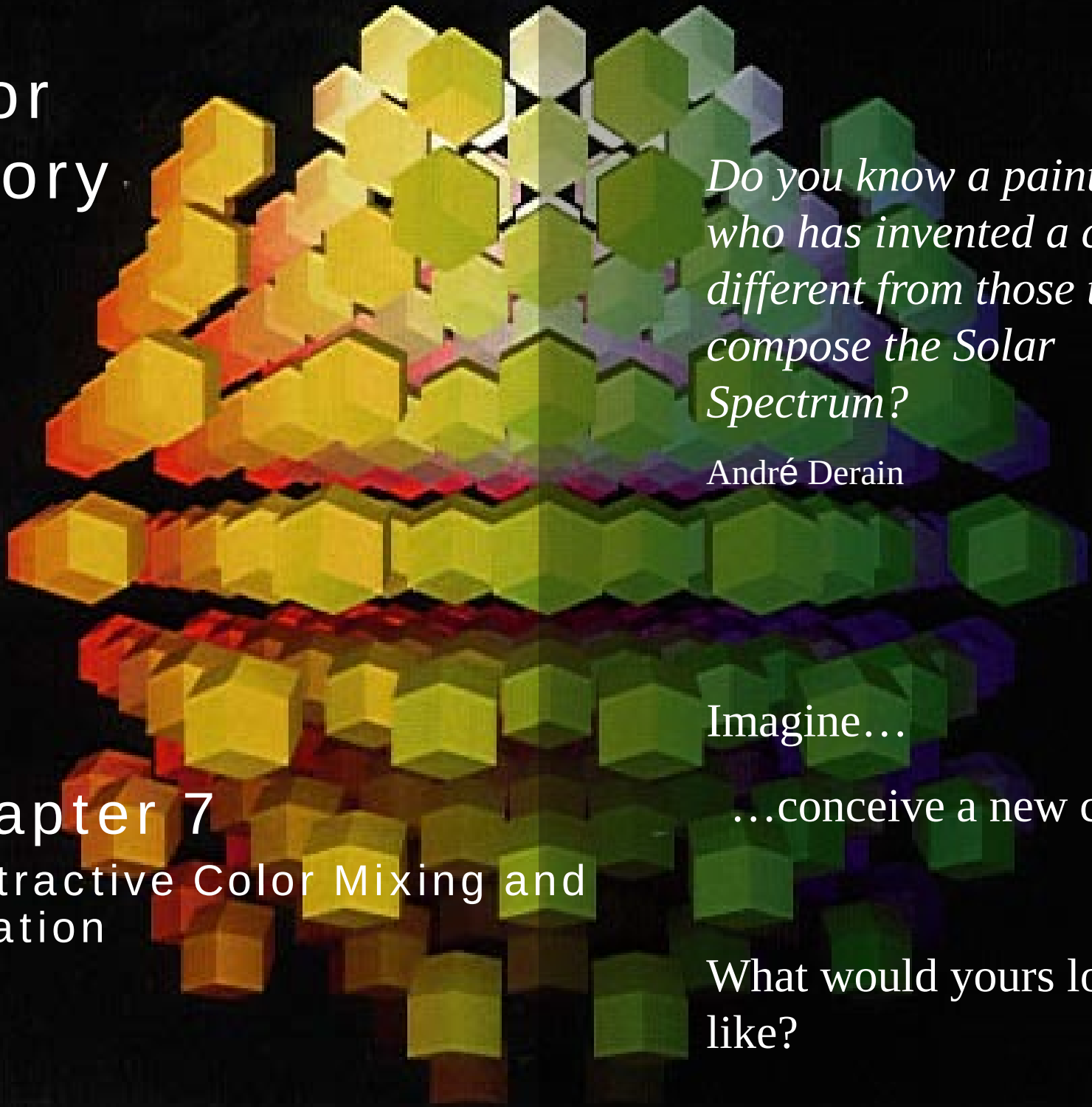
Color Theory



Do you know a painter who has invented a color different from those that compose the Solar Spectrum?

André Derain

Imagine…

…conceive a new color.

What would yours look like?

- Chapter 7
- Subtractive Color Mixing and Notation

Chapter 7

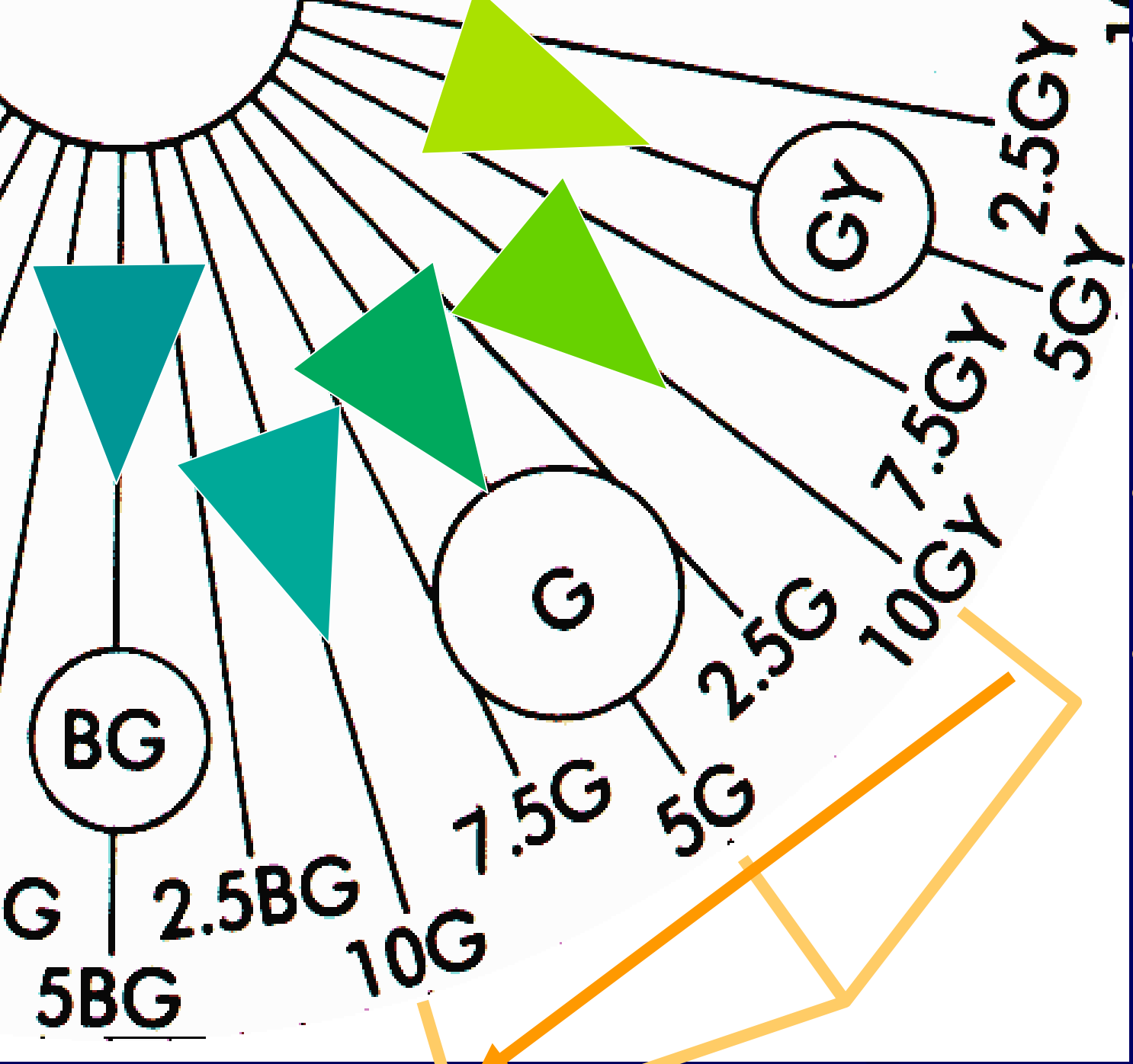
- Dyes vs. Pigments
- Color Specification Systems
  - Munsell Notation System
  - C.I.E. System
  - Pantone Matching System
- Mixing Oils and Acrylics
- Ceramic Glazes
- Colored Glass
- Color Printing
- Color Photography
- Fiber Dyes
- Fading of Subtractive Color

Dyes vs. Pigments vs. Lakes

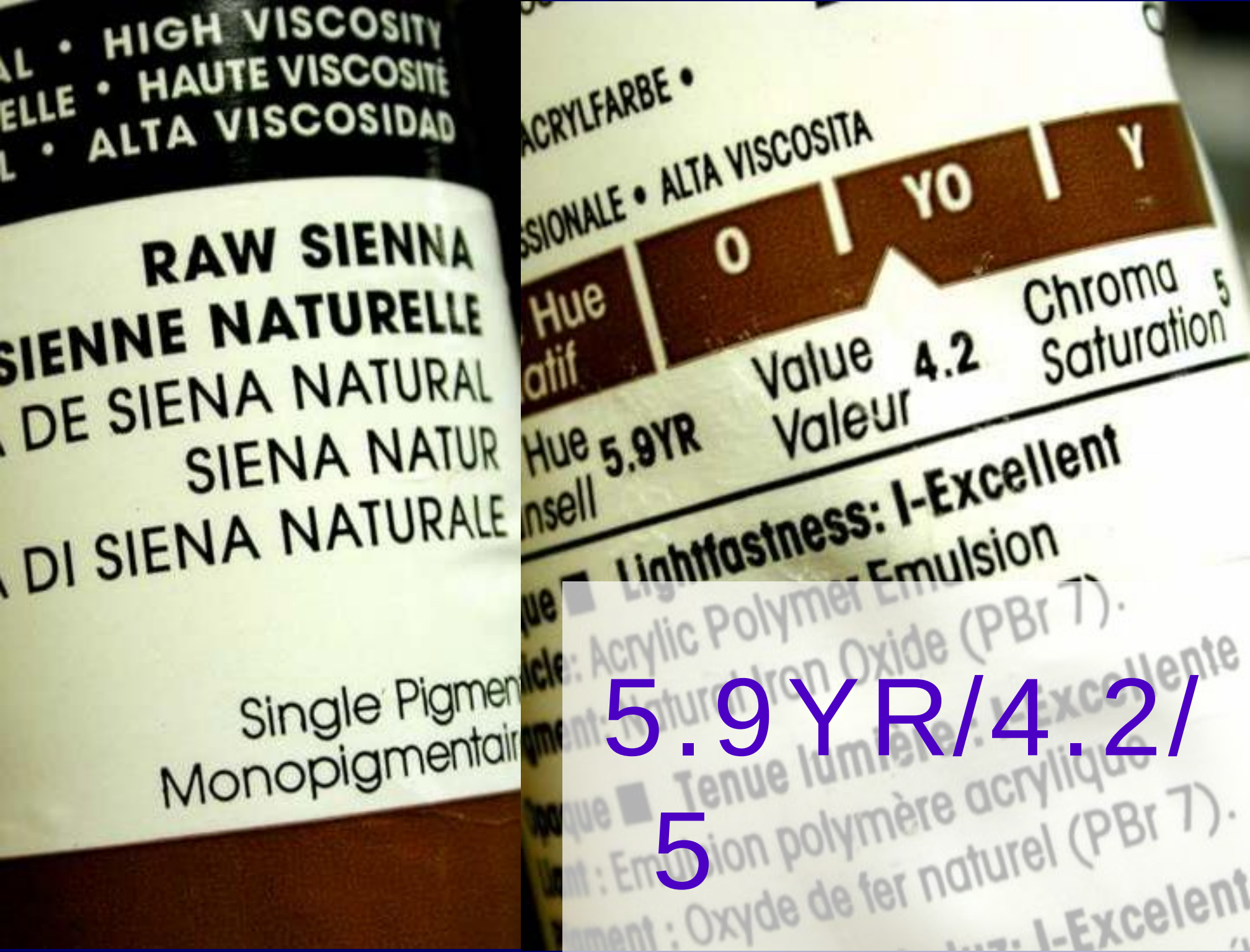
- Each of these are means of introducing color into a medium.
- **Pigments** are bits of power suspended (floating or mixed into) a medium. They tend to be opaque.
- **Dyes** are dissolved into a liquid solvent…in practice dyes are much, much smaller molecules than pigments. They tend to be transparent.
- **Lakes** are a compromise. Many paints need denser, more opaque pigments — traits that dyes to not offer. So dyes are used to stain a white pigment. Then that color pigment (a Lake) is mixed into a medium.

Color Specification Systems

- The goal is a *system for describing a VERY specific color*.
- All visual design professions need to describe & control the colors produced *by others*.
- It doesn't matter if the design looks great on your computer screen when you designed it, it must look good in the *finished product*.



- Munsell “Greens”
- 0G - YG (=10YG)
- 5G - G
- 10G - BG (=0BG)

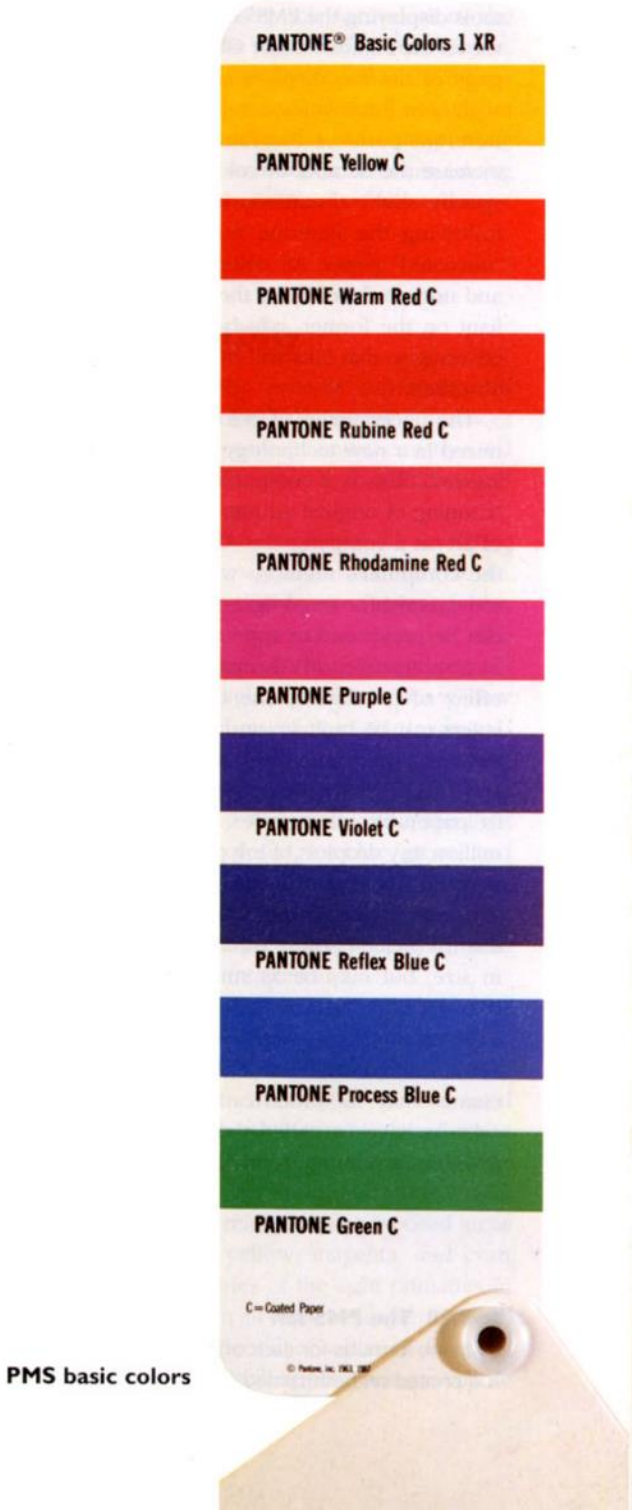

AL • HIGH VISCOSITY
ELLE • HAUTE VISCOSITÉ
L • ALTA VISCOSIDAD
RAW SIENNA
SIENNE NATURELLE
A DE SIENA NATURAL
SIENA NATUR
A DI SIENA NATURALE
Single Pigmen
Monopigmentair
ACRYLFARBE •
SSIONALE • ALTA VISCOSITA
Hue
atif
O
YO
Y
Hue 5.9YR
nsell
Value 4.2
Valeur
Chroma 5
Saturation
Lightfastness: I-Excellent
Emulsion
5.9YR/4.2/5

Pantone
—offset print “palette”

- Current Pantone Spot color formulations are based on 14 basic colors (source colors), plus transparent and opaque white and black. These 14 colors offer a wide color gamut.

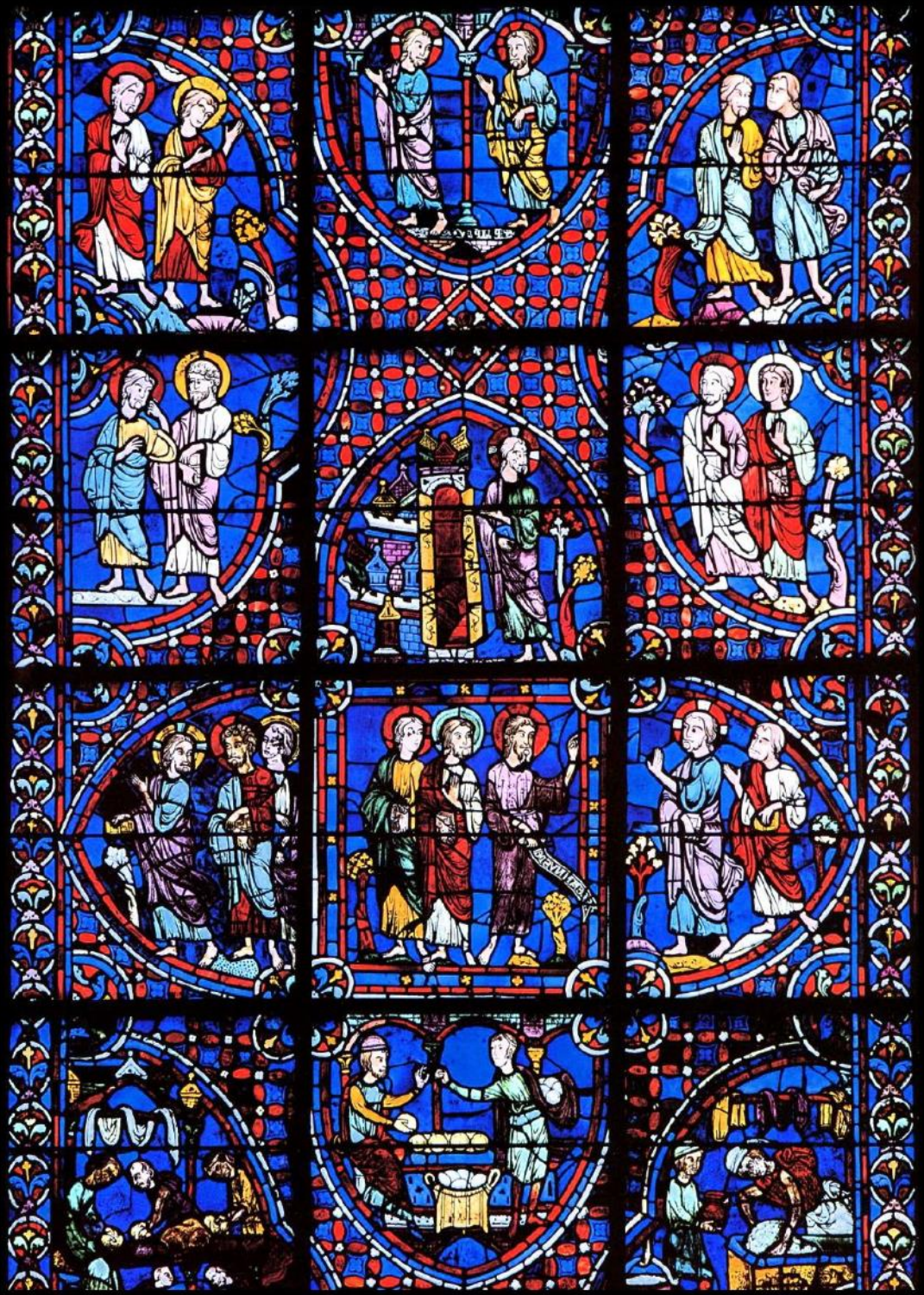
- Individual *spot colors* are mixed from these basic colors.

- Each PMS color has a formula or ‘recipe’ using these colors as ingredients.



PMS basic colors

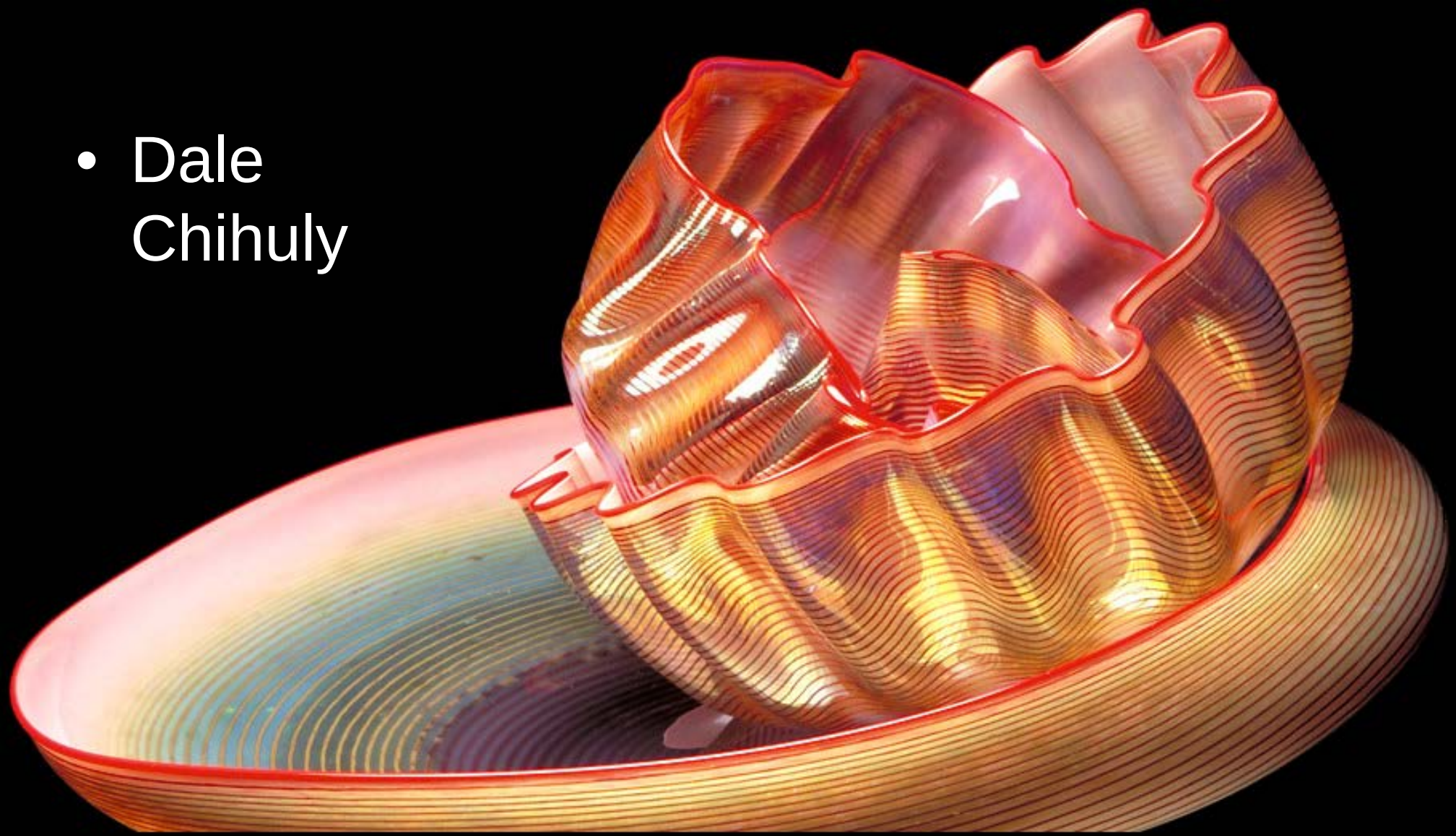
- Notre Dame Cathedral, Chartres, France

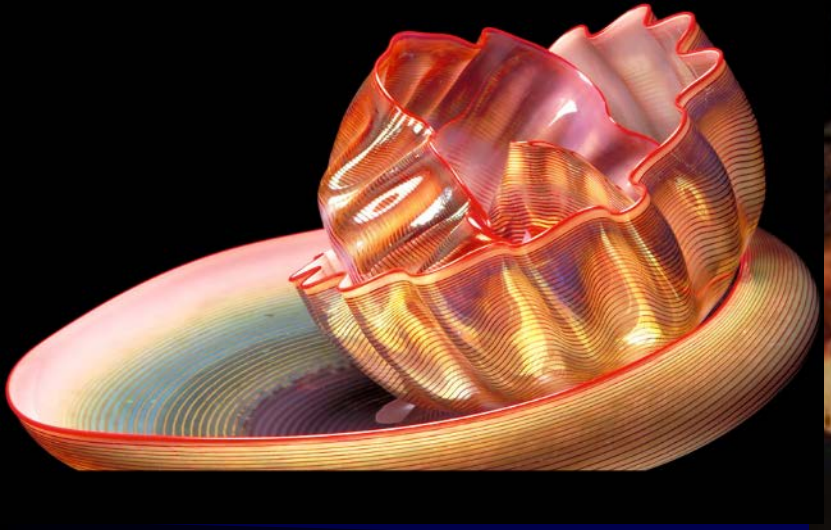


- Chartres Cathedral

- Dale Chihuly

- Dale Chihuly





- Video

- Dale Chihuly

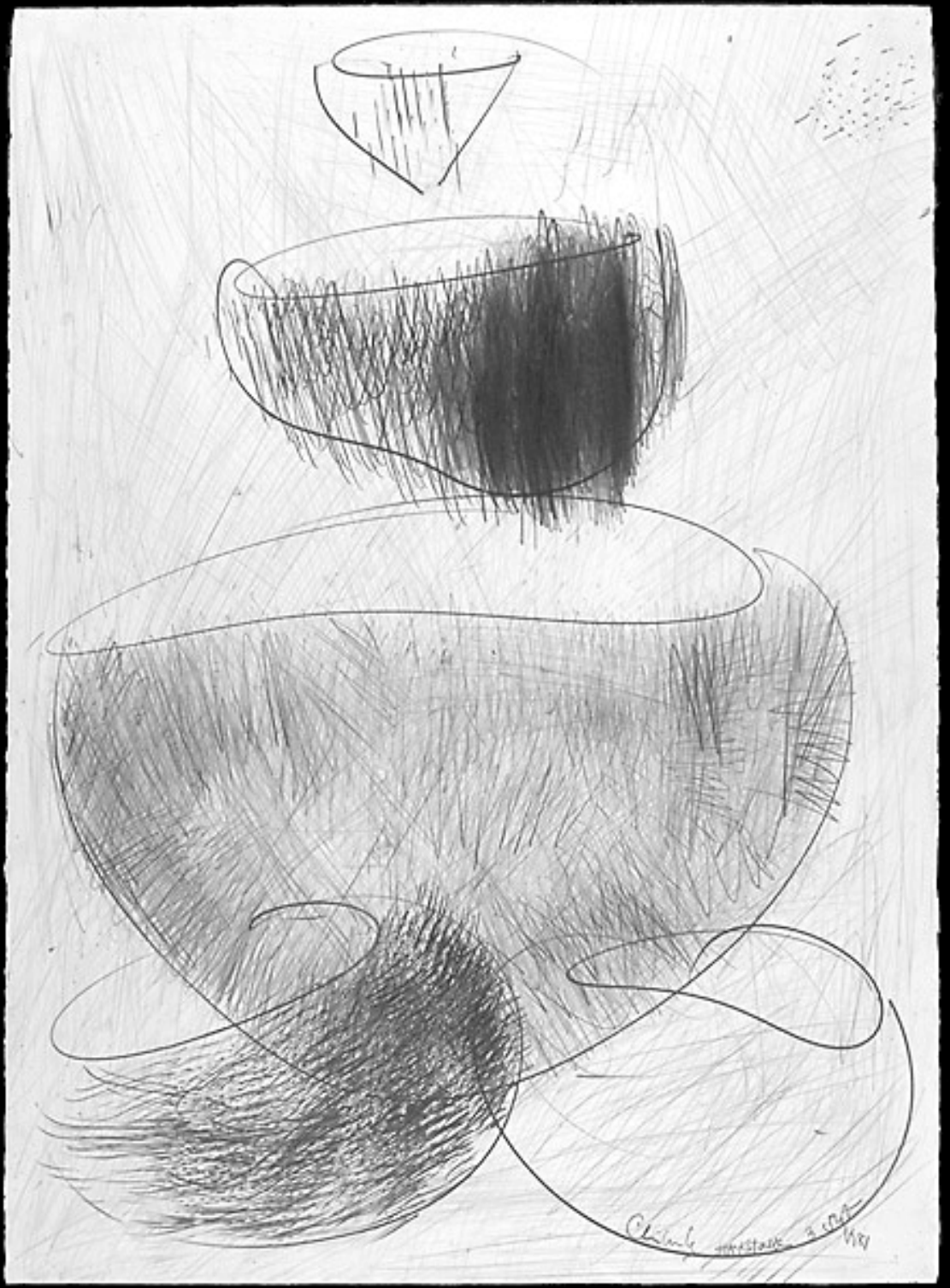
Dale Chihuly

Born in 1941 in Tacoma, Washington, Dale Chihuly was introduced to glass while studying interior design at the University of Washington. After graduating in 1965, Chihuly enrolled in the first glass program in the country at the University of Wisconsin. He continued his studies at the Rhode Island School of Design (RISD), where he later established the glass program and taught for over a decade.

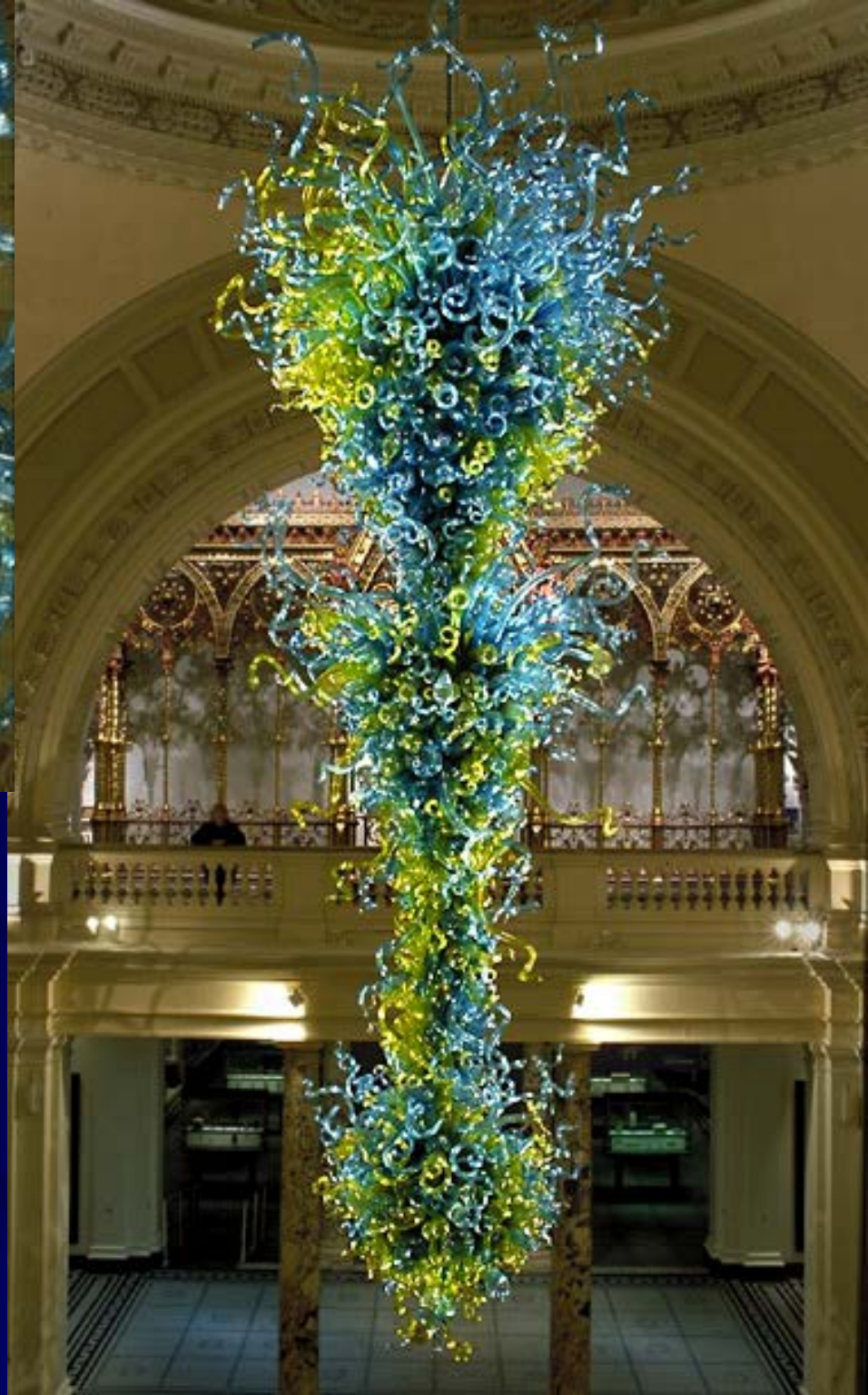
Dale Chihuly and a recent creation.

- Chihuly
- Concept drawings for *basket* series.

- Chihuly
- Concept drawings for *basket* series.



- Dale Chihuly
- Installations
- Victoria & Albert Museum, London



- Dale Chihuly
- Coral Gables, FL with floating spheres in the background

- Fiori Di Como, 1998, Ballagio Resort, Las Vegas

- Fiori Di Como, 1998, Ballagio Resort, Las Vegas

- Dale Chihuly
- Chihuly Over Venice
- Video
- Chihuly worked with glass studios all over the world to create pieces for the temorary Venice installation.

- Small quantities of Metallic oxides are mixed into glass to create color in glass

Glass :

Soda, silica, and lime.

- “Glass is a manufactured thermoplastic consisting commonly of silicates of calcium and sodium, composed of silica, lime and potash or soda.”
- Highly recyclable.
- Made primarily of the earth’s most available material — silicon *(that is, sand.)*

Dale Chihuly and a recent creation.

Stained/Blown Glass

- Opacity, transparency or translucency (opalescence) are determined by the relative proportions of the raw ingredients, which form glass after three or four hours smelting at a temperature in excess of 1,500 degrees Celsius.

- http://www.coloracademy.co.uk/Subjects/Glass/Glass.htm

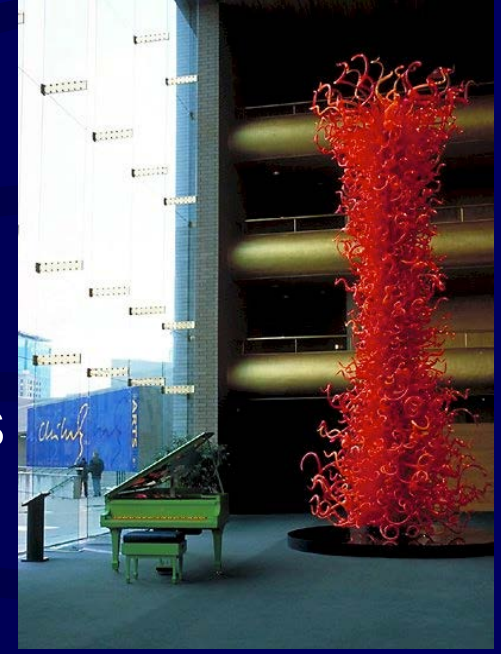
Glass :

Soda, silica, and lime.

- **Romans** added manganese or antimony to produce a colorless clear glass.
- Very small portions of **metallic oxides** are added to produce brilliant colors.
- The transparent nature of glass dramatically enhances the beauty of colored glass.

Chihuly *Bridge of Glass*, le Seaform Pavilion, Tacoma, Washington, Dale Chihuly 2002

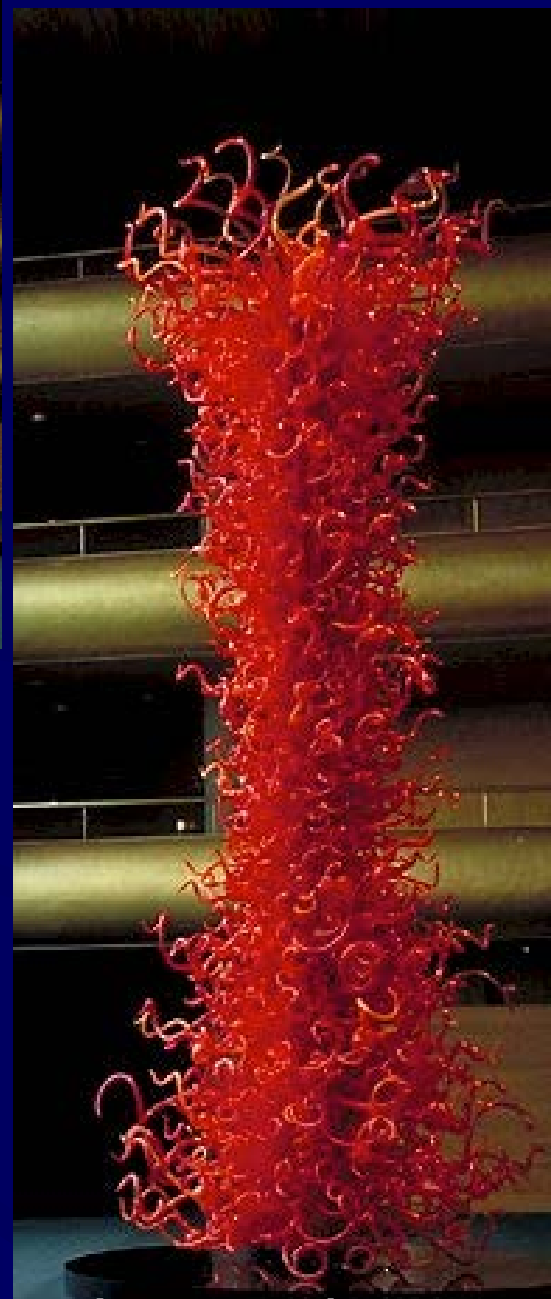
Colored Glass & Glazes



- To color glass and ceramic products, heavy metal oxides are either dissolved in the melts (**ionic coloration**) or incorporated into the melt as a pigment or stain (**pigmentation**).

- The coloring effect of the pigments and stains is determined by the nature of the **raw materials, the firing temperature, dwell time and kiln atmosphere** (reducing or oxidizing).

- http://www.bayferrox.bayerchemicals.com/bayer/chemicals/ipg.nsf/id/25F7D8640F7A66F5C1256CBE0059D4B8



Olympic Tower by
Dale Chihuly
Created as a cultural legacy to the 2002 Winter Olympic Games

Stained Glass

metallic “pigments”

- Oxides of cadmium, selenium or iron produce **red** glass.
- Oxides of cerium, titanium or vanadium give various **yellows**;
- oxides of nickel, chromium or tellurium give **greens**.
- copper oxide gives either **green or blue** glass.

- http://www.coloracademy.co.uk/Subjects/Glass/Glass.htm

Chihuly created the Yellow Neon Chandelier for the Columbus Visitors Center.

Created in 1995, the chandelier is made of 900 pieces of hand-blown glass. Weighing more than 1,000 pounds and measuring nine feet long and six feet wide, it contains 500 feet of neon tubing.

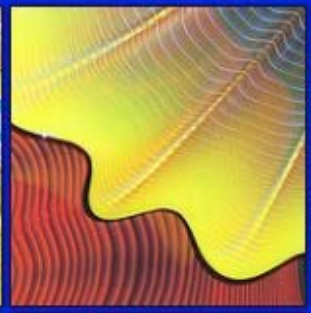
- Floating glass in St. Louis Botanical Gardens.

- Dale Chihuly

- Chihuly installation in Missouri Botanial Gardens.

- Chihuly chandelier in the Weidner Center in Green Bay, Wisconsin

















FRANKLIN PARK CONSERVATORY
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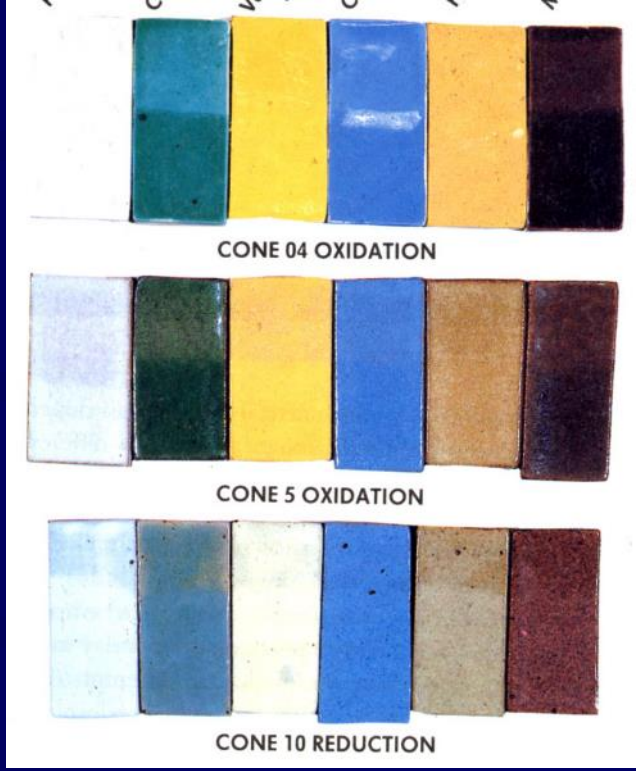
Ceramic Glazes

- Underglaze
- Overglaze
- Luster
- High Fire
- Stoneware
- Earthenware
- Raku
- …etc.

Ceramic Glazes

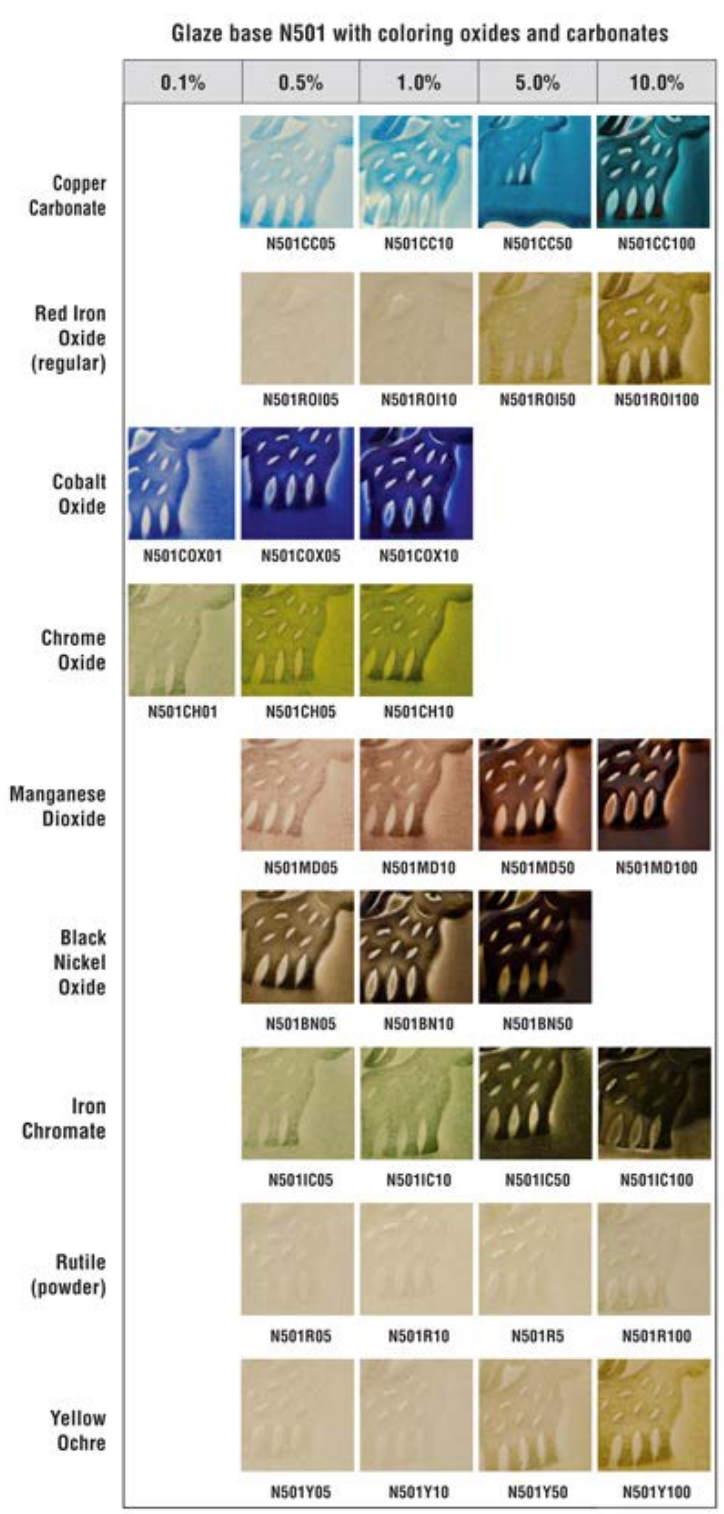


- Many potters still mix and test their own unique glazes, while a wide variety of commercial glazes are available.
- Different clay naturally has different colors – browns, oranges, white, etc. Glazes can be transparent over clay, or opaque.
- Glazes made of silicates – a form of glass.
- Glazes vary in their finish, as well as color: glossy, matte, transparent, opaque, irregular pits.

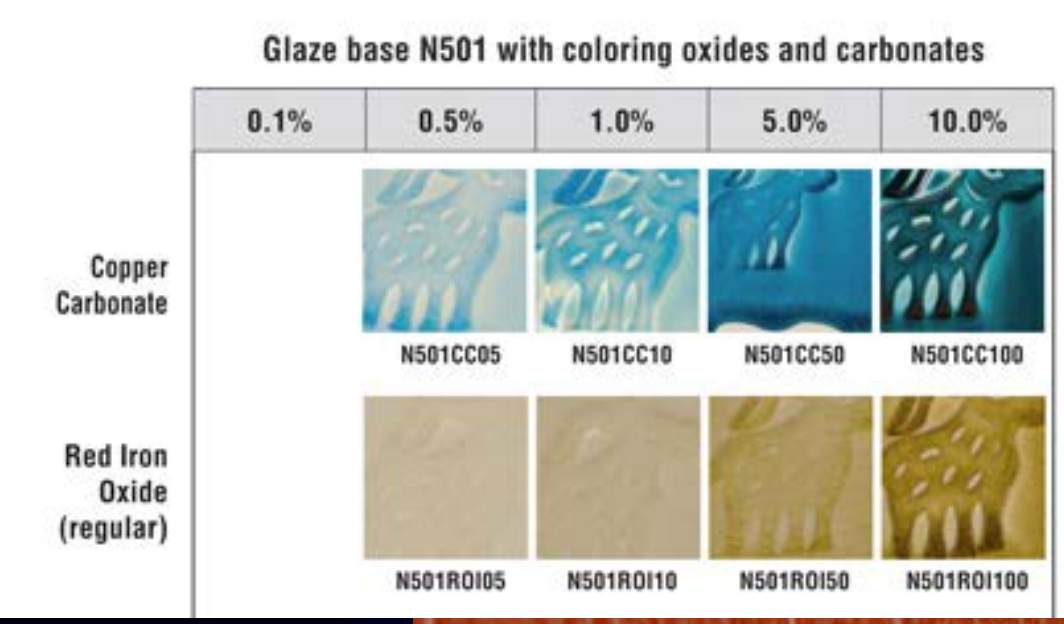
Colors hard to anticipate without testing

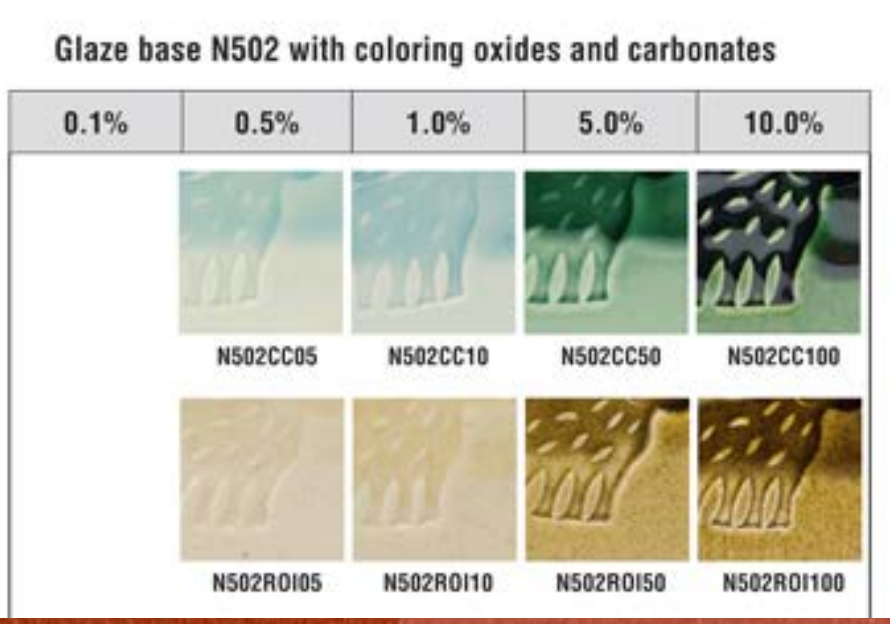
- Color of glaze not apparent until after firing – so potters must rely on prefired sample tiles and then reproduce the same firing conditions.
- Methods of firing also affect final glaze colors.
- Glazes must be selected for suitability to the particular clay body to which it will be applied.
- Fritted Glazes have shattered bits of water-soluble, molten chemicals added, increasing their color clarity.

- Ceramists must study the effects of various glaze formulas and of firing conditions.
- Glaze samples are here organized to show the effect of various metal oxides and concentrations within a glaze.



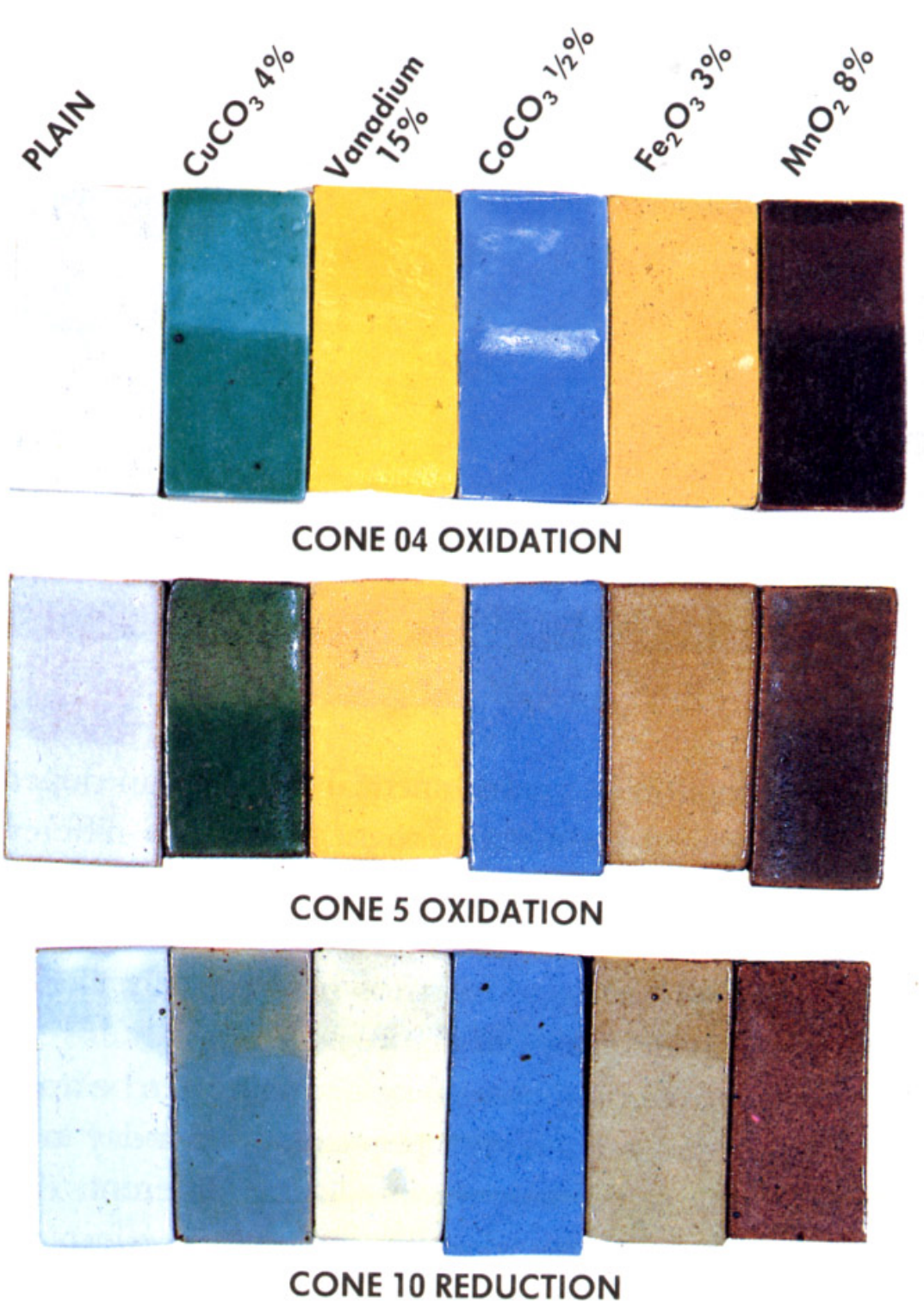
- The left and right sets use a different base glaze.
- The top and bottom rows use two different metallic compounds.
- Note that Iron Oxide (2nd row) is used as a pigment in paint — below is Liquitex swatch for Red Oxide.





http://ceramicartsdaily.org/

- Test tiles must be fired and the resulting colors observed.
- Firing conditions alter the color and finish of a glaze…
- …particularly the firing temperature; the same glaze will produce a different color and finish if fired to a different temperature.



- *What effects the final glaze?*

- The **thickness** of glaze application, the **angle** of the glaze on the ware, the type of **clay**, the **temperature** at which the green clay was bisqued, the **atmosphere** inside the kiln, the **top temperature** of the firing, and the **soak temperature** and **time**.

- (it makes mixing paint look easy.)

Fiber Dyes

- Over 8,000 dyes are now classified by chemical traits and applications.
- Most living plants produces something that can be used as a dye – leaves, stems, berries, seeds, barks and roots all offer possibilities.
- Natural dyes are most commonly yellow and earthy browns.

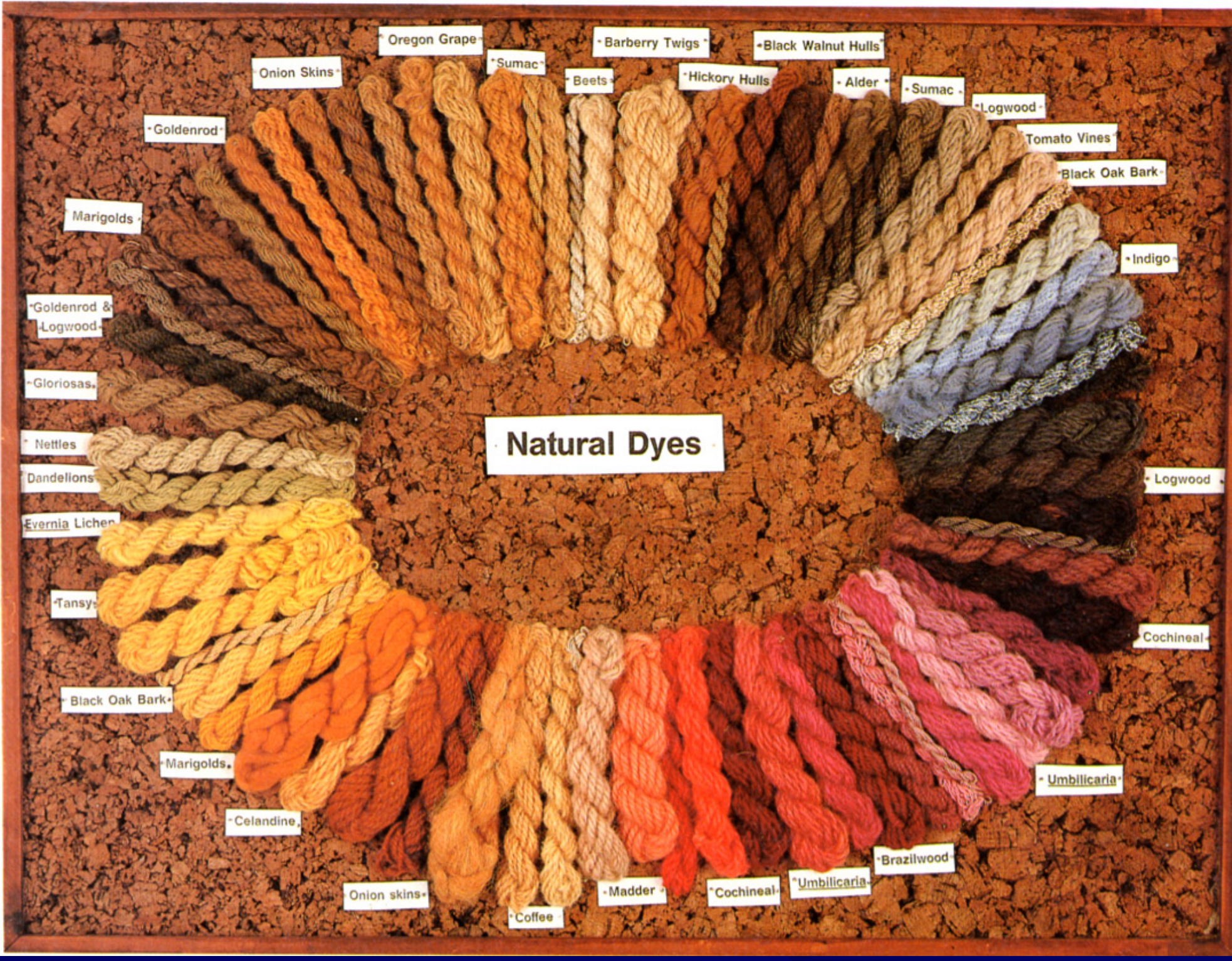
Production Dyes and Specifications

- Variations and inconsistencies in the way natural dyes behave can appeal to craftspersons and artists, but such variations are not wanted by commercial production.

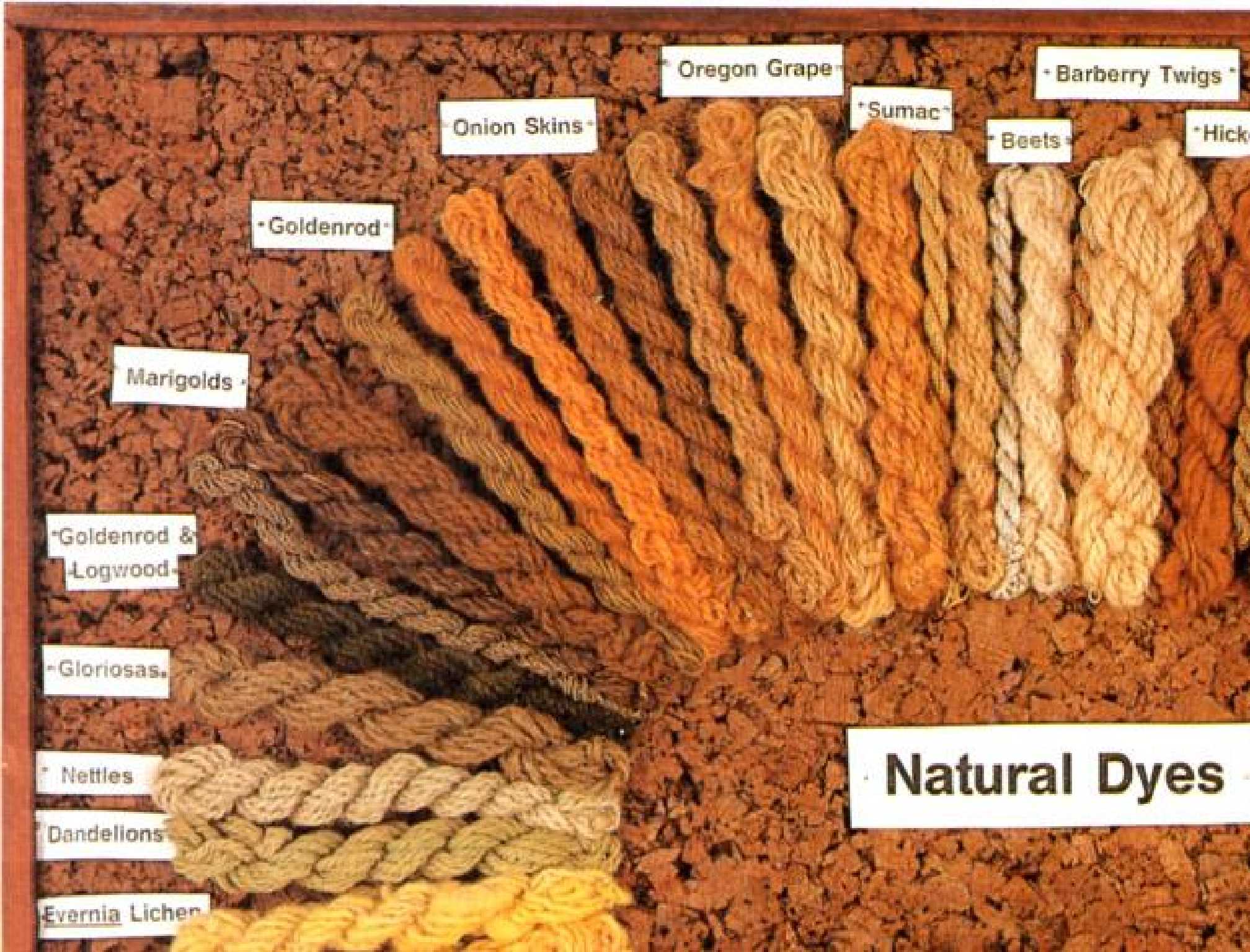
- (Remember what motivated Chevreul?)

Fiber Dye technical Issues

- Natural dyes only adhere to natural fibers.
- Artificial fibers must often be dyed by Dispersed Dyes.
- The color of the underlying fiber effects the final color of dyed fiber.
- Mordant -- A chemical that causes a dye to “set” or become stable. Some dyes must be soaked in mordants to produce fixed colors.
- Dyes often do not mix – to combine colors, fibers must be dyed one color at a time.


Natural Dyes
Oregon Grape
Barberry Twigs
Black Walnut Hulls
Onion Skins
Sumac
Beets
Hickory Hulls
Alder
Sumac
Logwood
Goldenrod
Tomato Vines
Black Oak Bark
Marigolds
Indigo
Goldenrod & Logwood
Gloriosas
Nettles
Logwood
Dandelions
Evernia Lichen
Tansy
Cochineal
Black Oak Bark
Marigolds
Umbilicaria
Celandine
Brazilwood
Onion skins
Madder
Cochineal
Umbilicaria
Coffee


Natural Dyes
Nettles
Dandelions
Evernia Lichen
Tansy
Black Oak Bark
Marigolds
Celandine
Onion skins
Coffee
Madder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Barberry Twigs
Onion Skins
Sumac
Beets
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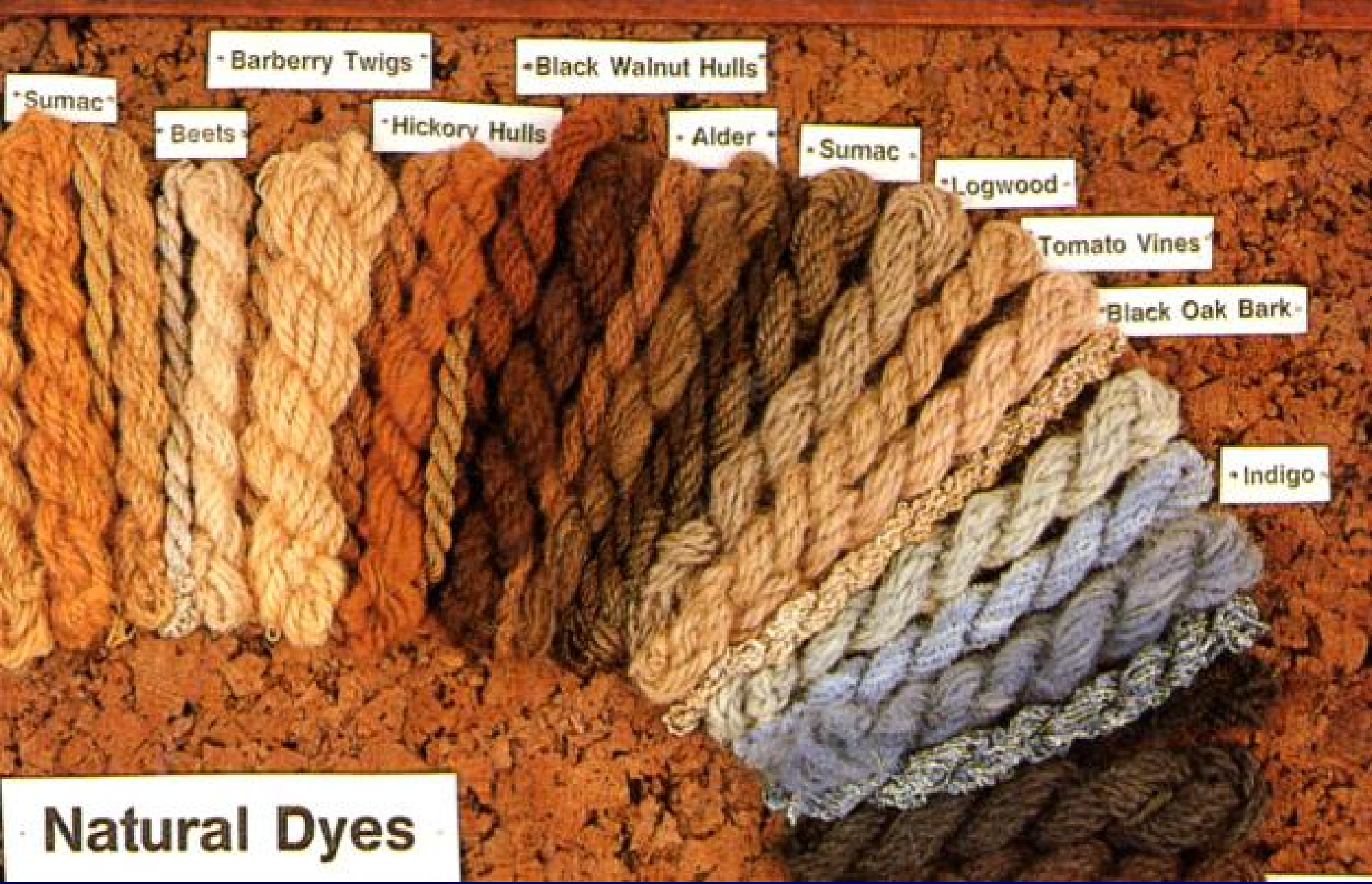
Goldenrod
Marigolds
Goldenrod &
Logwood
Gloriosas
Nettles
Dandelions
Evernia Lichen
Natural Dyes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Sumac
Logwood
Tomato Vines
Black Oak Bark
Indigo
Natural Dyes


Natural Dyes
Logwo
Cochinea
Umbilicaria
Brazilwood
Umbilicaria
Cochineal
Madder
Coffee

Types of Dyes

- **Reactive Dyes**, such as henna for hair coloring bond chemically with the fiber.
- **Vat Dyes** respond within the fiber only after a special follow-up treatment of air, light, or acid is applied.
- **Synthetic Dyes** have dramatically altered our color options and offer color stability rarely available in natural dyes.
- Direct Dyeing & Hand-dyeing procedure.

Naturally Colored Cotton

- Some cotton is ***naturally colored*** — it grows that way and **does not need to be dyed**.

- Weavers cultivated native **white, tan, green, yellow, red, and brown** colored cottons for thousands of years in South America.

- However, the fiber qualities of the cotton was **not suited to modern textile machines**. The fiber is relatively coarse, thus it was used only in artisan crafts.

FOX FIBRE®

COLOUR·BY·NATURE®

Naturally Colored Cotton

Pigmented fibers with the **color as a part of the lumen (the fiber itself)**.

- Naturally colored cottons have been **grown domestically for several thousand years in Central and South America**.

•http://cati.csufresno.edu/upda/95/spring/story1.html

Naturally Colored Cotton

- Naturally colored cottons are unique because they ***don't require dyeing*** in the fabric manufacturing process.

- In traditional processing, cotton fibers are first **bleached, then colored with dyes that often contain heavy metals**.

- The dying processes produce significant amounts of **contaminated waste water**.

http://cati.csufresno.edu/upda/95/spring/story1.html

Naturally Colored Cotton

- "With naturally colored cotton, textile mills can **reduce processing costs by using less water and energy and thus comply more easily with EPA regulations**".

- **Cotton plant breeders** from California and Arizona are hoping the latest commercial push of new **"environmentally-friendly" clothing** will win the hearts, and eventually the dollars, of U.S. consumers.

http://cati.csufresno.edu/upda/95/spring/story1.html

NATURALLY COLORED COTTON—PERU

- *Naturally pigmented cotton and fine fabrics have been* ***produced for nearly five millennia in Peru***, constituting the oldest recorded tradition of spinning and weaving in human history.

- The vast array of natural cotton colors has been well documented since the time of the New World explorers.

- http://www.perunaturtex.com/textile.htm

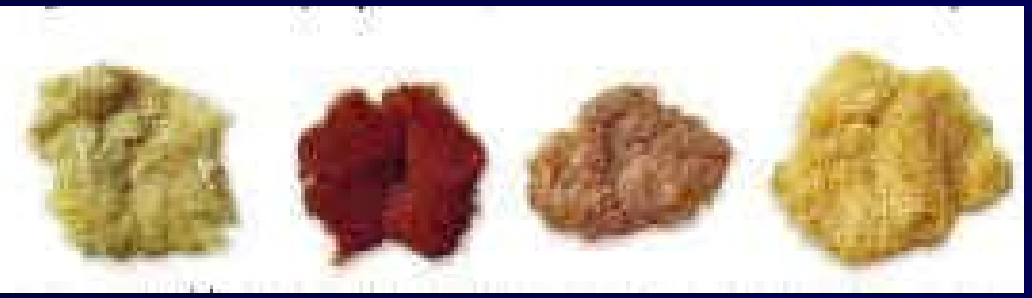
NATURALLY COLORED COTTON PERU

- When the *Spaniards crossed the Peruvian desert in 1531* they marveled at the extensive fields of *cotton growing in a range of colors* unlike anything they had seen before.

- Highly prized by the Europeans, these long stapled cotton plants of Central and South America, were transported around the world to become the progenitors of what today are considered to be the world's premier cottons.

- http://www.perunaturtex.com/textile.htm

NATURALLY COLORED PURUVIAN COTTON



Colored cotton was found growing in a few few places on Peru's north coast. The plant which had been carefully cultivated and maintained over millennia, is now producing naturally colored cotton for commercial uses.
80+ colors are now available.

- http://www.perunaturtex.com/scientif.htm

NATURALLY COLORED COTTON PERU

- *No dyes, chemicals or other synthetic processes* have been used to grow, soften or color the fibers.
- This exquisite pigmentation is achieved *organically*, in a chemical-free environment.

- http://www.perunaturtex.com/textile.htm

NATURALLY COLORED COTTON PERU

- Naturally colored fiber reduces chemical pollution on the field, in the factory and in the home.

- http://www.perunaturtex.com/textile.htm

Cotton not Coca (cocaine)

- *What!?*

- Some regions of Peru are currently dominated by coca farming. Drug-traffic income potential is high in this poor region.

- However, the Peruvian government is encouraging farmers to convert to organically grown, naturally colored cotton as a viable alternative source of livelihood.

- The **Native Cotton Project** seeks to establish a new and sustainable market for this fiber by transforming it into yarn, fabric and garments.

Machu Picchu

Cotton not Coca (cocaine)

- With marketing and technical assistance, the expansion of the current production base is likely to occur quickly and in a sustained manner, providing an attractive alternative to environmentally hazardous coca cultivation.
-
- **The revival of fine organic and naturally pigmented cotton textiles of Peru draws on the cultural heritage of great Andean traditions.**

- *…so buy (Peruvian) naturally-colored cotton, and fight drugs!*

China aims for colored cotton production

- Xinjiang Produces **30% of World's Colored Cotton Output**

- **Northwest China's** Xinjiang Uygur Autonomous Region, a leading cotton producer of China, reaped 44,000 tons of colored cotton a year.

- Xinjiang now grows approximately 46,700 hectares of colored cotton, making the region the **largest colored cotton production base in the world**, according to the regional development and reform committee.

- (Xinhua News Agency December 27, 2005)

Genetically Engineered Color

- Xinjiang has developed **seven colored cotton strains including brown and green cotton**.
- Researchers with the Xinjiang Genetically Modified Colored Cotton Institute had been working with the hereditary Science Institute of the Chinese Academy of Sciences to produce **red, blue and black cotton** **by transferring an external colored gene into naturally grown white cotton with sophisticated genetic engineering technology.**

- (Xinhua News Agency December 27, 2005)

Growing market for naturally colored cotton

- Global colored cotton output reached up to 160,000 tons last year and the sales of cotton yarn rose by over 300 times as compared with 2000.

- It is estimated that **colored cotton output will make up to 30 percent of world's total cotton in the next three decades**.

- (Xinhua News Agency December 27, 2005)

Colors due to genetics and soil and climate.

- “Historical records report the existence of browns with pink and lavender tints. The natural color is due to the plant’s inherent genetic properties.

- “Shades of colored cotton can vary over seasons and geographic location due to climate and soil variation
- http://www.perunaturtex.com/scientif.htm

Initially, naturally colored cotton was not suitable for mass production.

Because of low yields, the inability of the fiber to be machine spun (due to short fibers), and the availability of inexpensive dye-stuffs, naturally colored cottons have not been utilized for commercial textile production (Backe, 1994).

Viable Cottons have been developed and trademarked.

In 1982 Sally Fox, a plant breeder now based in Wickenburg, Arizona, began a breeding and selection program to improve the length and quality of naturally colored cotton fibers.

•By 1988 Fox had developed colored cotton hybrids with fibers long enough to machine-spin successfully (Fox, 1987). Success in breeding a machine-spinnable, naturally colored cotton fiber led Sally Fox to establish Natural

•Cotton Colours, Inc. Fox obtained a certificate of plant variety protection for her cotton and a registered trademark, FoxFibre®.

- The future of colored cotton looks bright in many places. It has attained near-celebrity status in the U.S. and Europe. And this year (2008) Peru's naturally pigmented and organically grown cotton exports will exceed $15 million.
-
- COTTON CLOTHES in naturally occurring colors are produced in Peru and sold internationally under the brand name Pakucho.
  Pakucho means "brown cotton" in the ancient Inca language.
- FoxFibre is another expanding brand, extending from Sally Fox's research.

- http://www.perunaturtex.com/scientif.htm

- Coloured chicks on display for sale at a local market place in Amman, Jordan. February 20, 2002.
  Merchants colour the chicks to attract children as thousands of Jordanian shoppers rush to the markets to buy goods and food ahead of the Muslim Eid al-Adha feast, a major Muslim holiday.
  Friday. 20 Feb 2002 **REUTERS/Ali Jarekji**

Coloring Chicks

Coloring embryos by injecting dye into eggs before they hatch has been practiced for years.

By dyeing the chicks, we can identify the young of certain hatches or groups. Some scientists use this method to observe movements of wild birds (especially birds like ducks) after they leave the nests.

- i

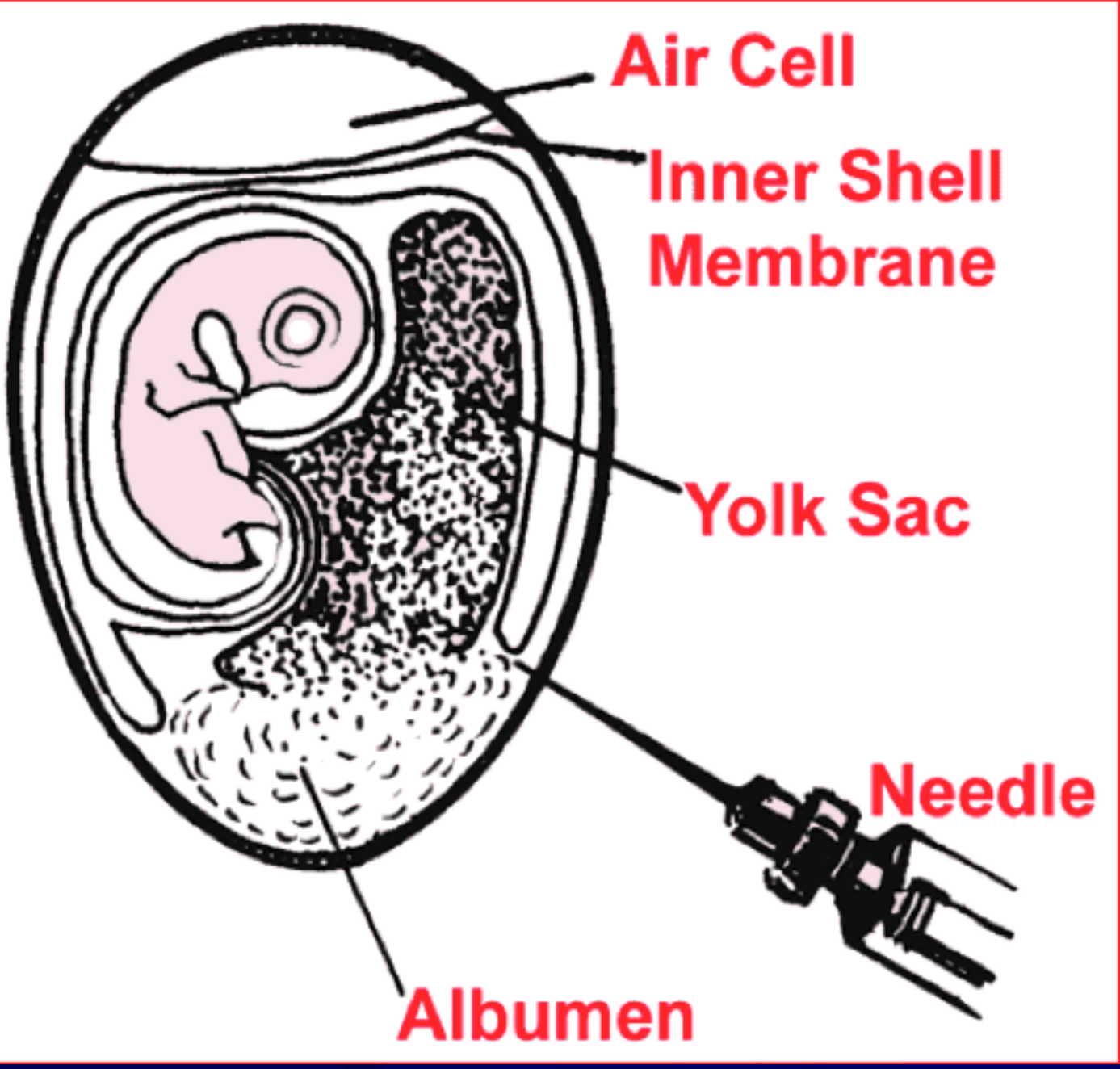
Coloring Chicks

By coloring chicks, we can study how the chick's feathers grow. The colored down (the fuzzy colors you see now) are replaced by juvenile feathers in about two weeks.

You can see how the feathers change by watching the color pattern change on the baby chicks.

Dyeing by injection of the egg doesn't affect the chick's health, appetite, or growth.

Coloring Chicks



Find out how:
http://chickscope.beckman.uiuc.edu/resources/egg_to_chick/coloring.html

Coloring Chicks harmlessly

Harmless vegetable dyes, such as food coloring dyes sold in grocery stores, work very satisfactorily.

Dyeing by injection of the egg will not affect the chick's health, appetite, or growth.

Find out how:
http://chickscope.beckman.uiuc.edu/resources/egg_to_chick/coloring.html

Subtractive Color Sources

- Pigments and Dyes are our sources of color.
- Natural and Synthetic agents are used.
- Paint, Printing, Glass, Glazes, Fibers are among the applications that rely on subtractive color mixing.
- Production printing and digital imaging have actively pursued systems for specifying, testing, and calibrating color output.
- Despite rampant advances in synthetic color, organic, natural sources of color are expanding as well.