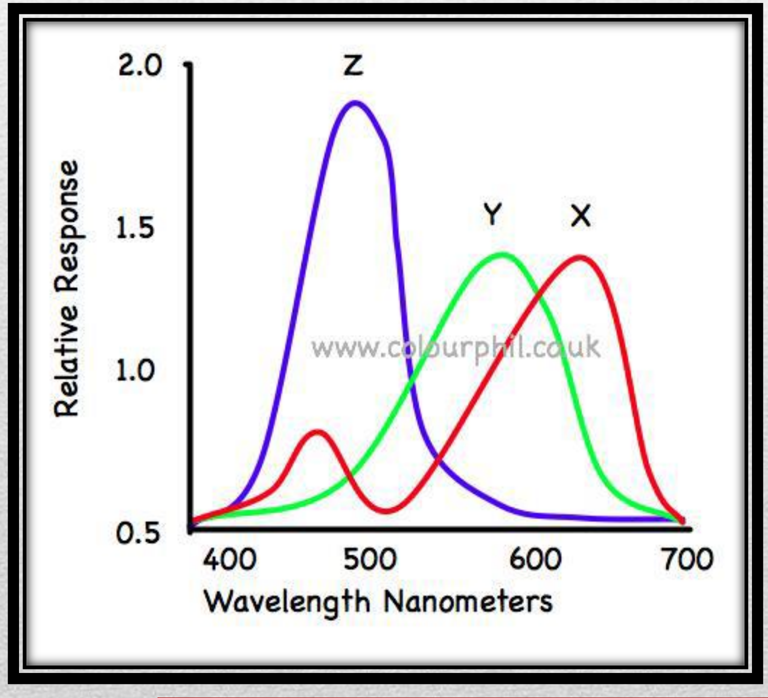
The CIE, or Commission Internationale de l'Eclairage (translated as the International Commission on Illumination), is the body responsible for international recommendations for photometry and colorimetry.

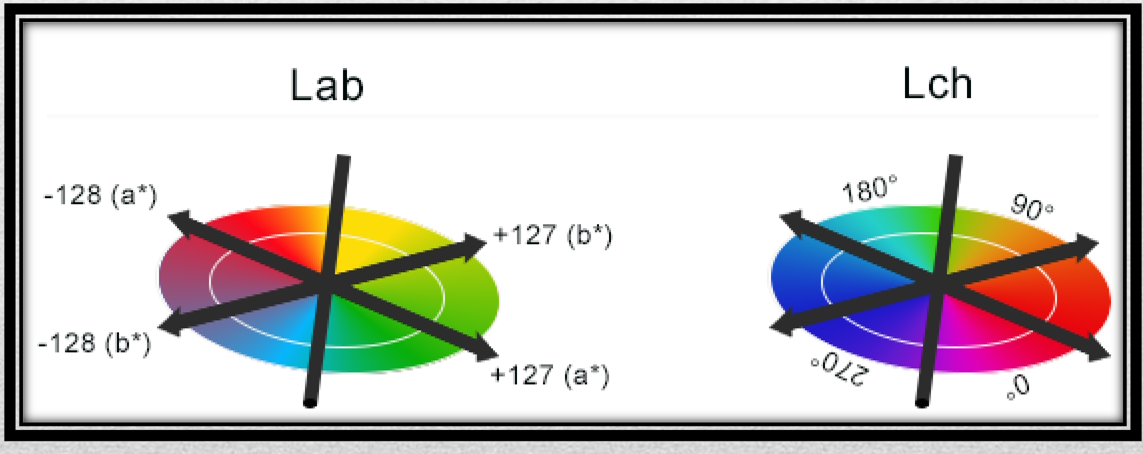
In 1931 the CIE standardized color order systems by specifying the light source (or illuminants), the observer and the methodology used to derive values for describing color.

The CIE Color Systems utilize three coordinates to locate a color in a color space.

These color spaces include:

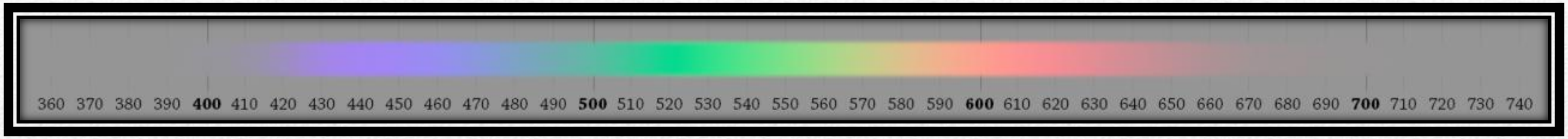
· CIE XYZ
· CIE L*a*b*
· CIE L*C*h°





Colors can be quantified using these color spaces by different calculations based upon specification of light source type and defining 'standardized' observers (these two parameters are accounted for using different mathematical formulae).

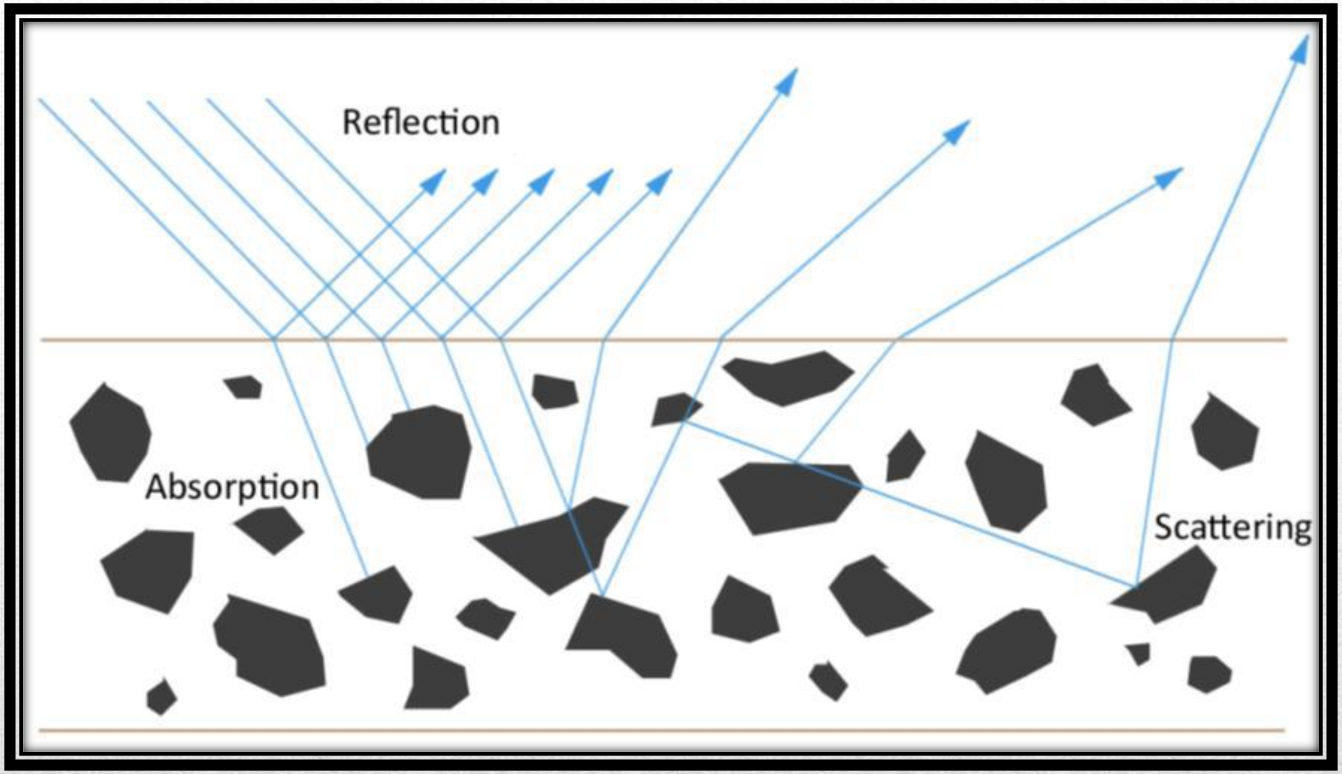
Instruments quantify color by gathering and filtering the wavelengths of light transmitted through, or reflected from, an object.



The instrument perceives the different intensities of different light wavelengths and these intensity values are recorded as points across the visible spectrum spectral data.

Spectral data is represented as a spectral curve.

This curve is the color's fingerprint.



Once we obtain a color's transmittance or reflectance curve, we can apply mathematics to map the color onto a color space.

To do this, we take the reflectance curve and multiply the data by a CIE standard illuminant or other illuminant.

The illuminant is a graphical representation of the light source under which the samples are viewed.

Each light source has an energy distribution that affects how we see color.

Examples of different illuminants are A – incandescent, D65 – daylight and F2 –fluorescent.

We multiply the result of this calculation by a CIE standard observer.

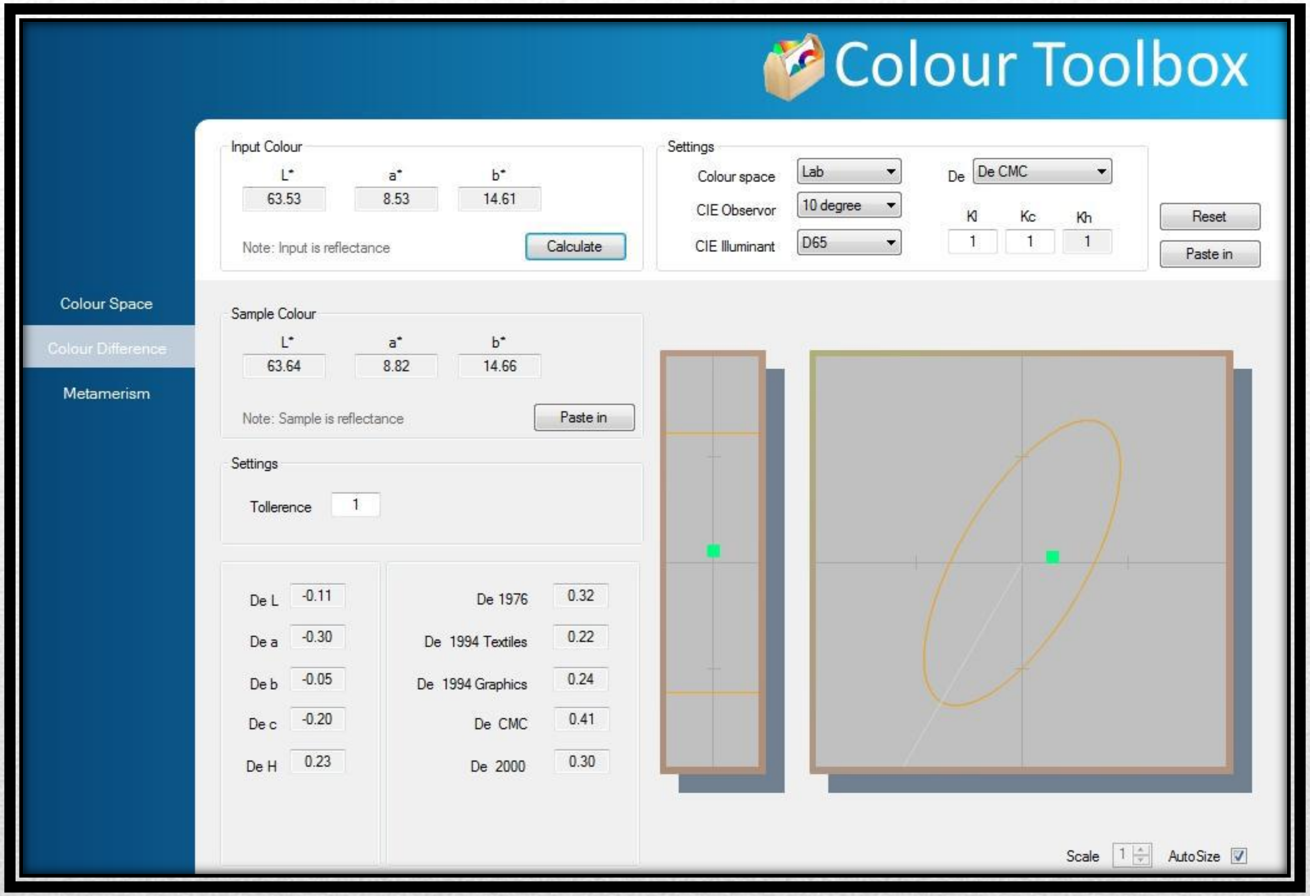
The CIE commissioned work in 1931 and 1964 to derive the concept of a standard observer, which is based on the average human response to wavelengths of light.

In short, a standard observer represents how an average person sees color across the visible spectrum when using a defined area of the eyes' retina.

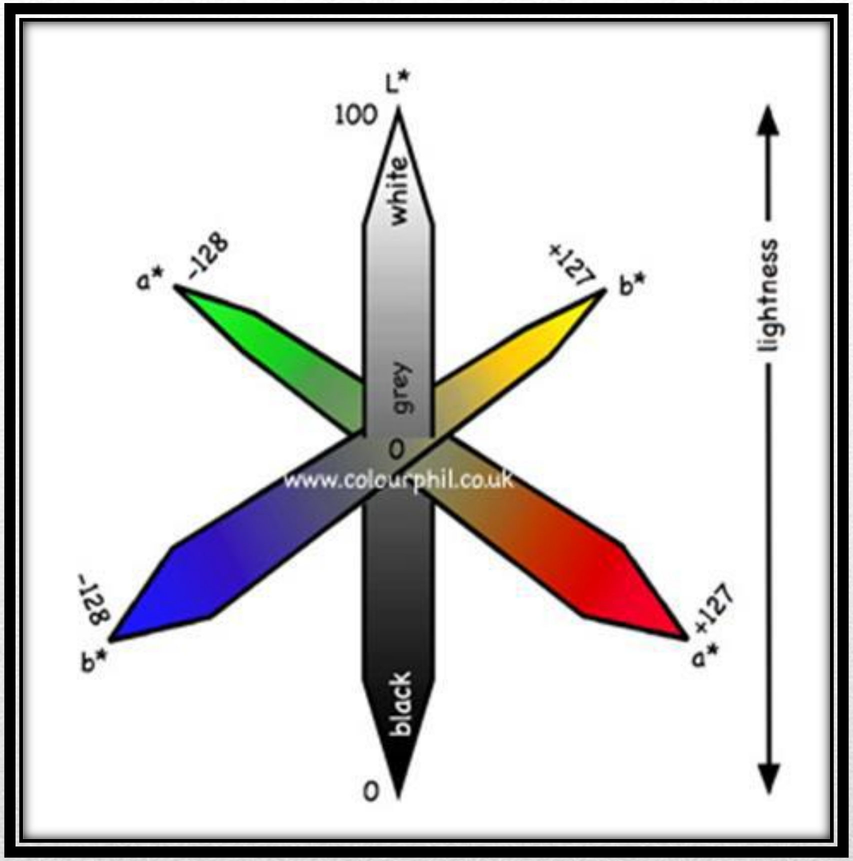
These values can now be used to identify a color numerically.

Cie lab (L*a*b*):

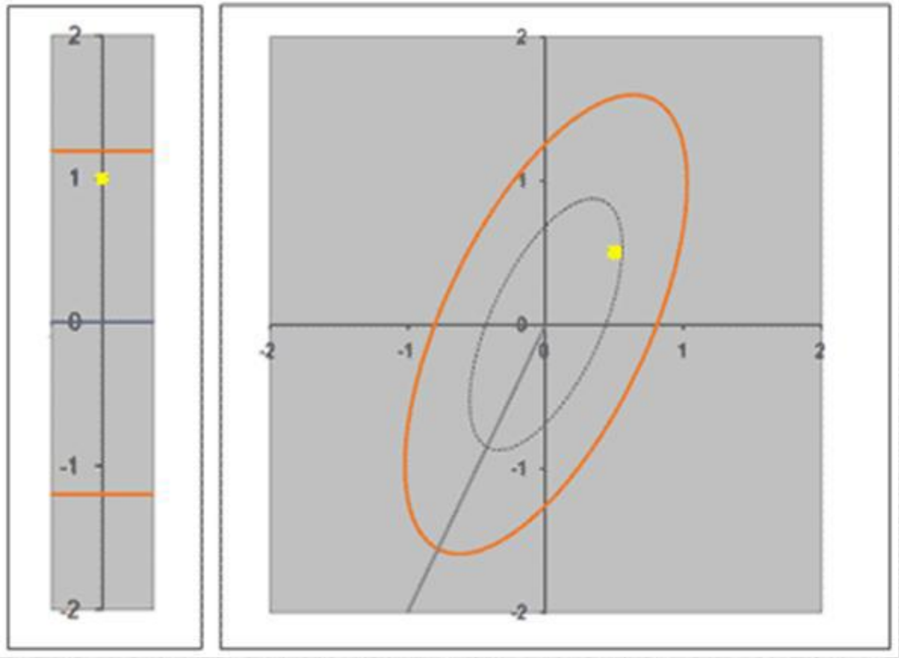

Colour Toolbox
Input Colour
L* 63.53
a* 8.53
b* 14.61
Note: Input is reflectance
Calculate
Settings
Colour space Lab
CIE Observor 10 degree
CIE Illuminant D65
De De 1976
Kl 1
Kc 1
Kh 1
Reset
Paste in
Colour Space
Colour Difference
Metamerism
Sample Colour
L* 63.64
a* 8.82
b* 14.66
Note: Sample is reflectance
Paste in
Metamerism
D65 De 0.01
A De 0.35
F2 De 1.02
F11 De 1.85
Correct Reflectance
Auto Scale



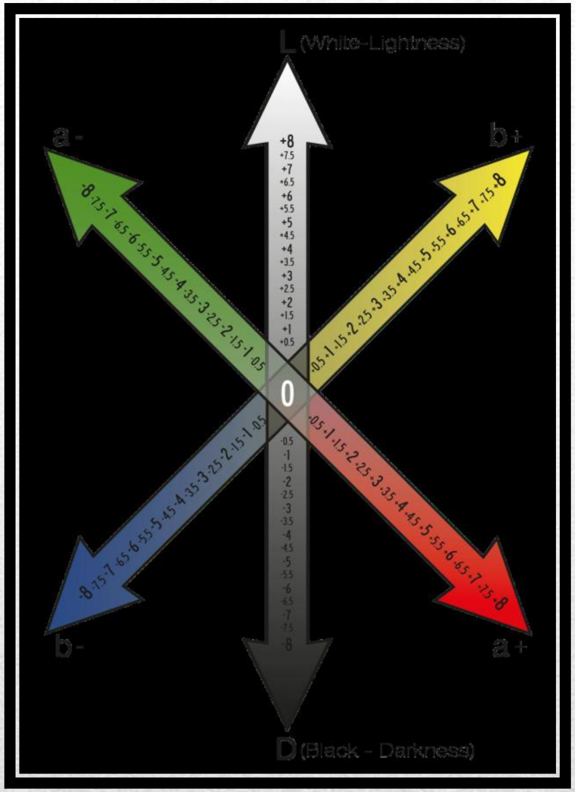
The Lab system defines any color into tri-stimulus values (L), (a), and (b).

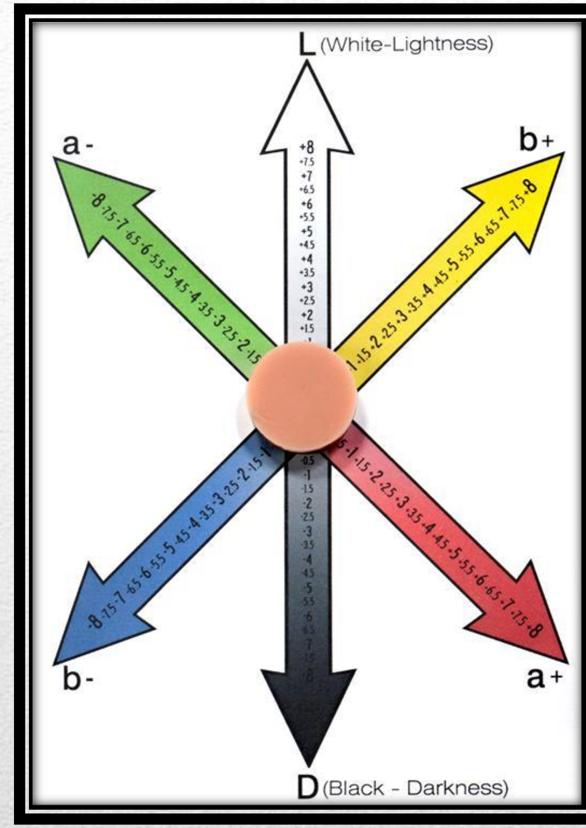


(L) In the L*a*b* system to measure colour, value is L*, and a* and b* indicate 2colour axes, with a* the red/green axis and b* the yellow/blue axis.

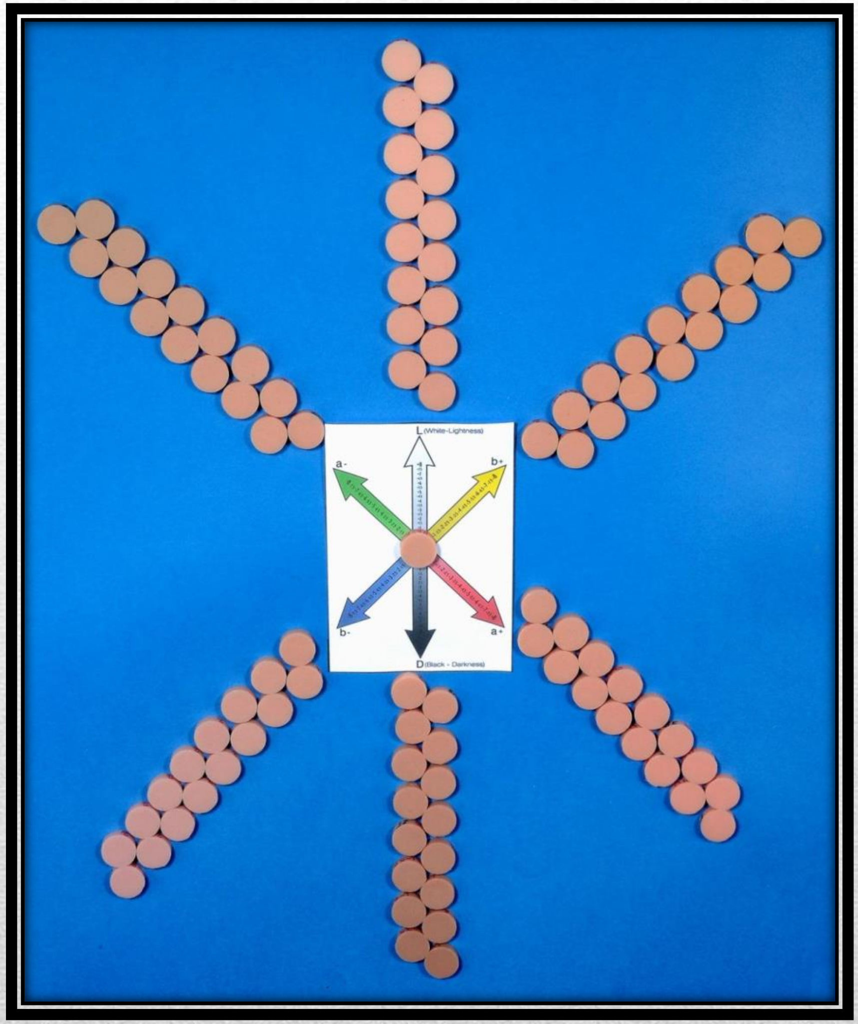


The lightness component (L) can range from 0 to 100.





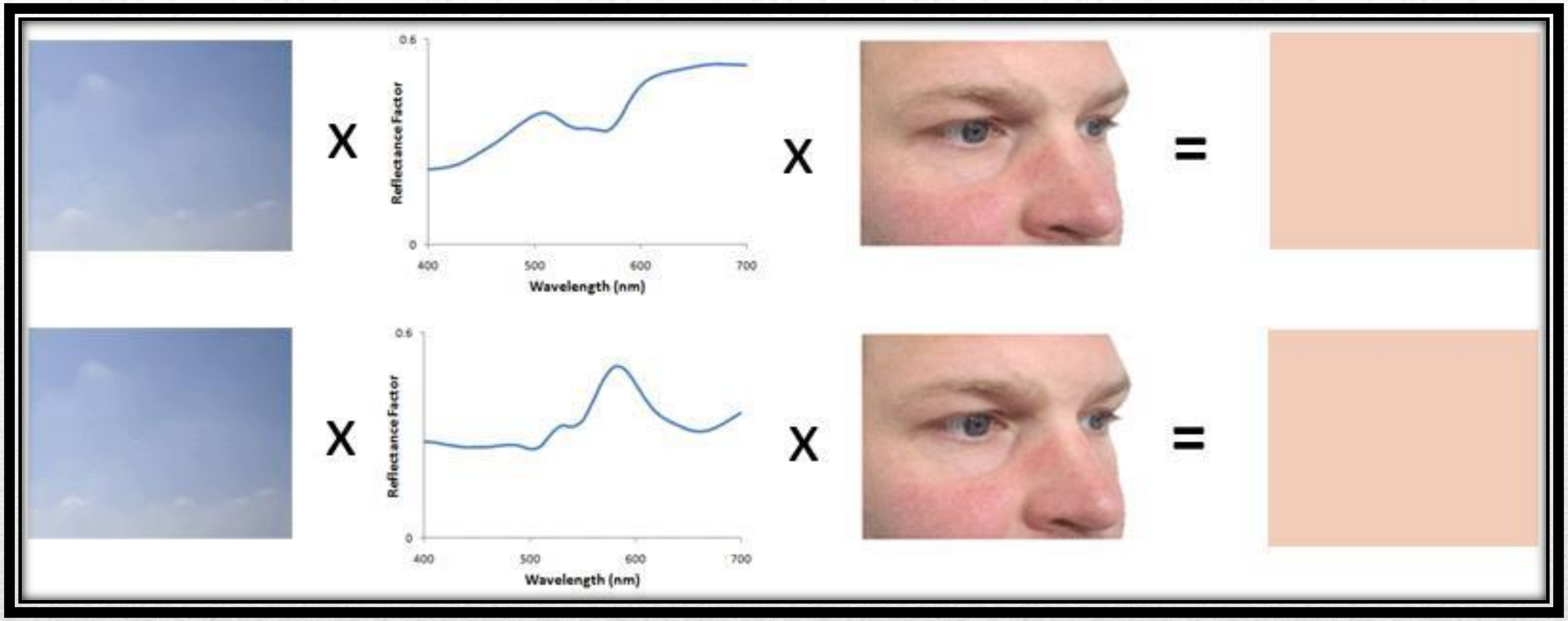
The (a) component (green-red axis) and the(b) component (blue-yellow axis) can rangefrom +128 to -128.


L (White-Lightness)
a-
b+
b-
a+
D (Black - Darkness)

Kubelka Munk Theory:

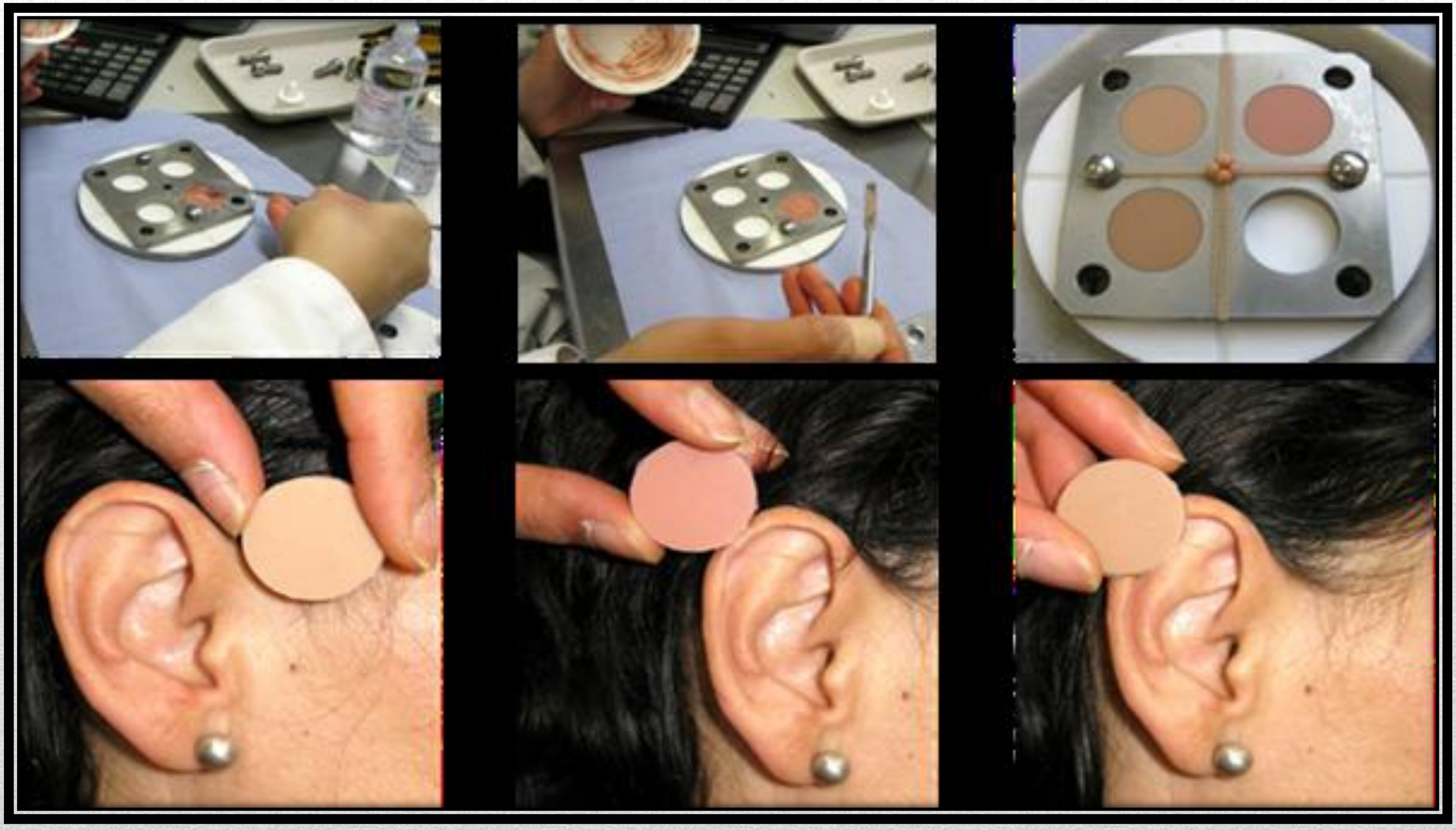
The solution of an optical reflectance theory by Kubelka and Munk (1931) and its subsequent simplification by Kubelka (1948) gave rise to the application of this theory to describe the color and translucency of colored materials within the paint and plastic industries.

Judd (1937) initially applied the Kubelka-Munk theory to dental materials, and O'Brien and his co-workers have advanced this theory in its application to dental composite and porcelain materials.



Optical properties of a base maxillofacial prosthetic material are significantly affected when pigmentation by pigments and dyes.

As a two-flux radiation transfer model, Kubelka-Munk (K-M) theory, which describes the overall effects of light energy in an ideal pigmented medium, is used to investigate optical absorption and scattering characteristics of pigmented maxillofacial materials, and further applied on pigmentation and coloration of maxillofacial materials.



Accuracy of the K-M theory with three different interfacial reflection corrections (IRC) on maxillofacial elastomers is evaluated, and the IRC value for translucent materials provides the least error for pigmented maxillofacial prosthetic elastomers.

Furthermore, rather than the first order linear regression model traditionally used in concentration additively, a newly proposed second order regression model in concentration additively is evaluated and recognized as a regression model with the least error in colorant formulation based on the K-M theory for pigmented maxillofacial materials.

Ways to Measure Colour:

Color matching to human skin during the process of maxillofacial prosthesis fabrication is often a significant challenge for prosthetic professionals.

Collecting accurate skin color information is an important issue during color matching.

Many approaches and techniques have been utilized to attempt to achieve an accurate skin appearance match.

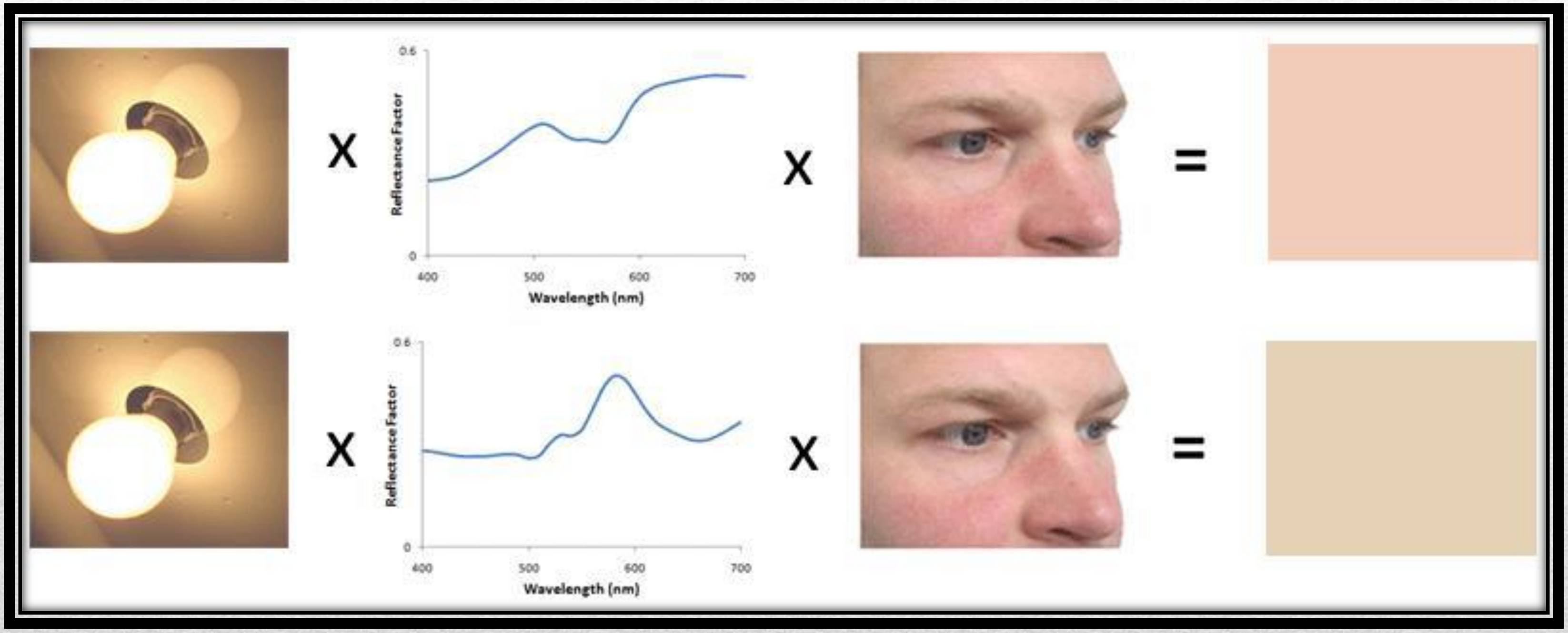
A chair-side visual trial-and-error method of mixing different pigments and dyes with a base maxillofacial prosthetic material is still widely used in current clinical practice.

The development of facial skin shade guides in a manner that is similar to that used for tooth shade matching has made some improvement.

Colorimeters are tri-stimulus (three-filtered) devices that make use of red, green, and blue filters that emulate the response of the human eye to light and color.

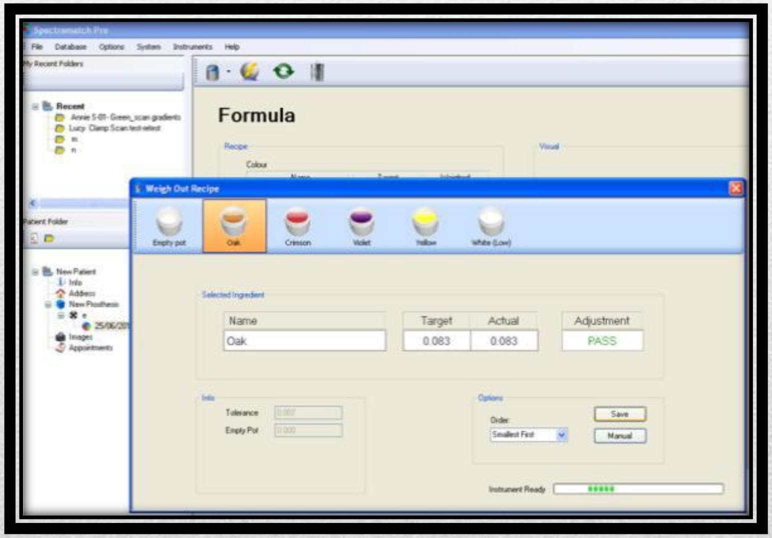
In some quality control applications, these tools represent the lowest cost answer.

Colorimeters cannot compensate for metamerism (a shift in the appearance of a sample due to the light used to illuminate the surface).


X
0.6
Reflectance Factor
0
400
500
600
700
Wavelength (nm)
X
=
X
0.6
Reflectance Factor
0
400
500
600
700
Wavelength (nm)
X
=

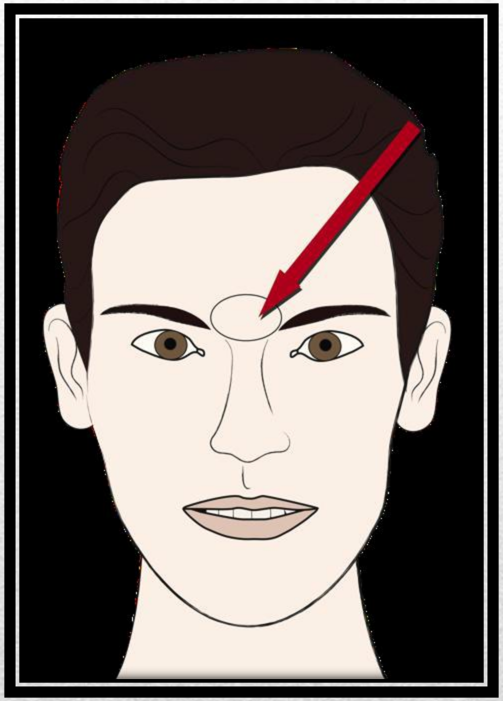
As colorimeters use a single type of light (such as incandescent or pulsed xenon) and because they do not record the spectral reflectance of the media, they cannot predict this shift.

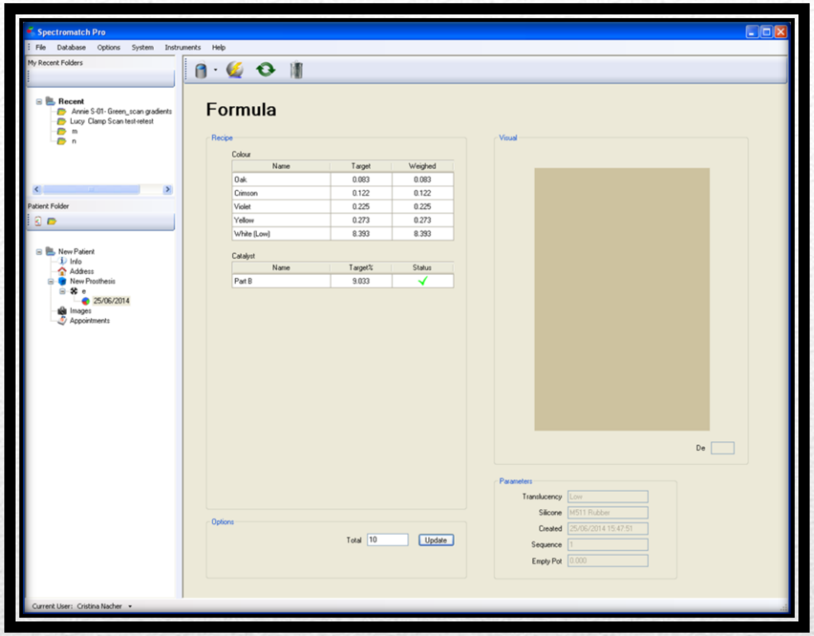
Spectrophotometers can compensate for this shift, making spectrophotometers a superior choice for accurate, repeatable color measurement.



Today, the most commonly used instruments for measuring color are spectrophotometers

Spectro technology measures reflected or transmitted light at many points on the visual spectrum, which results in a curve.





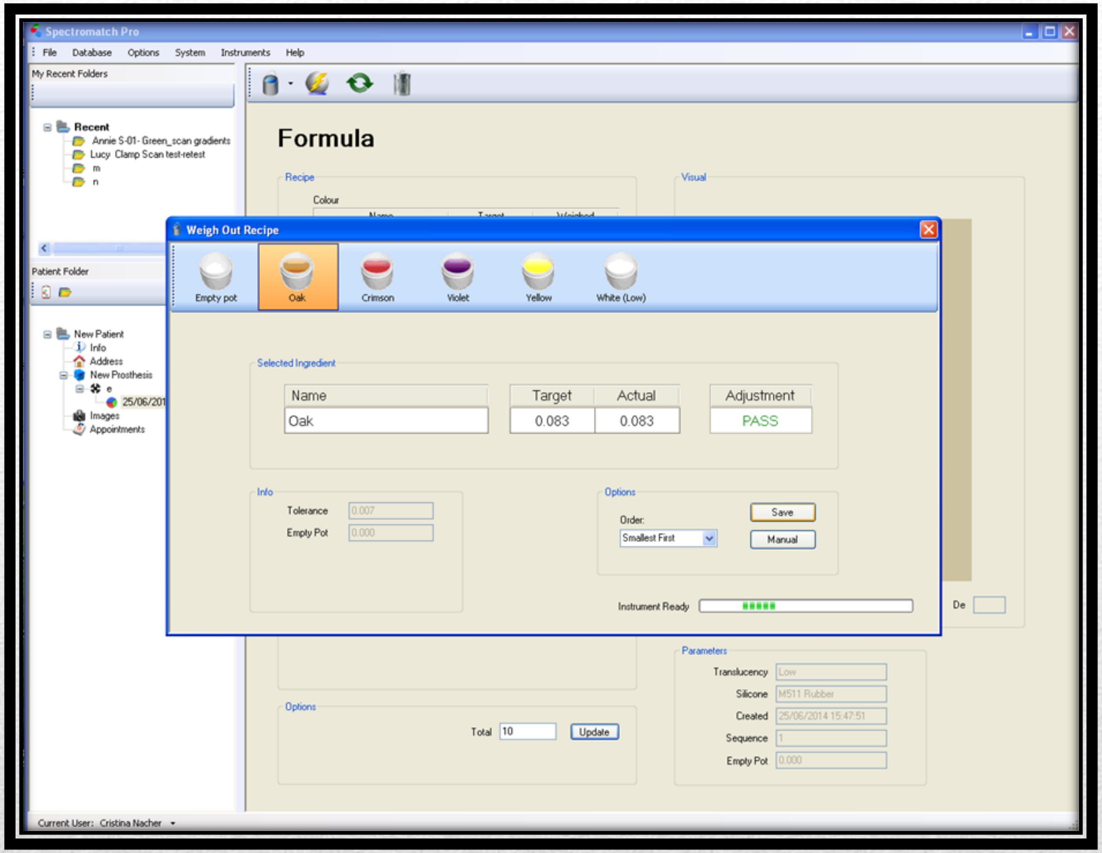
Since the curve of each color is as unique as a signature or fingerprint, the curve is an excellent tool for identifying, specifying and matching color.

Different Pigment Colouring Systems:

Pigments bring life to the prosthesis.

A trained and experienced Prosthetist is able to incorporate the right pigments in the precise proportion in order to get the optimal shade for the prosthesis.

Several components contribute to overall color and characterization of facial prosthesis.



Various types of pigments are available, each having their own set of advantages and disadvantages.

The clinicians‘ preference depends upon experience, handling, color stability and availability of the pigment.

The different pigments are:

The different pigments are:

1. Dry pigments: These are in the form of powders.

2. Pigments suspended in silicone oil.
3. Pigments in pastes.

Pigments and dyes play a key role in pigmentation and coloration of maxillofacial prosthetic elastomers.

Various pigments are used in maxillofacial prosthetics.

Inorganic and organic pigments are generally employed complementarily.

Addition of pigments and dyes into the base material might produce complicated reactions or interactions which in turn may cause various effects on properties of the material such as optical properties or appearance, biocompatibility, thermal and mechanical properties.

Intrinsic &extrinsic Pigments:

The pigments which are added and mixed into the silicone before curing are called intrinsic pigments.

it is applied within the mold during casting procedure this allows to simulate laminar structure of skin.

Depth of color and translucency can be more accurately achieved through intrinsic techniques.

A realistic three dimensional qualities are accomplished by incorporating subsurface details such as blood vessels, freckles and moles that enhance the overall esthetic results

Coloring intrinsically has functional advantages as well it increases service life of prosthesis since the coloring is less vulnerable to environmental conditions and handling.

These cure with the silicone and hence cannot be rubbed off easily.

The basic shade of the prosthesis must be achieved by intrinsic coloration as extrinsic coloring can change the look of the prosthesis only to some extent.

Flocks and Veins can also be added to enhance the look of the prostheses.

Flocks are nylon fibers.

They help in providing a 'life like‘ appearance and texture.

Flocks are available in various shades and are added in minimal quantities only as they have been shown to influence the mechanical properties of the elastomers significantly.

Veining fibers can also be added to give the prosthesis a darker or bluish hue resembling veins in particular areas.

Extrinsic Pigments:

Externally added pigments after curing the prosthesis are called extrinsically applied pigments.

Though extrinsic coloration is more predictable and can be evaluated in direct comparison with the patient skin it should be used sparingly due to its vulnerability to environmental condition and handling.

So one should attempt to perform the majority of coloration through intrinsic techniques.

These are physically applied onto the prosthesis with the help of a brush.

This is done in the presence of the patient so that the final coloring can be made to match the patient's skin tone as far as possible.

A single component silicone is added to seal the pigment down into the silicone.

Commercially available sealants are used to give a final finish and detailing to the prosthesis.

Manipulation of the color of the prosthesis is kept to minimal by this method.

They are mechanically bonded to the silicone and hence there is degradation of the color with repeated handling, cleaning and direct exposure to environmental factors.

Color Bleeding

The mechanical and physical properties of facial prosthetic materials have Improved over recent years, but the colour instability of the facial prostheses still limits the serviceability and is often the reason for remaking the prosthesis.

The principle reason for replacement of facial prostheses is degradation in appearance because of changes in color and physical properties.

Chen et al conducted a study to evaluate the reaction of 138 patients to their facial prosthesis.

Color fading was the most frequent response given by the patients for disliking their responses.

Factors that cause color instability are accumulation of stains, dehydration, water absorption, infiltration, surface roughness, chemical degradation, degradation from use, oxidation during double carbon reactions to produce peroxide compounds, and continuous formation of pigments due to degradation.

The intrinsic factors involve discoloration of the material itself with alterations in the matrix.

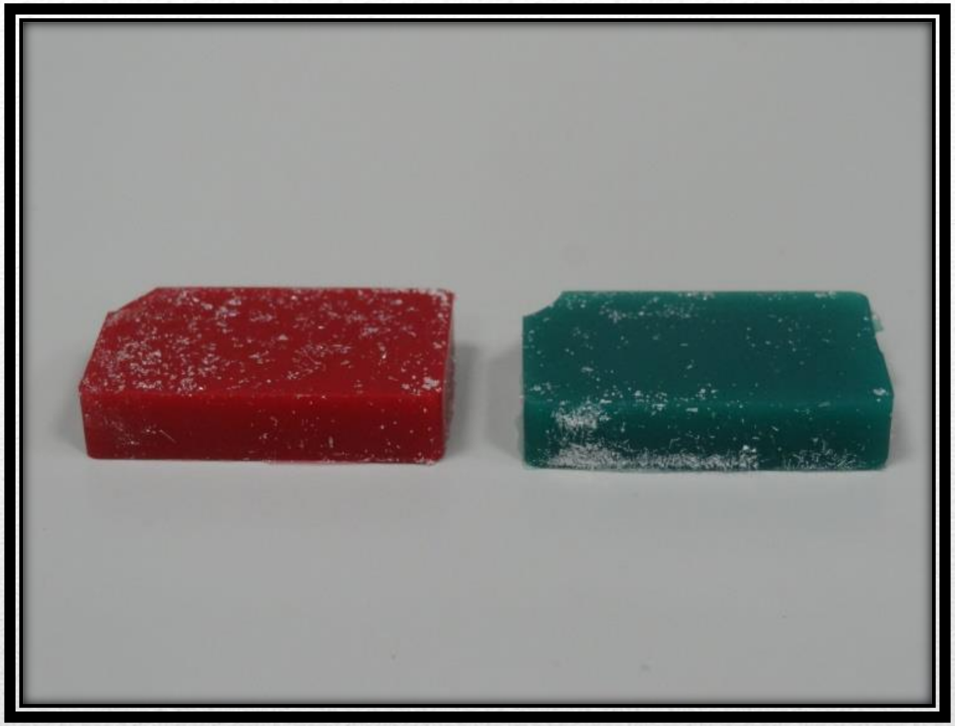
Extrinsic factors, such as the absorption and adsorption of substances, are chiefly responsible for discoloration.

As compared to external pigment, internal pigments exhibit less loss of colour because there are fewer chances of internal pigments to be dissolved during cleaning of the prosthesis.

Proper daily care and maintenance of the facial prosthesis should be specified in the literature given to the patient.

The patient should be instructed to avoid exposure to direct sunlight, application of water base or other makeup/ any cosmetic on prosthesis, use of isopropyl alcohol to clean the prosthesis.

Patient should be advised to use hats and sunglasses and quit smoking to increase the life of prosthesis.



The possibility of using UV absorbers maybe a partial solution regarding pigment stability of facial prosthesis.

UV absorber may help incase of facial prosthesis to increase the color stability besides applying UV protection internally to the silicone prosthesis; external protection from a spray with a UV inhibitor should be investigated.

The patient should be trained on how to insert and remove the prosthesis.

Research may need to be directed towards minimizing the degree of color changes and effect of human environment (sebum, alkaline perspiration) on color stability of maxillofacial prosthesis.

Conclusion:

Maxillofacial patients suffer from not only pains and dysfunctions but psychological problems associated with facial disfigurement, especially after surgery.

So success of prosthesis lies not only in its precise fitting but also in how well it intermingles with skin colour and how stable is the colour.

Thank you for your kind listening