COLORING TEXTILES WITH BUGS: OLD [COCHINEAL] AND NEW [BACTERIA]

September 29-30, 2018

Genspace, New York

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WORKSHOP PLAN

DAY 1-Sep 29th, 12:30-4 pm

Cochineal

Talk (30min), Naomi

Hands-on work (1 hour)

- Browse samples
- Crush cochineal, observe under the microscope
- Play with pH (lemon, potash, alum)

Bacteria

Talk (30min), Sumeyye

Hands-on work (1 hour)

- Painting with bacteria

DAY 2-Sep 30th, 3-7pm

Cochineal

Hands-on work (2 hours)

- Textile dyeing

Bacteria

Hands-on work (1 hour)

- Printing bacterial designs on textile

Making Bacteria + Cochineal Collages

Hands-on creativity time (1 hour)

- Create your own collages by combining bacterial prints with pieces of Cochineal dyed textiles for a final art piece.

Outline

- Dyeing background and basics
- Classification of organic dyes
  - Direct dyes
  - Mordant dyes
    - Mordant dye process
      - Mordants (types and examples)
      - Additives (potash)
  - Vat dyes
- Textiles
- Common red colorants in Early Modern Europe (1400-1700)
  - Safflower, henna, lac, redwoods, kermes
- Cochineal
  - History, cultivation, use
  - Industry and applications today
- Natural colorants and sustainability
- Review of pH and cochineal (for hands-on activity)

RESOURCES AND REFERENCES

- Historical recipe examples of cochineal dyes and colorants
- Resources and references
  - Sources of historical evidence
  - References and links

Dyeing background and basics

http://cameo.mfa.org/wiki/Dye

Dye definition and sources

A **DYE** is a compound that absorbs into and colors another material, and is generally a complex organic material.

Natural dyes have historically been extracted from:

- **PLANTS**
  - Such as alkanet, annatto, archil, brazilwood, buckthorn berries, cudbear, cutch, fustic, madder, indigo, litmus, logwood, morinda, quercitron, safflower, saffron, sassafras, sumac, turmeric, turnsole, walnut, weld, and woad
- **INSECTS**
  - Such as kermes, lac dye, cochineal
- **LICHENS** (algae or fungi) and **SHELLFISH**
  - Such as archil (lichen) and Tyrian purple (extracted from mollusks)

Synthetic dyes were first derived in 1856 (from coal-tar extracts to create mauve)

DYESTUFFS
The raw organic materials used to create a dye

https://maiwa.com/pages/natural-dyes

Natural colorants

While colors can be extracted from all plants and some animal products, not all of these colorants have **good dyeing properties**.

They are not **COLORFAST**

pomegranate

https://www.thespruce.com

grass

https://www.123rf.com/photo_37142470_smashed-pomegranate-on-the-table.html

Light fastness tests of textiles dyed with natural colorants. Small squares of each sample were exposed to light of varying intensities and for different durations. The squares exposed to the brightest light for the longest time have faded the most.
http://www.conservationphysics.org/fading/fade.pdf

Color fastness

FASTNESS

The resistance of color to fading.

A colorfast dye will maintain its color when exposed to light, steam, high temperatures, soap, salts, and other environmental conditions.

LIGHT FASTNESS

How resistant a color is to fading when it is exposed to light, especially sunlight.

http://cameo.mfa.org/wiki/Fastness

What creates, changes, or affects the color?

- Dyestuffs
- Textile
- Dyeing time
- Dyeing temperature
- Mordants
- Additives
- Acidity/alkalinity of dye bath

https://maiwa.com/pages/natural-dyes

Classification of organic dyes

Types of dyes (by chemical class)

Indigoids

Anthraquinones

Flavonoids

Carotenoids

Neo-flavonoids/homoisoflavonoids

Types of dyes (by process)

DIRECT DYES

Colorant forms a direct bond to the textile fiber

MORDANT DYES

Colorant needs to bind to a coordination metal as a bridge between the dye and textile fiber

VAT DYES

A chemical reaction (reduction) in the dye vat is needed to bind the dye to the textile

Turmeric
http://www.saniapell.com/homemade/the-colour-of-food-homemade-fabric-dyes/

Cochineal
http://www.dtcrafts.co.uk/dyesFixers/earthues/dy201.htmlw

Indigo
https://gailcreativestudies.wordpress.com/2016/06/29/indigo-in-south-east-asia-guest-blogger-penny-peters/indigo-dye-vat-near-sapa-vietnam/

Direct Dyes

Direct dyes

The dye binds to the textile fiber via hydrophobic interactions, hydrogen bonds and, where applicable, via ionic interactions.

Compared to the other dyeing processes, the fastness to both light and washing are poor.

Turmeric

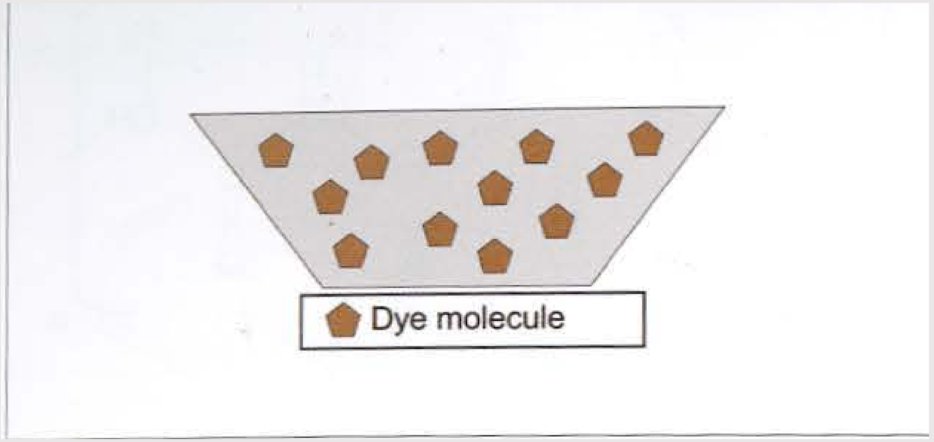
http://www.saniapell.com/homemade/the-colour-of-food-homemade-fabric-dyes/

Saffron

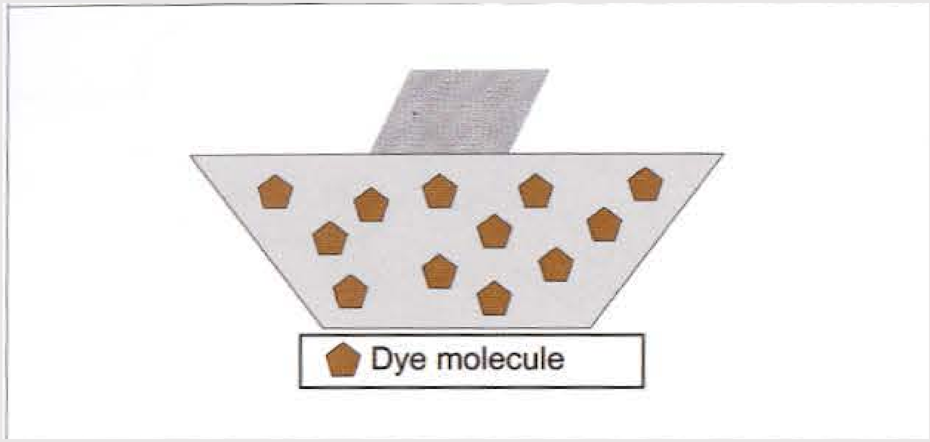
https://tatianabarry.livejournal.com/18580.html

Direct dye process

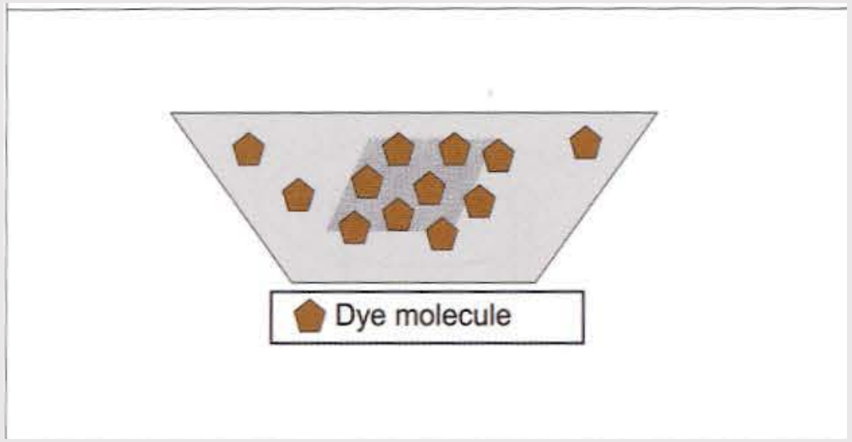
(1) Dye extracted from dye plant



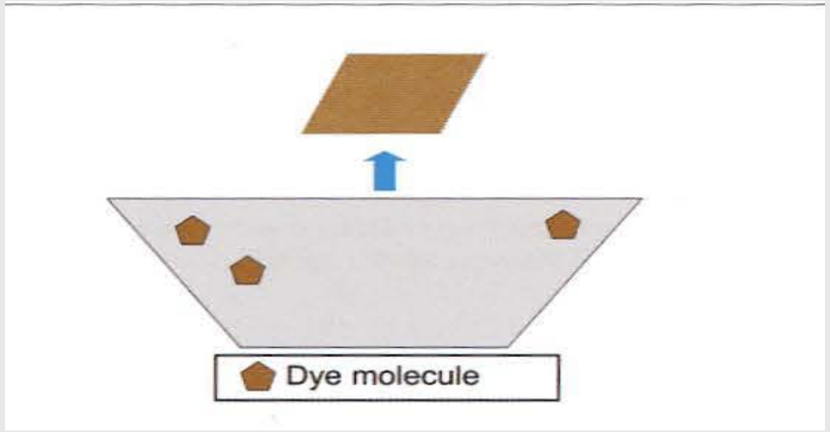
(2) Textile is added to dye bath



3) Dye molecules absorbed by textile



(4) Textile is removed



Mordant Dyes

Mordant dyes

Mordants are the largest natural dye class.

https://www.westlakeknits.ca/products/cochineal-natural-dye-natural-source-of-red-pink-and-magenta

http://shetlandhandspun.blogspot.com/2015/02/cochineal-and-logwood.html

The word “mordant” is derived from the Latin *mordere*, "to bite“, as historically it was thought that the mordant would allow the dye to bite onto the fiber to create a colorfast textile.

Mordant dyes

Mordants are commonly metal salts or other coordination metals that form a bridge between the textile fiber and the dye, resulting in a dye-metal-textile complex. The mordant attaches via neighboring C=O and C-OH groups in the dye.

Due to this complexation, mordant dyes have very good fastness to washing and better light fastness.

It is important to be aware that mordant dyes will also dye directly to give a (pale) color to unmordanted wool. This means that, in the case of a mordanted textile, part of the dye attached to the textile fiber may be bound directly to it, while another part is bound via the mordant. The part that is dyed directly will show poor fastness to light and washing.

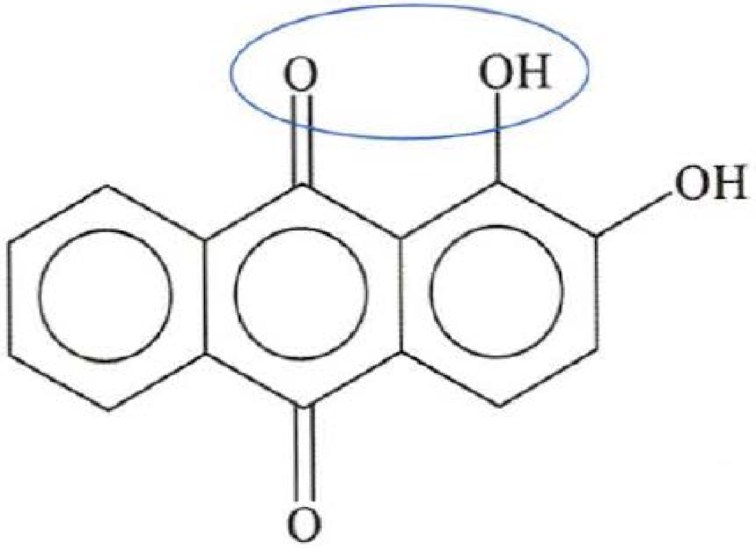


Figure 2 Probable position for coordination with aluminium ions taking alizarin as an example (Sanyova 2000/1: 66–78).

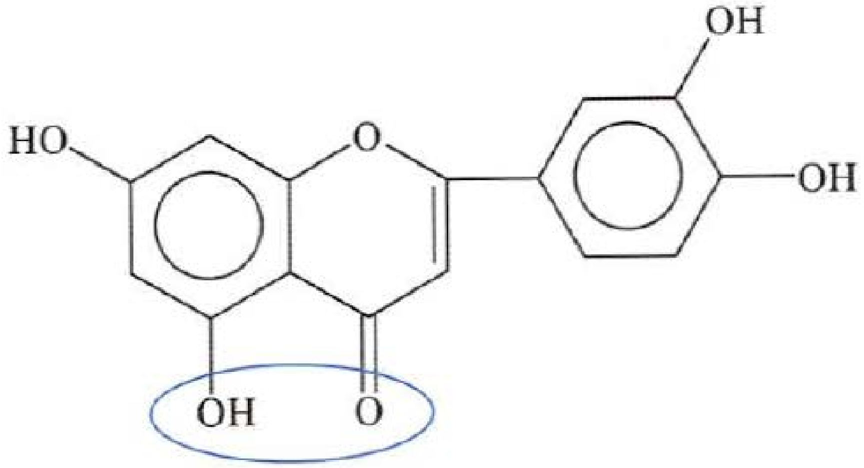
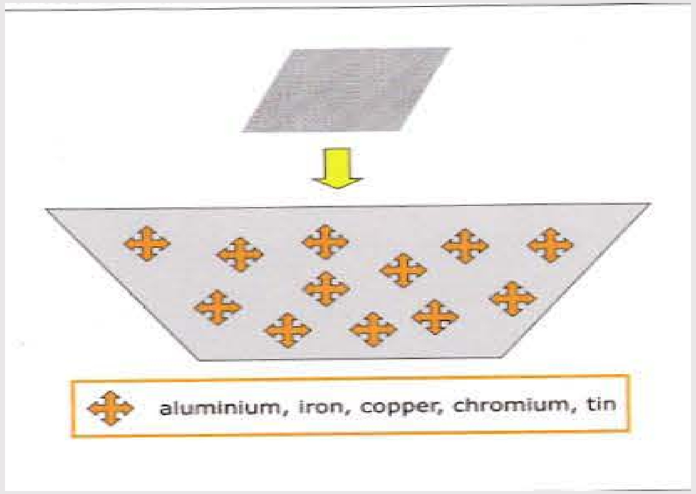


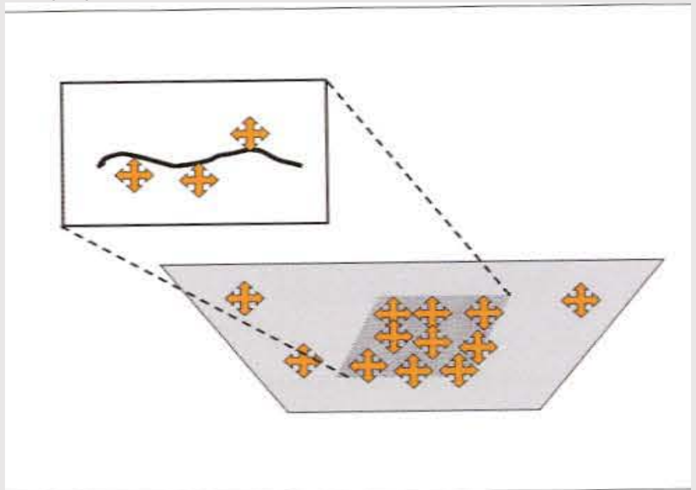
Figure 3 Probable position for coordination with aluminium ions taking luteolin as an example (Amat *et al.* 2010).

Mordant dye process

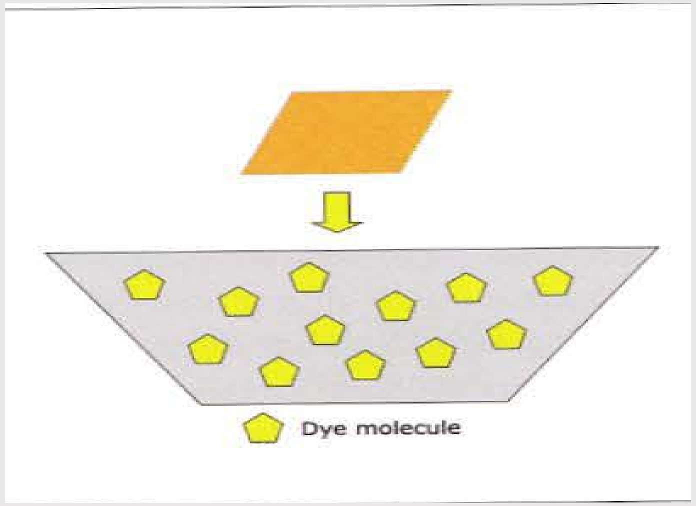
(1) Mordant bath is prepared by dissolving metal salts in water. Textile is then added



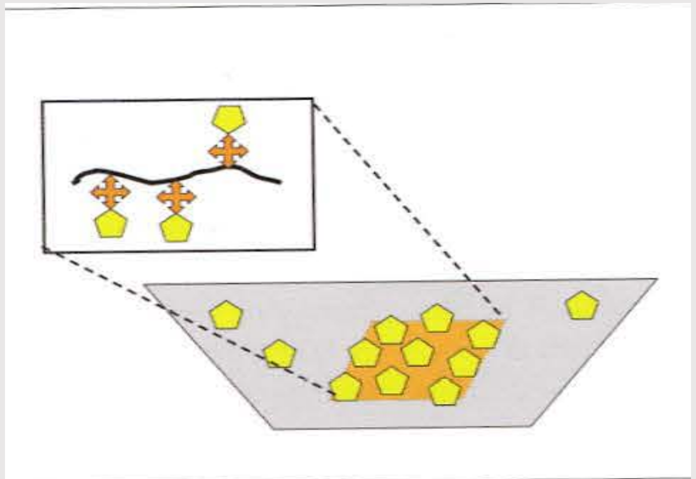
(2) Metal is bound to the textile



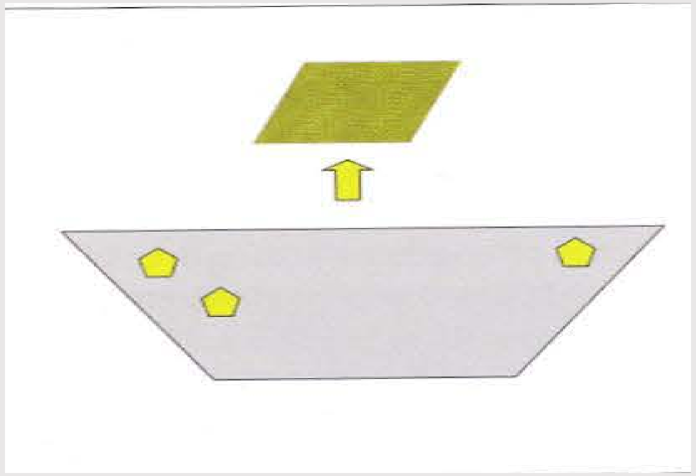
(3) Mordanted textile is added to dye bath



(4) Dye molecules bind to coordination metals of mordanted textiles



(5) Dyed textile is removed

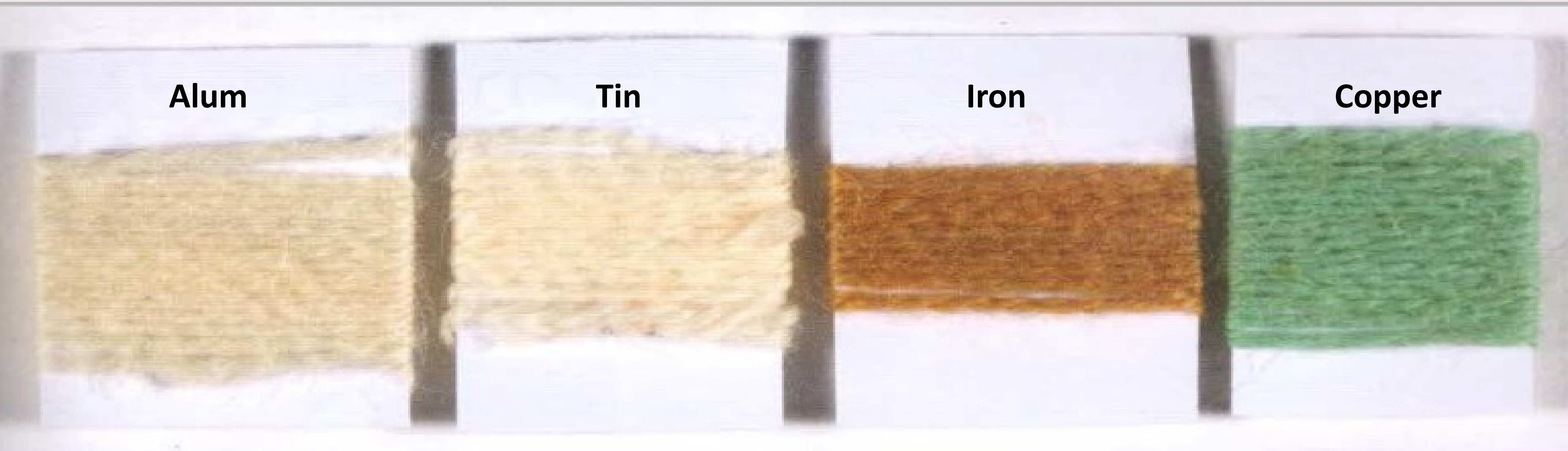


Mordants

Mordants

Metal salts, including those of aluminum, tin, iron, copper, and chromium.

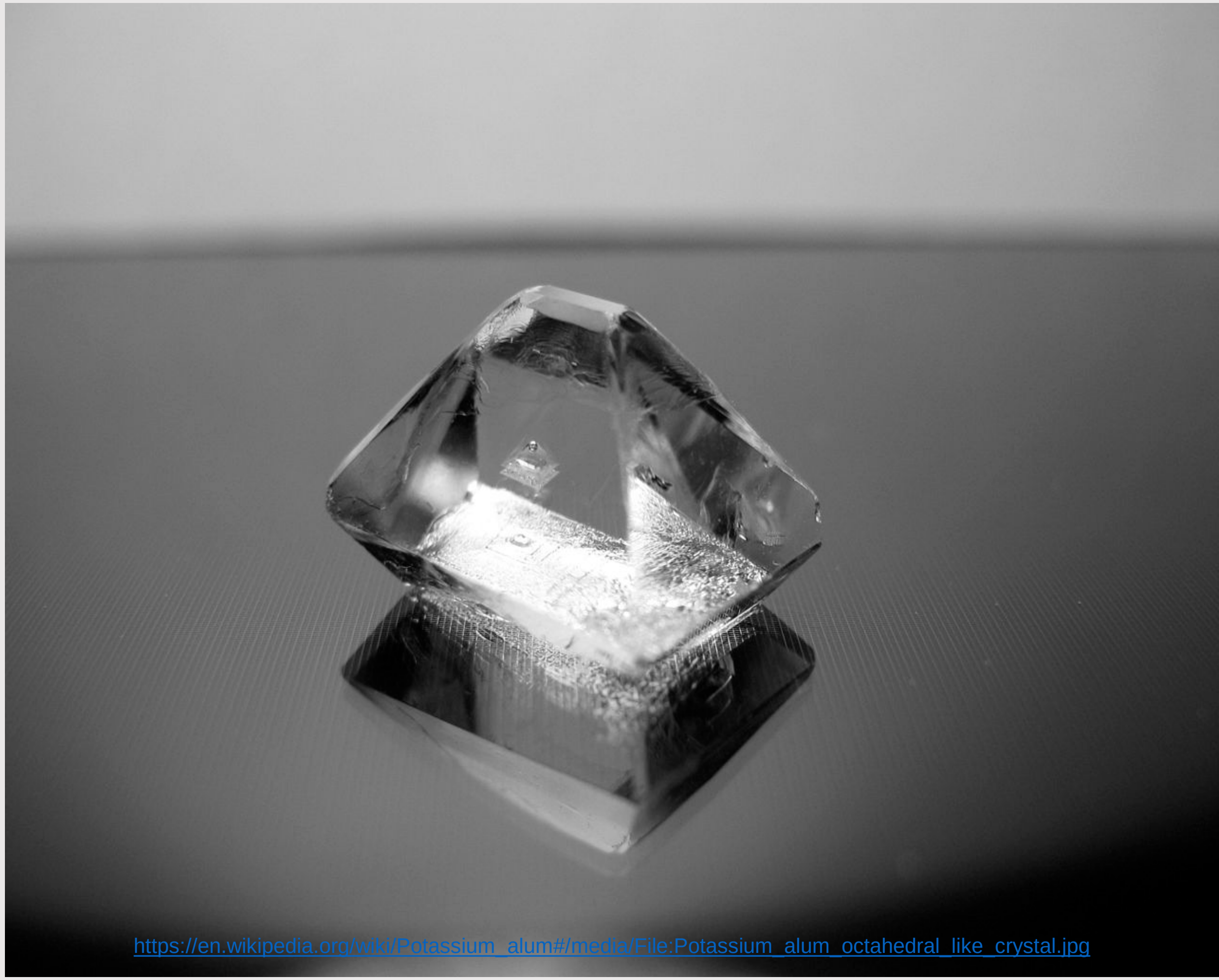
Mordants help form a dye-metal-textile complex to create a colored textile that is more color and light fast (or in some cases, completely facilitating the coloring of the textile).



Mordant: Aluminum

Used since antiquity.

Aluminum is the most important and most vastly used mordant.



Most commonly extracted from alum (also known as potash alum or potassium alum). **Aluminum potassium sulfate,** $KAl(SO_4)_2 \cdot 12H_2O$

- Acidic – pH of 3

Mordants: other metals used since antiquity

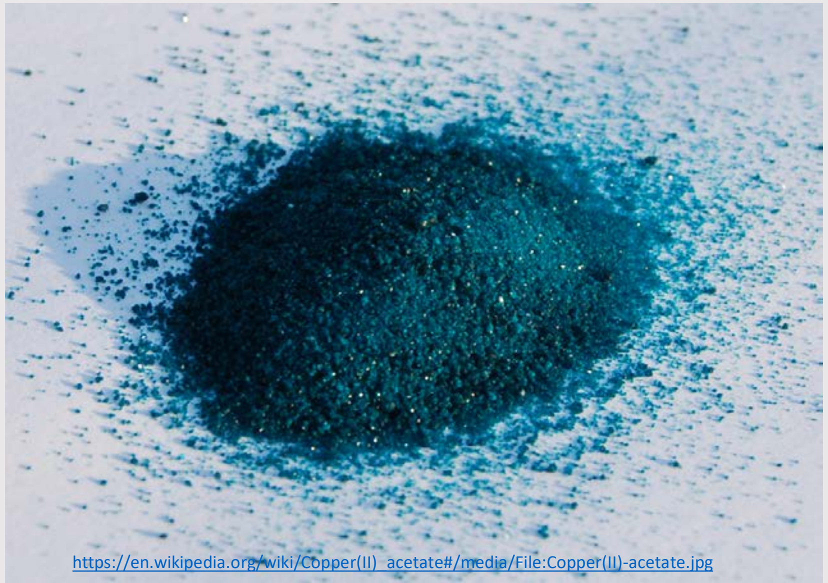
Iron

- Usually in the form of iron(II) sulfate (also known as ferrous sulfate, vitriol, green vitriol, copperas) $FeSO_4 \cdot 7H_2O$
- Sometimes iron acetate $C_{14}H_{27}Fe_3O_{18}$

http://shop.kremerpigments.com/en/solvents-chemicals-und-additives/chemicals/inorganic-substances/5771/ironii-sulphate

Copper

- Usually copper(II) sulfate (also known as cupric sulfate, blue vitriol, Roman vitriol) $CuSO_4 \cdot 5H_2O$
- Sometimes copper acetate $Cu(CH_3COO)_2$



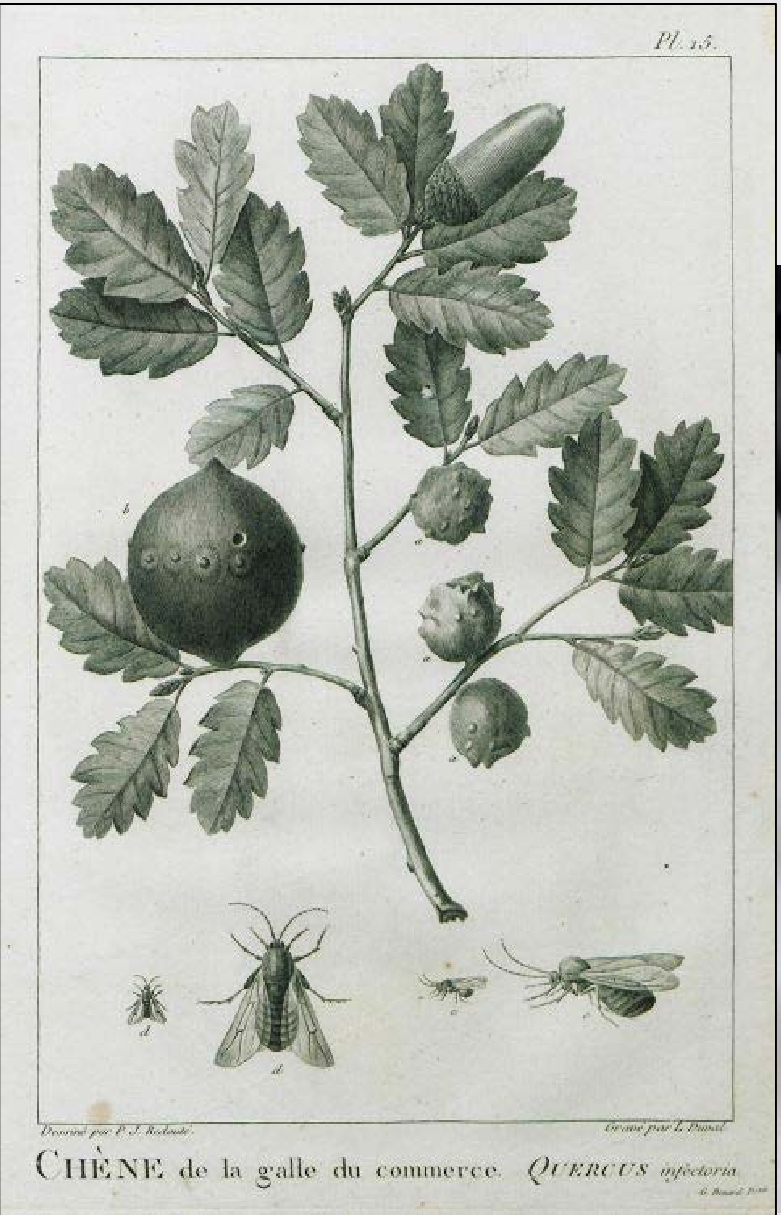
https://en.wikipedia.org/wiki/Copper(II)_acetate#/media/File:Copper(II)-acetate.jpg

https://en.wikipedia.org/wiki/Copper(II)_sulfate#/media/File:Copper_sulfate.jpg

Mordant: Plant-based used since antiquity, Tannin

Tannins, in the form of oak galls, bark, wood, and leaves of certain tree families like oak, sumac

- Tannic acid $C_{76}H_{52}O_{46}$



Oak galls formed on *Quercus infectoria*

https://en.wikipedia.org/wiki/Sumac#/media/File:SumacFruit.JPG

Mordants: used more recently

Since 17th century

- Tin, usually as tin(II) chloride (also known as stannous chloride) $SnCl_2$

Since 19th century

- Chromium usually as chromate $CrO^{2-}{}_4$ or dichromate $Cr_2O^{2-}{}_7$

https://en.wikipedia.org/wiki/Chromate_and_dichromate

https://en.wikipedia.org/wiki/Tin(II)_chloride#/media/File:Tin(II)_chloride.jpg

Additive: Potash

Potassium carbonate K_2CO_3

- Alkaline – pH of 12

Addition of potash to dye baths in based on historical examples

It can result in:

- Greater solubility of the dyestuff
- A different hue due to a reversible pH change of the dye
- Perhaps a conversion of the dye glycosides (sugars) to the corresponding free dye molecule
- Perhaps conserve the glycosides in the dyestuffs (seen in weld which becomes brighter)

Effect on dye color

- Anthraquinone dyes, particularly **kermes** and **cochineal** become much paler while **madder** becomes dull or pale
- In historical recipes, it is much more common to find preparation of these dyes in "sour water" aka acidic conditions.

Vat Dyes

Vat dyes - indigoids

These dyes are not soluble in water as such but must be converted into a water-soluble form. This conversion, actually a reduction, can be achieved with reducing agents such as sodium dithionite, but historically this was done by fermentation.

The fermentation vat could take hours or even days to develop in such a way that the insoluble dyes were converted into their soluble *leuco-form* needed for the dyeing process.

Textiles

Textiles

The chemical interaction between the dye and the textile fiber is dependent on the dye itself and the type of fiber to be dyed.

There are two main textile groups: those with proteinaceous fibers - primarily wool and silk - and those such as cotton or linen that have cellulosic fibers.

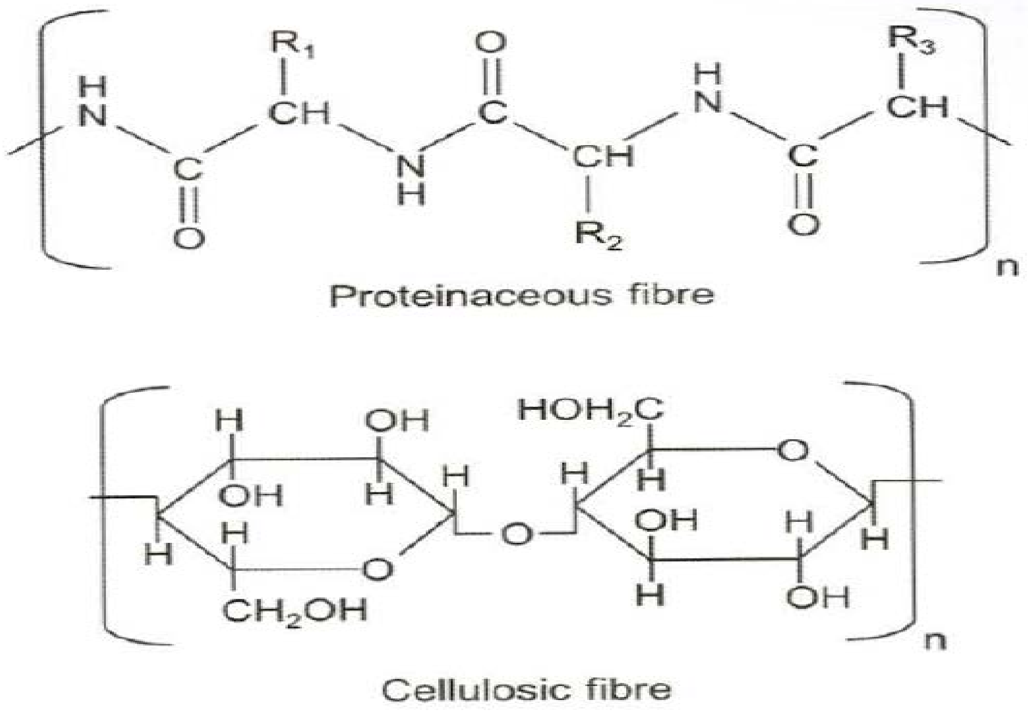


Figure 1 The basic structure of proteinaceous and cellulosic fibres.

Common red colorants in Early Modern Europe (1400-1700)

Safflower or bastard saffron

Botanical name: *Carthamus tinctorius* L.

Chemical class: carthamin (C-glucosylquinochalcone)

Region: Mediterranean, spread to southern and central Europe

Dye type: Direct

Petals contain a water-soluble yellow dye that is discarded in the process of obtaining an alkali-soluble red. Textile is dyed by placing in red alkaline solution and adding an acid like lemon juice.

http://www.tropicos.org/Name/2700365

http://collections.vam.ac.uk/item/O485844/fukusa-gift-cover-unknown/

Japanese (ca. 1868-1912), silk

Henna

Botanical name: *Lawsonia inermis* L

Chemical class: lawsone or isojuglone (naphthoquinone)

Region: India, tropical and subtropical regions, spread to Mediterranean, Spain, and Sicily

Dye type: Direct or mordant dye.

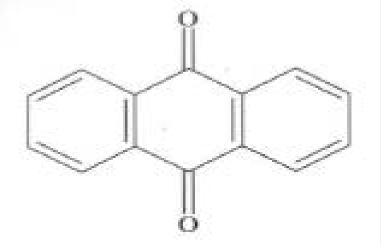
Leaves are used to obtain orange-red to brown colors.

http://www.tropicos.org/Name/19200244

https://www.metmuseum.org/art/collection/search/447118

Indian (ca. 1640-50), cotton

Lac



Species name: *Kerria lacca*, *Kerria chinensis*

Chemical class: laccaic acid and erythrilaccin among other similar constituents (anthraquinone)

Region: Southeast Asia. Spread to Mediterranean and then Europe.

Dye type: Mordant dye.

Scale insect parasitic on several tree species including bastard teak *(Butea monosperma* (Lam.)

Secretes a protective coating that encloses itself in a sticky brown mass similar to resin, known as sticklac. When purified, this is known as shellac which was less economically important than the dye unlike today.

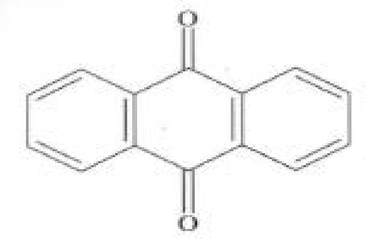
https://www.researchgate.net/figure/Some-lac-insects-known-from-the-New-World-a-Kerria-lacca-on-Albizzia-sp-Peradeniya_fig1_51254451

http://collections.vam.ac.uk/item/O61099/hanging-unknown/

Indian (ca. 1700), cotton and silk

15. Fragment of a caftan or robe with deer in a pearl roundel. Eastern Iran or Sogdiana, 8th–9th century. Compound twill weave silk (*samit*), the bright pink dyed with lac; 13⅜ x 17⅜ in. (34 x 44 cm). The Metropolitan Museum of Art, Purchase, Rogers Fund, by exchange, 2006 (2006.472)

Madder



Botanical name: *Rubia tinclorum* L.

Chemical class: alizarin (anthraquinone)

Region: Native to Middle East and east Mediterranean, then spread to Europe.

Dye type: Mordant dye.

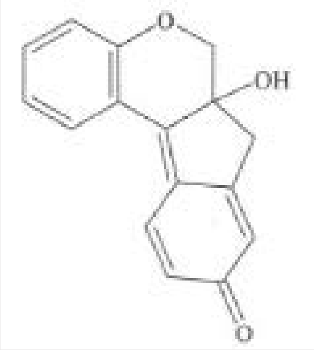
Range of red-orange-brown dyes obtained from the roots of a bedstraw.

https://www.metmuseum.org/art/collection/search/445750
Egyptian (5th-8th century), linen and wool

http://collections.vam.ac.uk/item/O146101/jacket-unknown/
Iranian (ca. 1800-1870), cotton and silk

Redwoods

(sappanwood, brazilwood)



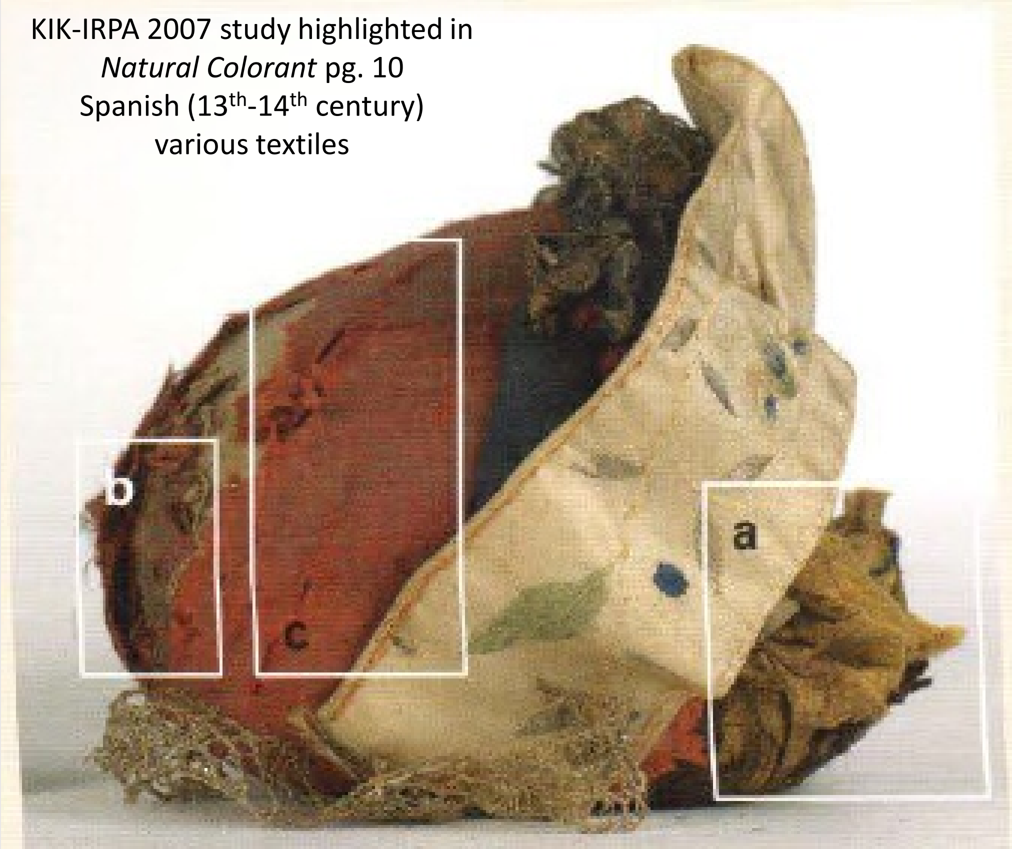
Chemical class: Brazilin, colorless until oxidized by air becoming orange-red braziliein (homoisoflavonoid)

Dye type: Mordant dye.

Extracted from orange-red wood, inner bark of trees, such as **sappanwood** *(Caesalpinia sappan* L.) - region: Central and southern India, Burma, Thailand, Indochina, southern China, Malaysia. Imported into Europe in early Middle Ages; **brazilwood** (*Caesalpinia brasiliensis*) and **pernambuco wood** (*Caesalpinia echinata Lamarck)* - region: Brazil and Caribbean Islands, then imported into Europe; **peachwood** *(Haematoxylum brasiletto* Karsten) - region: Central America, then imported into Europe.

Brazilwood

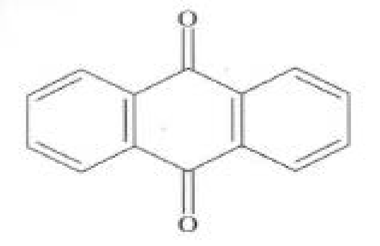
KIK-IRPA 2007 study highlighted in *Natural Colorant* pg. 10
Spanish (13th-14th century)
various textiles



Logwood

Sappanwood

Kermes



Species name: *Kermes vermilio*

Chemical class: kermesic acid (anthraquinone)

Region: Limestone coastal regions around the Mediterranean in Spain, southern France, North Africa, and the eastern Mediterranean.

Dye type: Mordant dye.

http://shop.kremerpigments.com/en/dyes-und-vegetable-color-paints/natural-organic-dyes-und-vegetable-color-paints/4920/kermes-lice

http://www.projectnoah.org/spottings/255006061

Scale insect parasitic to an evergreen oak (*Quercus coccifera* L.).
Scarlet red color used to dye the highest quality fabrics.
Used extensively throughout Europe until the arrival of cochineal from the New World in 16th century.

Dye is contained in the unhatched eggs of insect, and so can be extracted from females with unhatched eggs (more common) or from the eggs directly.

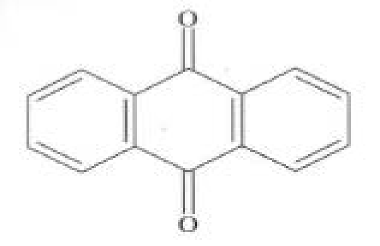
Kermes

http://collections.vam.ac.uk/item/O264602/woven-silk-unknown/
Spanish (ca. 15th century), silk damask

http://collections.vam.ac.uk/item/O261109/woven-silk-unknown/
Spanish (ca. 14th century, woven silk and satin

Cochineal

Cochineal



Species name: *Dactylopius coccus*

Chemical class: carminic acid (anthraquinone)

Region: Cultivated in Mexico and Peruvian Andes, before Spain brought to Europe in 1523 where it spread rapidly.

Dye type: Mordant dye.

http://www.projectnoah.org/spottings/1136866002

Scale insect found on prickly pear or Barbary fig cactus *(Opuntia ficusindica* (L.)).

Led to decline of use of kermes as it is almost **20% by weight more potent than kermes**. Dye is extracted from females with unhatched eggs.

Cochineal in the Americas

32. Coca bag. Peru, Moche, 5th–6th century. Tapestry-weave cotton and camelid hair, the red dyed with cochineal; 5 x 6 in. (12.7 x 15.2 cm). The Metropolitan Museum of Art, Bequest of Arthur M. Bullowa, 1993 (1994.35.88)

Cochineal red was known as a dye in Mexico and South America at least as early as the second century B.C. and was used profusely by Precolumbian peoples.

It colored special ritual and ceremonial textiles worn by rulers in both Mexico and Peru and was an important tribute item in the medieval economies of Latin America.

Habitats and areas of cultivation of cochineal in the Americas, from the 16th to the 19th century

While known and used throughout the Americas, cochineal was first brought to Europe in 1523 by the Spanish.

This new world dye revolutionized red colorants in Europe. Cochineal was ten times more powerful than any other “old world” red.

The Cultivation and Mystery

While other colorants that had been imported into Europe also eventually saw the import of the cultivation of the colorants in Europe, cochineal's production stayed a mystery to the majority of Europe for centuries.

There are three main reasons for this long-standing mystery:

1. The delicate environment and careful cultivation required to encourage insect growth and harvest them for use
2. The wide-spread confusion about what cochineal actually was
3. The monopoly maintained by the Spanish over cochineal cultivation

1) Environment and Cultivation

- Cochineal survive almost exclusively on the nopal (prickly pear) cactus native to Central and South America.
- As young insects, cochineal attach themselves to the cactus with straw-like mouthpieces where they feed on the nectar for the rest of their lives.
- The cacti require specific levels of atmospheric temperature, humidity, rainfall, pest control, and soil conditions, which can make their cultivation outside of certain parts of the Americas (and the Mediterranean with similar climates today) quite difficult.
- When the cochineal have reached a certain maturity and size, they must be delicately removed from the cactus by hand. For example, Aztec documents mention tools like turkey feathers or deer tails to gently brush the insects off before leaving them in the sun to dry.
- Many attempts to bring the insects or even the cacti back to Europe failed just because of environmental conditions.

Furthermore, the type of cochineal that produce the most potent red color had been carefully cultivated and bred by Mexican peasants for centuries to become larger and more potent dye producers. Even if Europeans found wild cochineal in other parts of the Americas, they were the small, wild variety with poor dyeing properties.

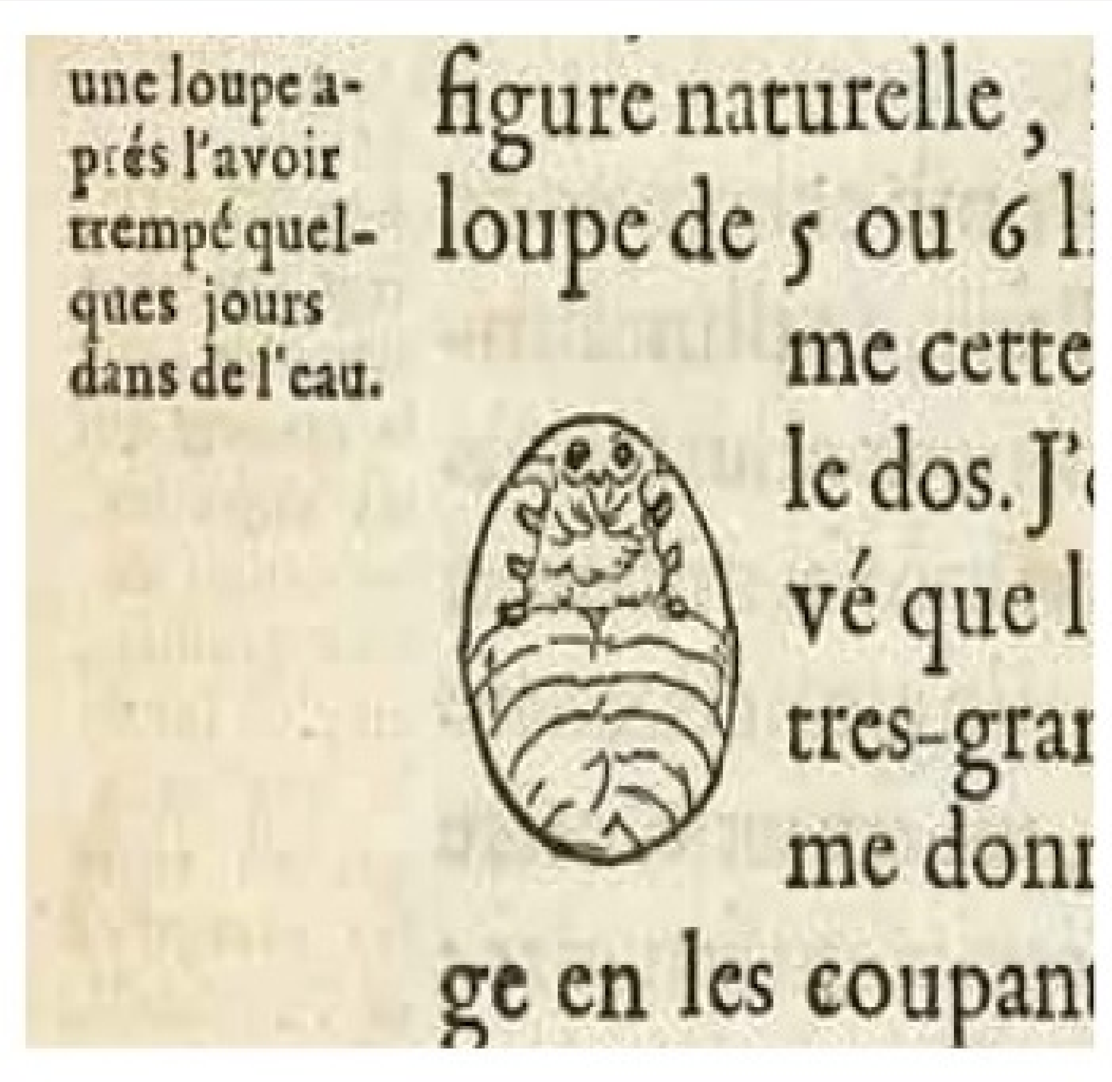
When Europeans did get hold of true Mexican cochineal, any attempts to bring them back to Europe failed, as the insects could not survive in the change of environment, often dyeing on the way back to Europe or perishing in Europe without access to nopal cacti.

2) Europe: What is Cochineal?

- Dried cochineal don’t really look like insects. What the little silver-purple grains are just by looking at them is still hard to distinguish.
- Many different theories developed throughout Europe:
  - Richard Hakluyt, and English collector and editor of volumes of travel tales, wrote (1589–1600): "The Cochinilla is not a worme, or a flye, as some say it is, but a berrie that groweth upon certaine bushes in the wilde fielde.“
  - French explorer Samuel de Champlain wrote(1599–1602) : "It comes from a fruit the size of a walnut which is full of seed within . . . and is esteemed as gold and silver.“
  - Some of the confusion also came from theories about Kermes. Pliny (AD 23-79) described kermes, or coccus, as a berry that turns into a worm, a belief that was held about cochineal throughout the Renaissance

2) Europe: What is Cochineal?

- Cochineal was not accurately described until it was examined under a microscope by **Nicolaas Hartsoeker in 1694** and then, in even greater detail, by **Antoni van Leeuwenhoek in 1704**.
- Leeuwenhoek, backed by **Robert Boyle** and the British Royal Society, surprisingly first described cochineal as seeds in 1685.
- Only after Boyle heard that cochineal may be parts of a fly, he asked Leeuwenhoek to examine the samples again to look for insects.
- During this second investigation, Leeuwenhoek concluded instead that “each tiny grain is a part of a little animal”. The cochineal bits were really "females whose body is full of eggs“.
- While these advances in lens-making technology and investigations into the true identity of cochineal should have cleared up the mystery, the mystery persisted throughout most of the eighteenth century. Faulty communication and skepticism led to doubts for centuries.

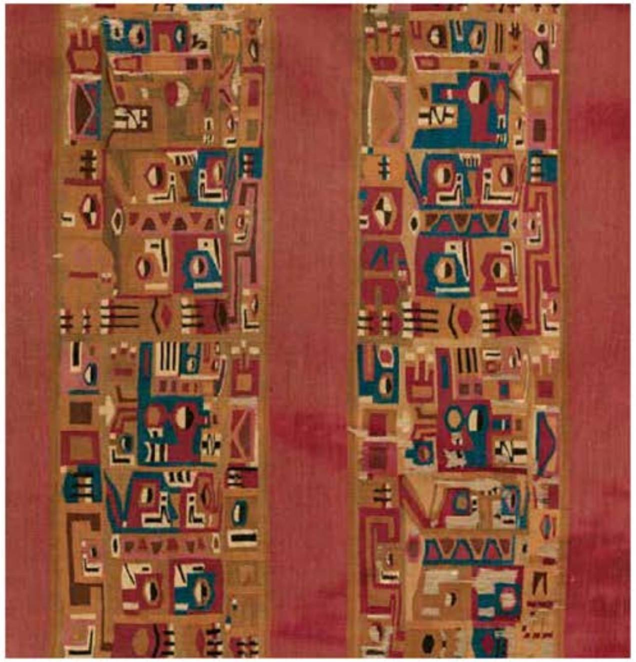


Nicolaas Hartsoeker’s representation and description of cochineal under a microscope. *Essay de Dioptrique* (Paris, 1694), sect. I, p. 52

3) Spanish monopoly

- With such a powerful and profitable new colorant, the Spanish were determined to keep their stronghold on cochineal.
- They also prohibited the export of live cochineal from Mexico, censored information about it, and forbade foreigners from traveling to their colonies.
- For three centuries, the English, French, and Dutch resorted to espionage, piracy, bribery, and theft to learn the secret of this fabulous dye and break Spain's monopoly, to no avail.
- The Spanish also encouraged the confusion about what cochineal was and did not spread information about the delicate environment required to cultivate them.

33. Tunic. Peru, Moche-Wari, 7th–9th century. Cotton and camelid hair colored with cochineal red and other dyes, in interlocking warps and wefts, with tapestry and openwork border; 34¼ x 58 in. (87 x 147.3 cm). The Metropolitan Museum of Art, Bequest of Jane Costello Goldberg, from the Collection of Arnold I. Goldberg, 1986 (1987.394.706)



34. Tunic fragment (detail). Peru, Wari, 7th–9th century. Tapestry-weave cotton and cochineal-dyed camelid hair, 22½ x 80 in. (57.2 x 203.2 cm). The Metropolitan Museum of Art, Gift of George D. Pratt, 1930 (30.16.1)

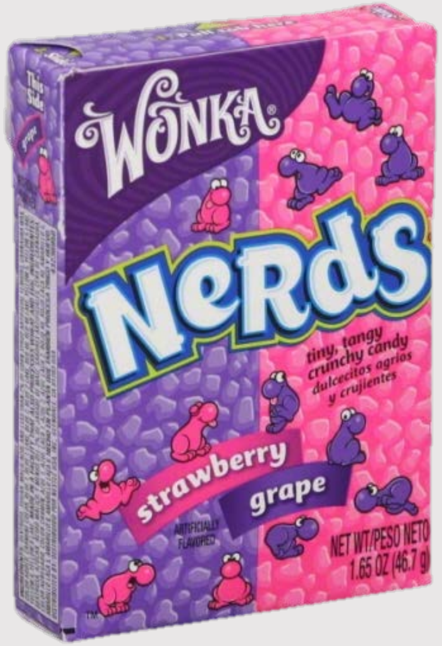
20

Cochineal industry today

- “Carmine” (natural red #3), as cochineal colorant is known to consumers, is present in numerous foods, candies, and cosmetics: grapefruit juice, strawberry yogurt, lipstick, blush, paint, and decorative home items.
- The ancient industry has seen a recent economic revival in South and Central America where cochineal insects are native. Today, Peru exports the most of the dye; the country produces close to 200 tons of it each year.
- Nearly 70,000 insects are used to make one pound of dye.
- Cochineal is the only natural red food coloring authorized by the FDA.

Azithromycin
https://www.drugs.com/imprints/93-7169-13643.html

http://lorealparisusa.com



Cochineal industry today

- Cochineal insects thrive on the prickly pear cactus.
- Rather than going into the field each day to harvest cochineal insects, workers simply collect the cactus leaves they live on.
- They then store the leaves inside a greenhouse, where the bugs can continue to thrive.
- The insects burrow into the cactus where they feed for life.
- Workers use tough brushes to scrape the insects off the cacti leaves – just like in the 16th century.

Brodwin, Erin. "These Crazy Pictures Show How Companies Use Bugs To Make Red Dye For Food And Cosmetics." *Business Insider*, Business Insider, 27 Oct. 2014, www.businessinsider.com/how-farmers-make-red-dye-from-bugs-2014-10
Baranyovits, F.l.c. "Cochineal Carmine: an Ancient Dye with a Modern Role." *Endeavour*, vol. 2, no. 2, 1978, pp. 85–92., doi:10.1016/0160-9327(78)90061-3.

Memorial de Don Gonfalo Gomez de Cervantes def modo de vivir que tienen los indos, y def henejicio de las minas de la plata, y de la cochinella./Relaci6n de [lo] que toca la grana cochinilla (Mexico, 1599), Anonymous Pictorial Manuscript, pp. 98 verso 1-2. British Museum, London (Add. Ms. 13964 [Am2006,Drg.210])

Cochineal

https://www.metmuseum.org/art/collection/search/91678
British (1750-75), silk and wool(uniform for redcoats)

20. Samples of silk cloth dyed with cochineal, showing the many different hues that can be achieved by adding mordants and other modifiers to the dyebath

https://www.metmuseum.org/art/collection/search/320804
Peruvian (ca. 16th-17th century), camelid hair and cotton

https://www.metmuseum.org/art/collection/search/452823
Turkish (ca. 1819-20), silk, metal wrapped thread

Natural colorants and sustainability

Synthetic dye and textile industry


River pollution, freshly synthetic dyed fabrics are washed in the river. Photo by: Jakarta Post

https://madebyayo.shop/blogs/let-s-go-ayo/wear-the-change-you-want-to-see-in-the-world

[Image Source: *Blaynk/Kickstarter*]

https://interestingengineering.com/organic-bed-sheets-cotton-rainwater-and-wind

Table 18.1 *Reasons for natural dyes: a set of reasons for the increasing interest in natural dyes has been listed and categorized in four different classes*

	Categories			
Reasons	*Innovation*	*Economics*	*Personal reasons*	*Ethics*
New products	X			
Better range of price	X	X		
Luxury product	X	X		
Health aspects	X		X	
Medicinal benefit	X		X	
New sources of income		X		
Specific costumer group		X		
Increasing oil price		X		
Governmental regulations		X		
Waste and waste water treatment		X		
Limited resources		X		X
Fashion		X	X	
Change in mind of society		X		X
Change in mind of costumers			X	X
Protect environment			X	X
Resources for future generations		X	X	X

R.A.M. Mussak, T. Bechtold, Natural colorants in textile dyeing, in Handbook of Natural Colorants, ed. by T. Bechtold, R.Mussak (Wiley, Chichester, 2009), pp. 315–338

Essential restrictions for an environmentally friendly dyeing strategy

- Limitations of chemicals and solvents to avoid hazardous effluents
- Substitutions of primary agricultural products by waste, side- and by-products if available or collection from the wild
- Careful selection of mordants (heavy metals must not be used)
- Minimization of inputs (water, energy)

R.A.M. Mussak, T. Bechtold, Natural colorants in textile dyeing, in Handbook of Natural Colorants, ed. by T. Bechtold, R.Mussak (Wiley, Chichester, 2009), pp. 315–338

“Natural dye may seem like the winner, having the smaller footprint, but they’re not economical or a sustainable source on a large manufacturing scale. While synthetic dyes are more versatile and easier on the manufacturer’s pocket, it carries a large pollution footprint. ”

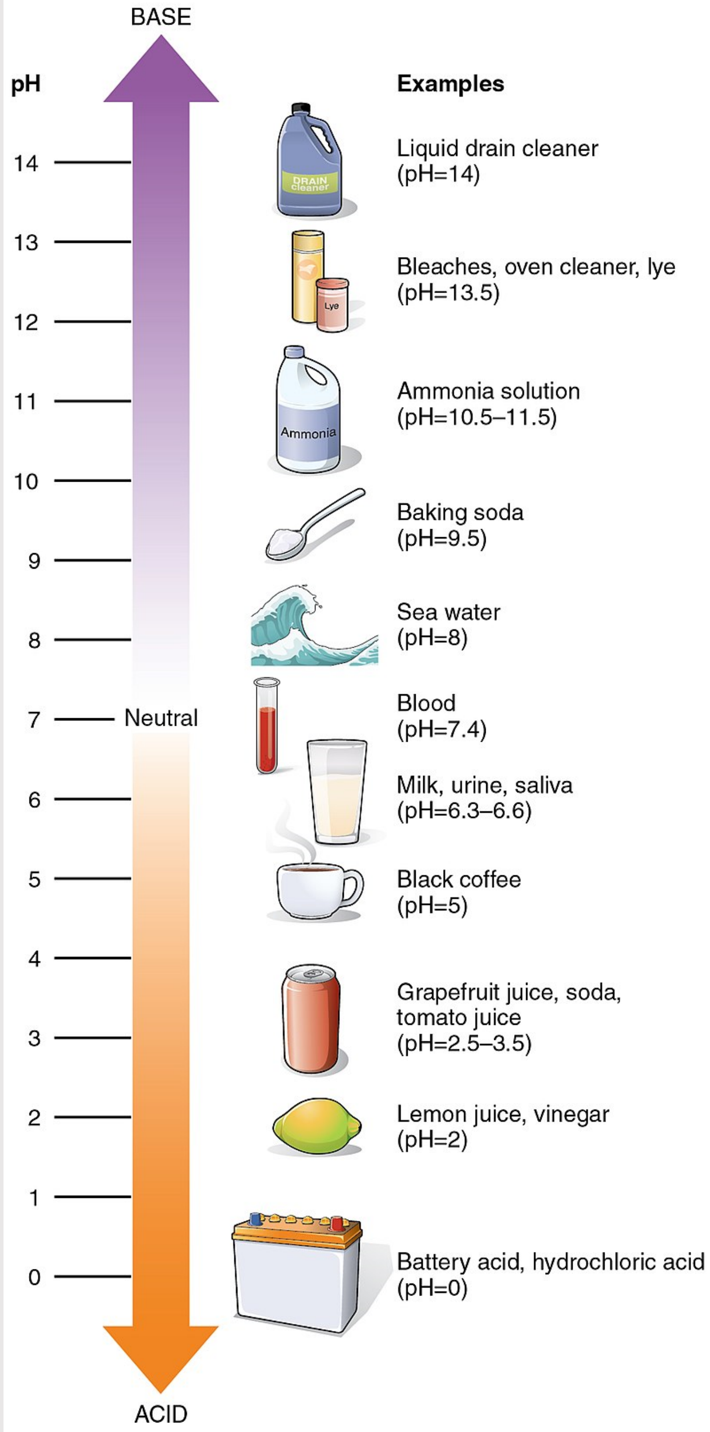
http://tdsblog.com/dye-off-natural-vs-synthetic/

Fig: Environment pollution by textile waste water

http://fashion2apparel.blogspot.com/2017/08/environmental-pollution-control-textile.html

https://avani-earthcraft.com/blogs/blog/the-case-for-natural-dyes

Review of pH



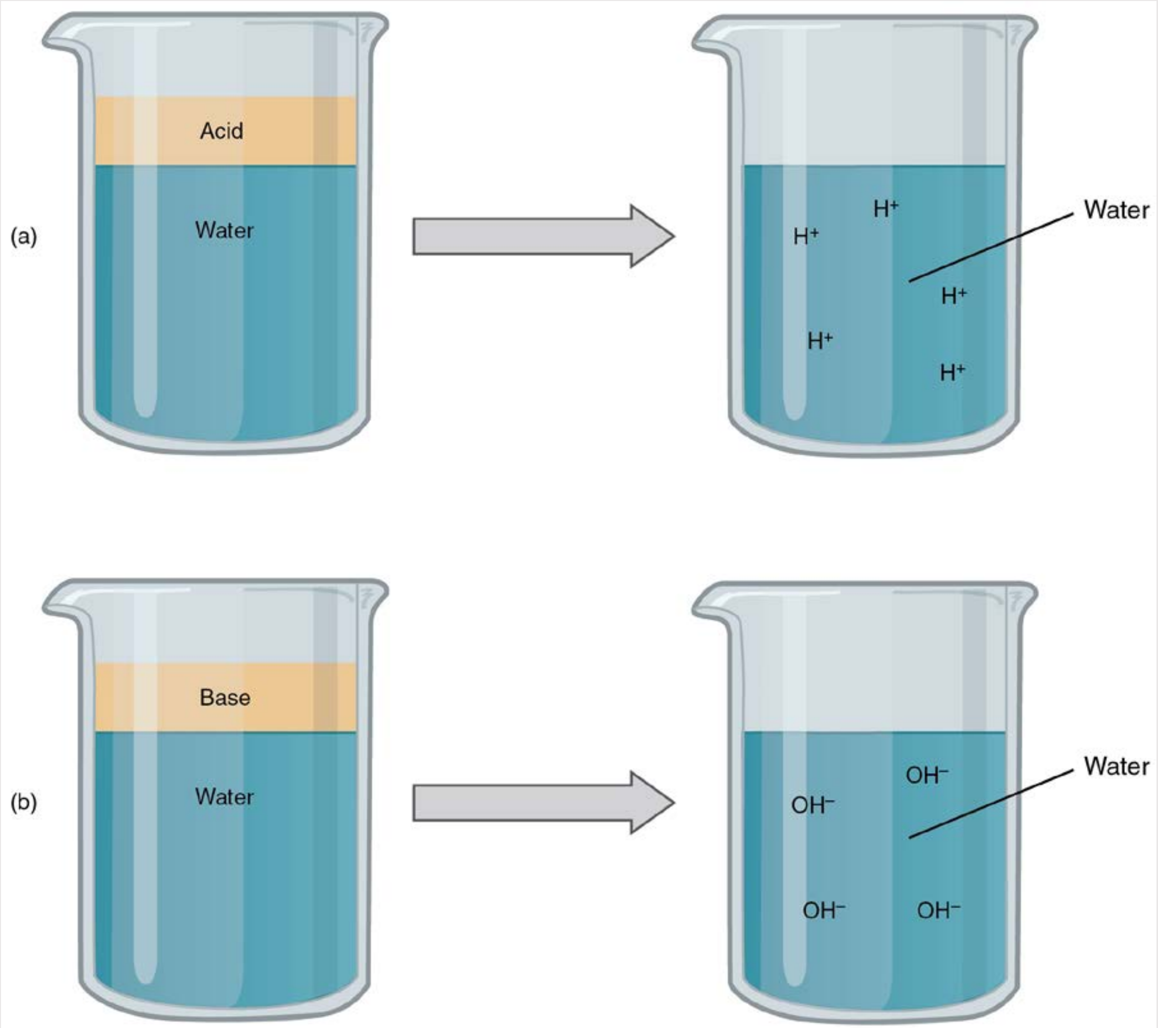
Overview of pH

pH is a numerical scale from 0 to 14 that describes the relative acidity or alkalinity of a solution

ACID
Donates a hydron (proton or hydrogen ion H^+)

BASE/ALKALI
Releases hydroxide (OH^-) ions.

Many times the terms “base” and “alkali” (or basic and alkaline) are used interchangeably.
More precisely, an alkali is a base that can be dissolved in water.



https://cnx.org/contents/FPtK1zmh@6.27:5ORVCb_A@3/Inorganic-Compounds-Essential-

Cochineal and pH

Historical Recipe Examples

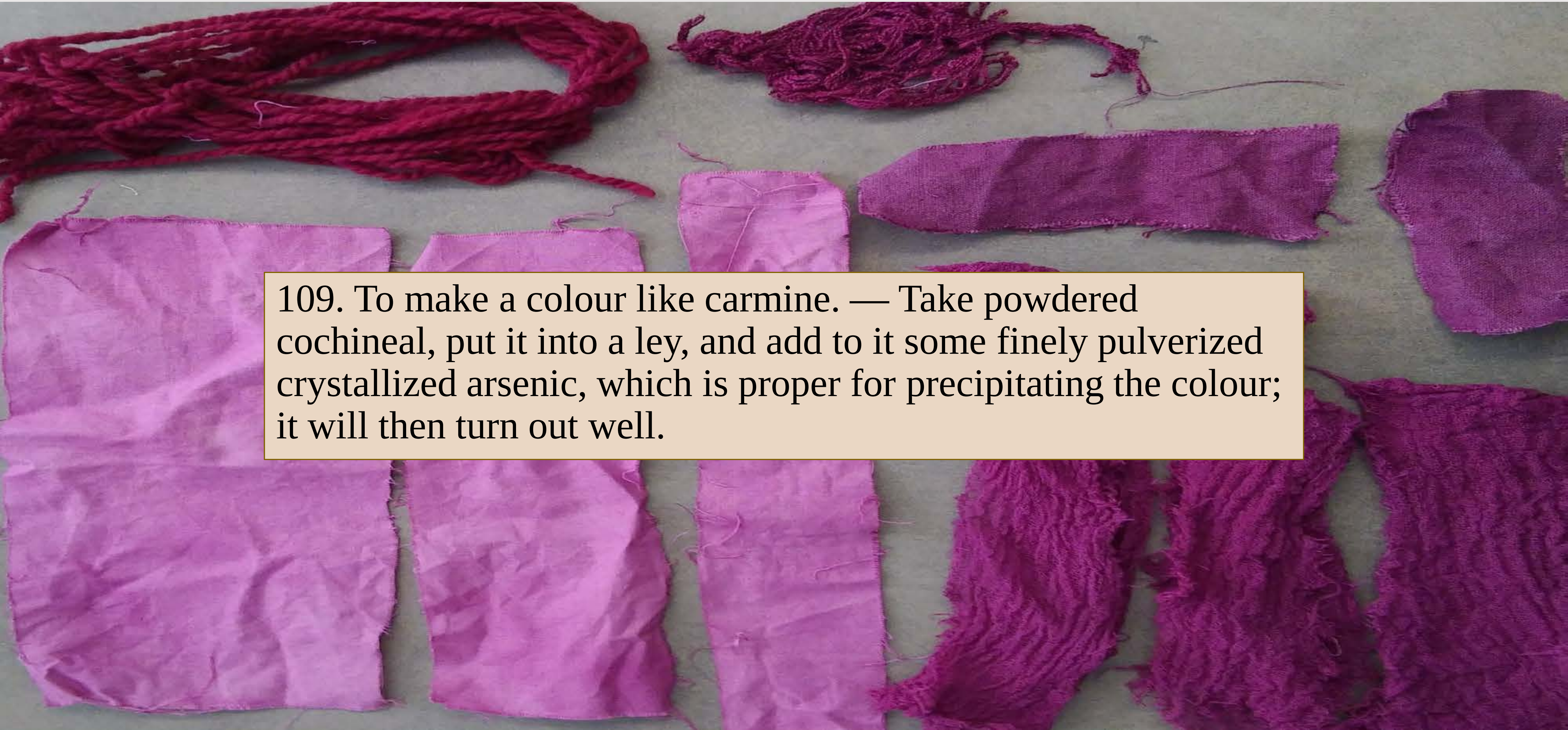
Neueroffneter curioser Schatz-Kasten (Anon. 1706: 556, translated)

As quoted in Kirby, et. al. *Natural Colorants*

To dye nice carmine-coloured cloth. One has to take for 8 pounds of woollen cloth 2 *Loth* of cochineal, 2 quarters of wheat flour, or *Gaitz* [?]; the bran must be soaked in water for 8 days so that the water gets really acid. When one wants to dye then, the water must be poured off from the bran into the kettle. But the cochineal must be soaked before in warm water overnight. When one now dyes, a good fire must be made under it to warm the [bran) water. Then take a little of it [the warmed bran water], stir it with some dye and put it in the kettle as long as one still has some dye. When now it starts to boil, and one wants to give it an after-treatment *[meistem]*, one must take lye extracted three times, or one takes 1.5 or 2 quarters of ashes of pressed wine-grapes, pours it into lukewarm water, and passes the dyed cloth through it until the shade is to your liking.

Paduan Manuscript (pg. 698)

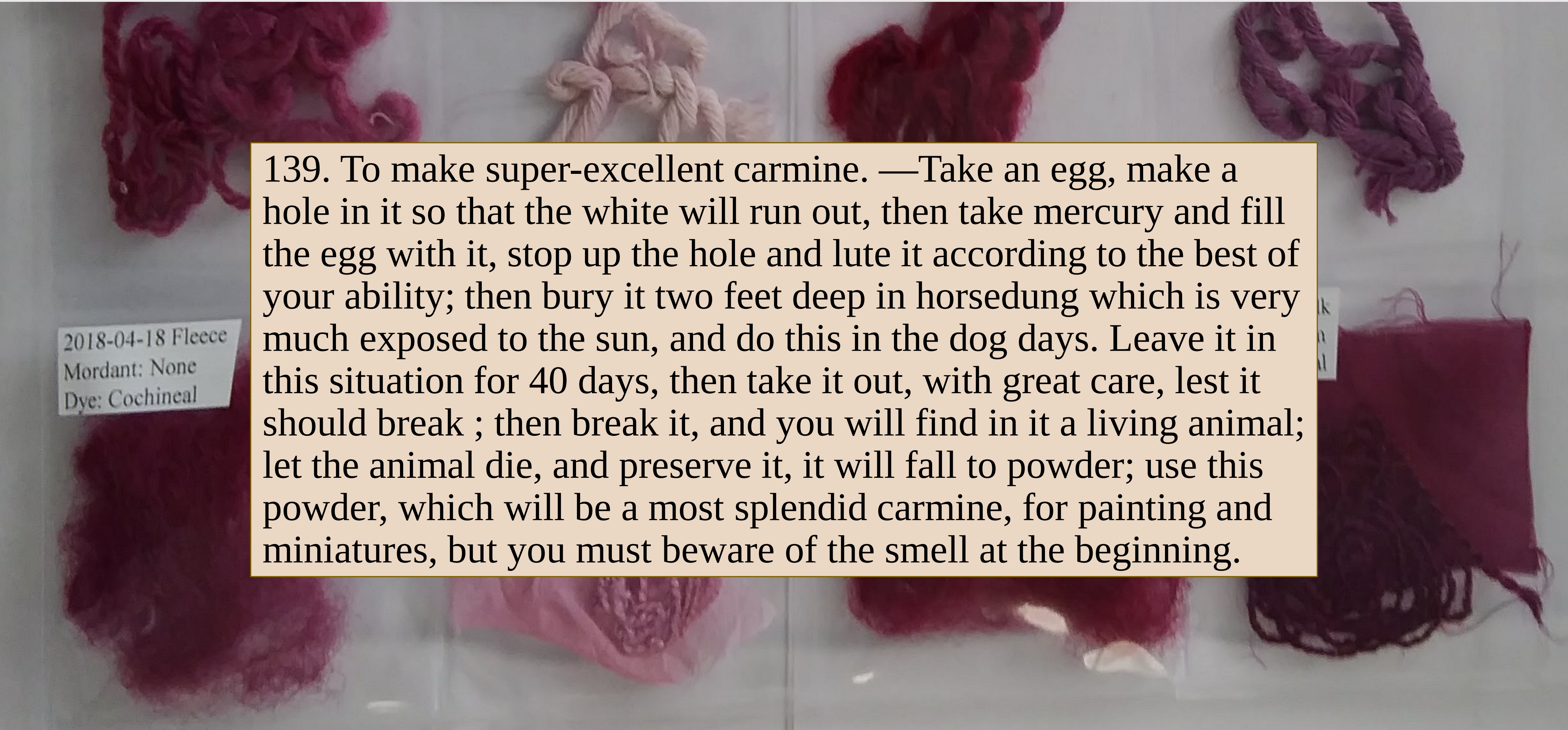
Original Treatises, Dating from the XIIth to XVIIIth Centuries, on the Arts of Painting in Oil, Miniature, Mosaic, and on Glass of Gilding, Dyeing, and the Preparation of Colours and Artificial Gems by Mary P. Merrifield (1804)



109. To make a colour like carmine. — Take powdered cochineal, put it into a ley, and add to it some finely pulverized crystallized arsenic, which is proper for precipitating the colour; it will then turn out well.

Paduan Manuscript (pg. 710)

Original Treatises, Dating from the XIIth to XVIIIth Centuries, on the Arts of Painting in Oil, Miniature, Mosaic, and on Glass of Gilding, Dyeing, and the Preparation of Colours and Artificial Gems by Mary P. Merrifield (1804)



139. To make super-excellent carmine. —Take an egg, make a hole in it so that the white will run out, then take mercury and fill the egg with it, stop up the hole and lute it according to the best of your ability; then bury it two feet deep in horsedung which is very much exposed to the sun, and do this in the dog days. Leave it in this situation for 40 days, then take it out, with great care, lest it should break ; then break it, and you will find in it a living animal; let the animal die, and preserve it, it will fall to powder; use this powder, which will be a most splendid carmine, for painting and miniatures, but you must beware of the smell at the beginning.

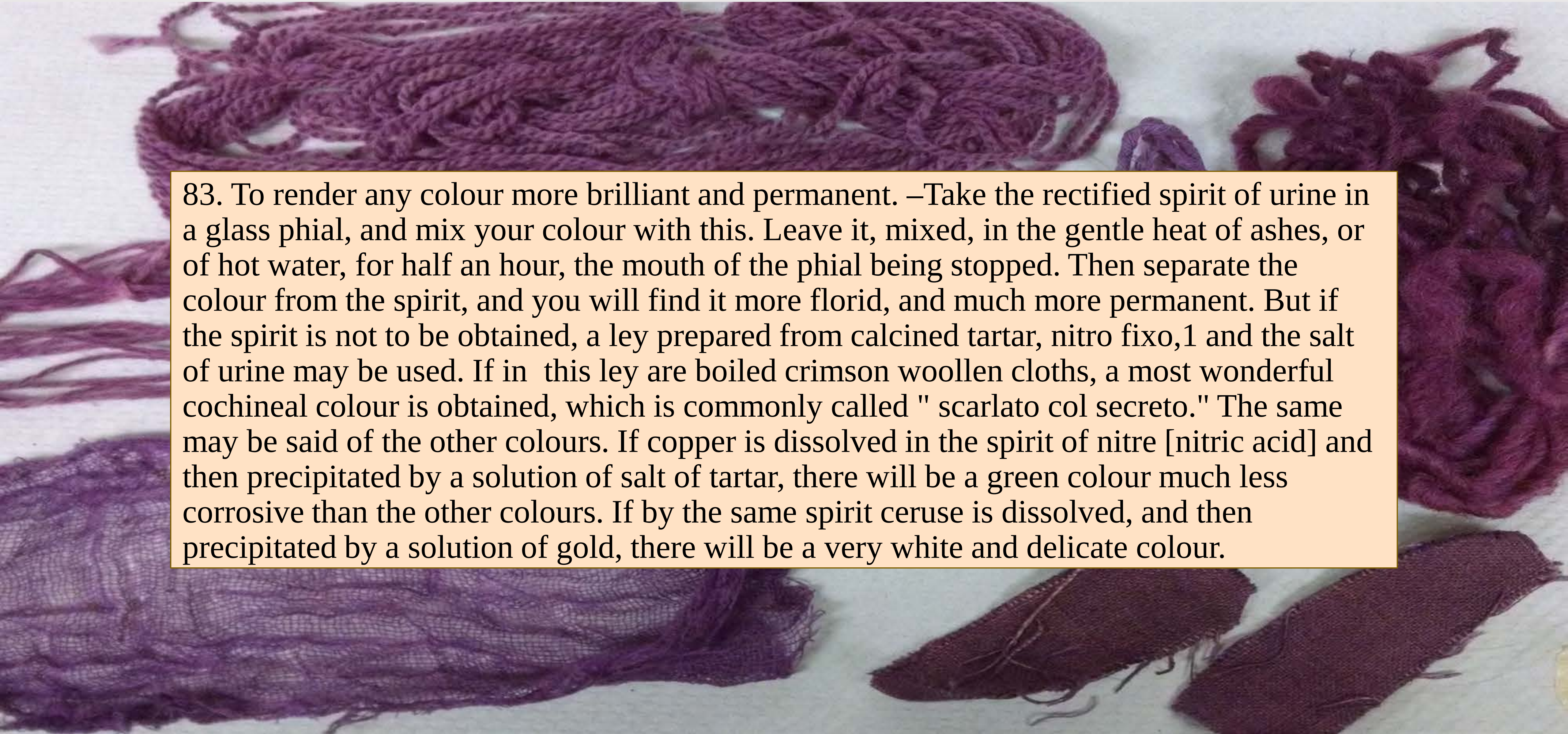
Paduan Manuscript (pg. 660)

Original Treatises, Dating from the XIIth to XVIIIth Centuries, on the Arts of Painting in Oil, Miniature, Mosaic, and on Glass of Gilding, Dyeing, and the Preparation of Colours and Artificial Gems by Mary P. Merrifield (1804)

22. How to prepare cochineal. —Boil it with lemon juice, garlic juice, and burnt alum.

Paduan Manuscript (pg. 682-684)

Original Treatises, Dating from the XIIth to XVIIIth Centuries, on the Arts of Painting in Oil, Miniature, Mosaic, and on Glass of Gilding, Dyeing, and the Preparation of Colours and Artificial Gems by Mary P. Merrifield (1804)



83. To render any colour more brilliant and permanent. –Take the rectified spirit of urine in a glass phial, and mix your colour with this. Leave it, mixed, in the gentle heat of ashes, or of hot water, for half an hour, the mouth of the phial being stopped. Then separate the colour from the spirit, and you will find it more florid, and much more permanent. But if the spirit is not to be obtained, a ley prepared from calcined tartar, nitro fixo,1 and the salt of urine may be used. If in this ley are boiled crimson woollen cloths, a most wonderful cochineal colour is obtained, which is commonly called " scarlato col secreto." The same may be said of the other colours. If copper is dissolved in the spirit of nitre [nitric acid] and then precipitated by a solution of salt of tartar, there will be a green colour much less corrosive than the other colours. If by the same spirit ceruse is dissolved, and then precipitated by a solution of gold, there will be a very white and delicate colour.

The Plictho (pg. 145-147)

The Plictho: instructions in the art of the dyers which teaches the dyeing of woolen cloths, linens, cottons, and silk by the great art as well as by the common by Giovanventura Rosetti (active 1530-1548)

To dye silk in perfect crimson color.

122. First arrange the silk over the small rods that it be eight ounces of silk each. Couple them two by two so that it stays well in cooking. It needs half a bucket of water for each pound of silk. See that your work load is pocketed in manner that in the pocket it be not too tight, in fact better wide. Take eight ounces of black soap for each pound of silk to be worked and it need be boiled at a gentle boil a half hour and no more. Then take it out of the pocket, and wash it well to advantage so that in such manner that by the hand is known its scroop. To alumate it, takes ounces of alum for each pound of cooked silk and that the roche alum be fine. Note that as you dissolve the roche alum it needs be dissolved in river water that is well boiling in a cauldron. Let it cool, and when it is cool take it out and throw it into a tub and over that, as much water that in all it be one bucket for each pound of cooked silk. It makes the water biting as it must be; that is, one bucket of bath for each pound and see that you understand. When you want to use the water, divide it and make it to eight rods of about eight ounces each, and you put them in that tub where is the bath of alum. Make it stay well under the water and it must stay in the said alum fourteen hours and up to thirty. As you take out the silk from the alum, wash it well to advantage, and when you will have done this, divide it again as is said above for dyeing.

Also, the crimson needs to be soaked and it needs to soak according to the season, and especially when you work urgently. See that it be well soaked above all, and that it be well ground similarly to advantage. Then make up the bath and put in as much water as is half a bucket per pound of load. Then put bath into the cauldron and make a bright fire and see that it boil. As it begins to boil, have set up three fazi of poppo for each pound of load, and it must be well pestled and sifted. You will put the said poppo into the cauldron and stir well and then put your load inside and go turning it over as usual, with a good fire below and that it fail not and that it be a bright fire. Make it boil thus a half hour and not more. Then take it out and have ready a tub of water and put it in immediately as you take it out of the cauldron. Wash it therein, and squeeze it well to advantage. Then you will go to wash it at the river so that the grease of the crimson comes out of the silk.

Having done this, divide it and return to give it the aluming in a tub and that it be sweeter than the first one. Put your load inside as you did the other time, and let it stay inside fifteen hours to advantage*and then take it out and wash it well in river water. Then divide it up and make rods as above to dye the silk the second time. Then have ready first a half bucket of bath as before and make it boil and when it raises the boil see that there are made ready two fazzi of popo for each pound of silk worked. Soak it in the cauldron, pestled as I said above at first, and it needs a half fazo of indigo that has been to soak 24 hours, for each pound, and that has been soaking in a vase of glass. Throw it inside and stir well and then put in your load as you did before. Make it boil a half hour with bright fire and then take it out and it will be dyed competently. Have set up two tubs of water and first wash your load in one and then throw it into the other and then to the flowing river to advantage. And this is approved by Master Matthio of Odati from Venice.

Note this rule; with four pounds of crimson one makes good color and with five one does better, and up to six for each pound of silk. But do not pass beyond this relation to the cooked silk because it dyes perfectly and do not pass that sign.

And it needs crimson, minute and German and it will be perfect color.

When the crimson that you want to grind is soaked it is divided by eye and you take for the first time two thirds and the second the rest and manage as is said above.[136]

Resources and References

Sources of historical evidence

- Analysis of existing objects, such as surviving textiles and paintings in museum collections
  - However, it must be kept in mind that these represent only a small part of history. They are items that have been selectively collected by museums or upper class. Many were made for or bought by the elite, were luxury or just generally expensive items
- Recipe books and collections, instruction manuals
- Work orders, inventories, accounts, orders for materials, import records, and guild regulations

Reference books with recipes

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- Putting the Red in Redcoats: http://www.history.org/foundation/journal/Summer12_newformat/dye.cfm
- A short introduction (about cochineal): https://medium.com/@zip_lehnus/paint-it-red-cochineal-the-wonder-bug-51d280c41d56
- Artist Screen-Prints Fabrics With Bacteria: http://mentalfloss.com/article/504090/artist-screen-prints-fabrics-bacteria
- American Society for Microbiology: Bacterial Dyes in Fashion: https://www.asm.org/index.php/general-science-blog/item/6929-bacterial-dyes-in-fashion

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