COCHINEAL DYE: HISTORY, CHEMISTRY, AND PREPARATION

Naomi Rosenkranz

Assistant Director, Making and Knowing Project

Center for Science and Society, Columbia University

Last updated 2023-03-31 by NJR

Contact: njr2128@columbia.edu

Much of this material was initially developed as part of public workshops at Genspace Community Lab (New York), made possible by the Public Outreach Grant, *Colorant Sustainability Workshops* (Naomi Rosenkranz and Sumeyye Yar), from Columbia University's Center for Science and Society.

Safety

- **Hotplates**
  - If a hotplate is turned on, someone should be watching it
  - When not in use, unplug the hotplate
  - Keep flammable items away from the heating surface (including sleeves!)
  - Locate fire extinguishing and fighting methods
  - Be careful not to burn yourself or others
- **Glass beakers**
  - Risk of shattering due to “shock”
  - Don’t place cold beakers on very hot plates OR very hot beakers on cold surface
- Dyeing materials: **metal salts** (aluminum potassium sulfate, potassium carbonate, iron sulfate, and copper sulfate) & **dried cochineal**
  - Ok to be washed down the drain or thrown in municipal trash as per MSDS sheets and safety regulations
  - Do not require PPE like gloves or masks, but should still not be ingested

Dye definitions

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://mygermfreehome.com/ Photo Credit: Shutterstock

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.

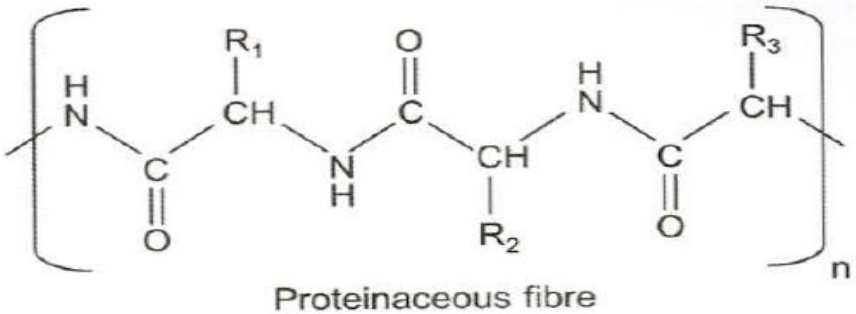
http://cameo.mfa.org/wiki/Fastness

Textiles

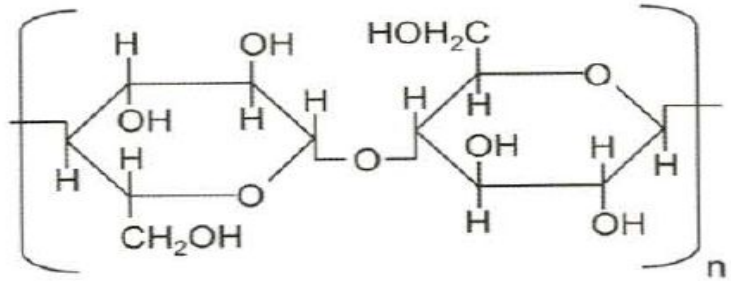
Textiles

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

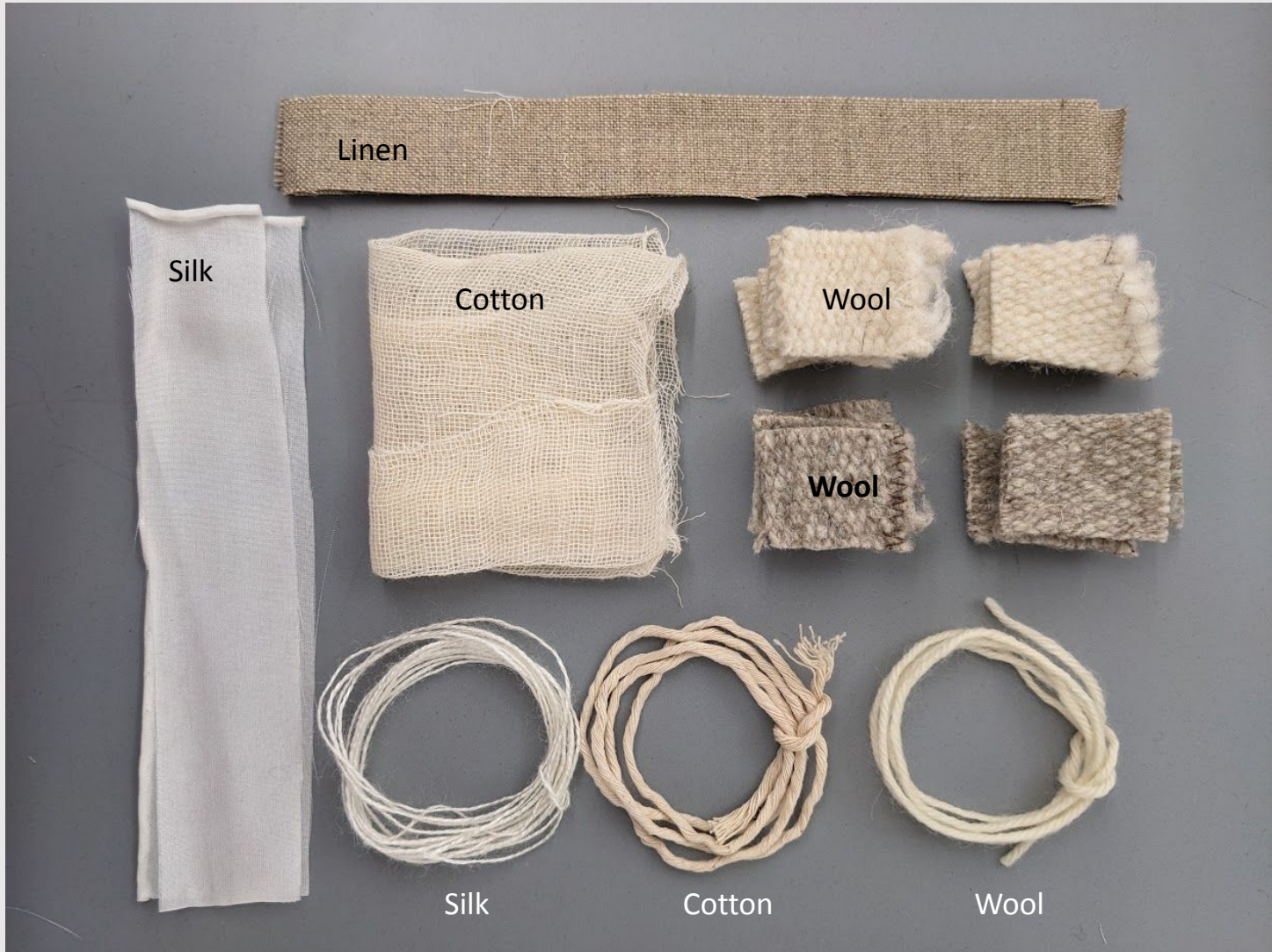
There are two main textile groups: those with **proteinaceous fibers** - primarily wool and silk - and those such as cotton or linen that have **cellulosic fibers**.



Proteinaceous fibre



Cellulosic fibre



Classification of organic dyes

Types of dyes (by chemical class)

Indigoids

Indigo

Anthraquinones

Cochineal

Flavonoids

Weld

Carotenoids

Turmeric

Neo-flavonoids/homoisoflavonoids

Logwood

Types of dyes (by process)

DIRECT DYES

Colorant forms a direct bond to the textile fiber

Turmeric

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

MORDANT DYES

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

Cochineal

http://www.dtcrafts.co.uk/dyesFixers/earthues/dy201.html

VAT DYES

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

Indigo

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

Classification of organic dyes

Direct dyes

Mordant dyes

Vat 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

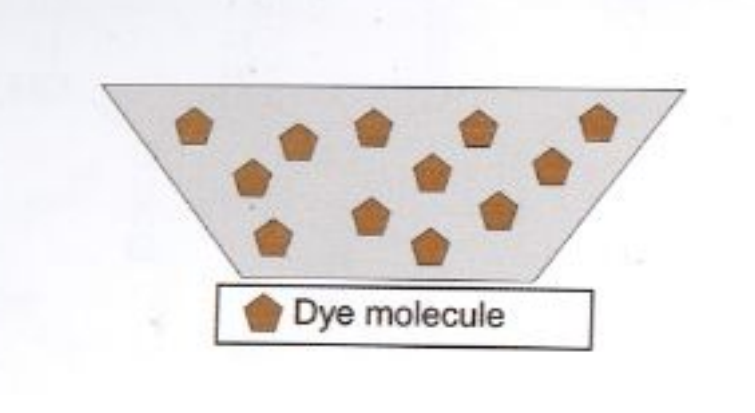
http://www.saniapell.com/homemade/the-colour-of-food-homemade-fabric-dyes/

Saffron

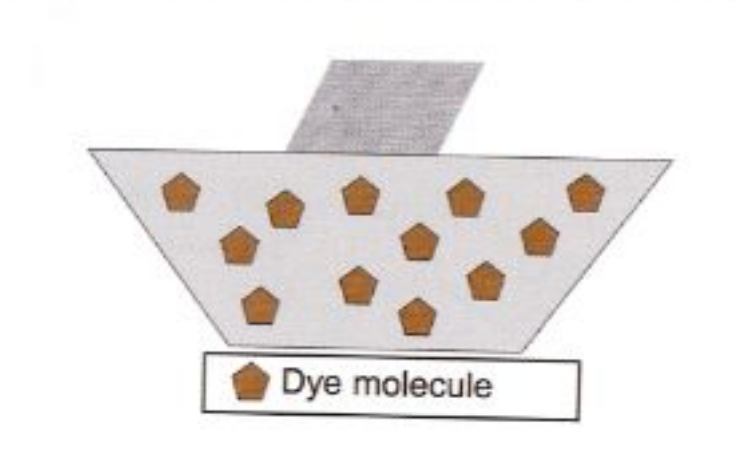
https://tatianabarry.livejournal.com/18580.html

Direct dye process

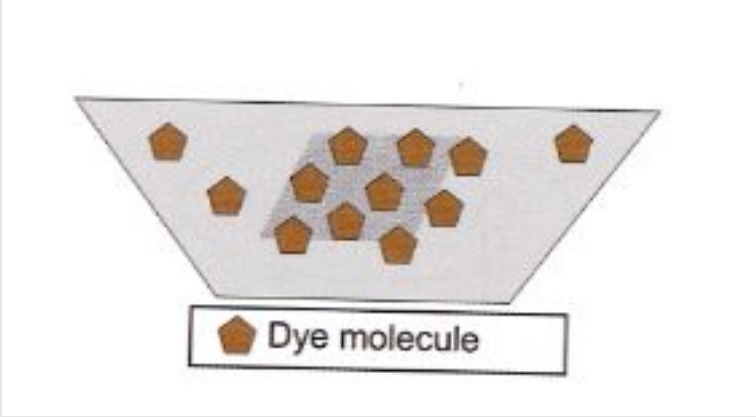
(1) Dye extracted from dye plant



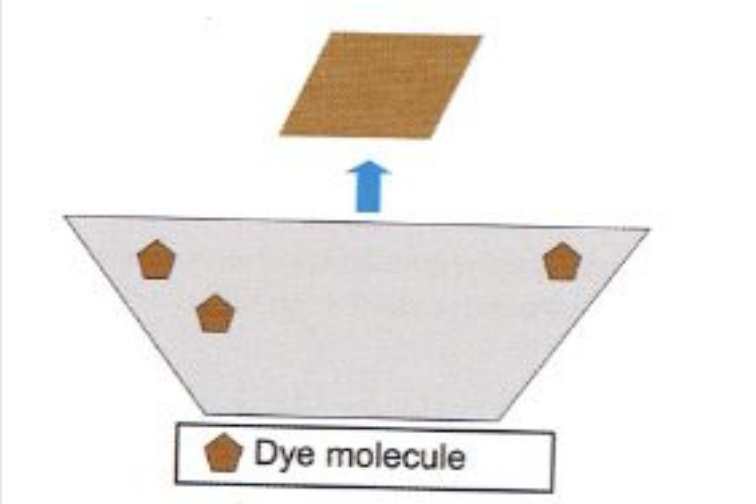
(2) Textile is added to dye bath



3) Dye molecules absorbed by textile



(4) Textile is removed



Adapted from Jo Kirby et al, *Natural Colorants for Dyeing and Lake Pigments: Practical Recipes and their Historical Sources* (Archetype, London, 2014), 26.

Classification of organic dyes

Direct dyes

Mordant dyes

Vat dyes

Mordant dyes

Mordants are the largest natural dye class.

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

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

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.

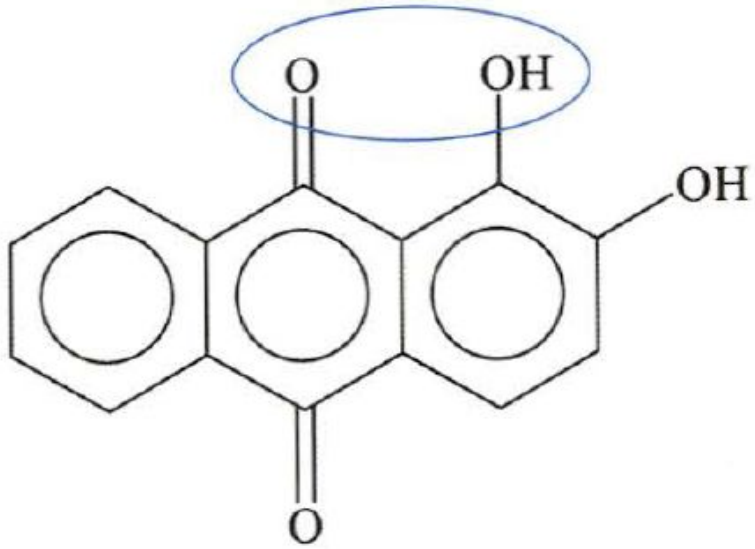


Figure 2 Probable position for coordination with aluminium ions taking alizarin as an example (Sanyova 2000/1: 66–78).

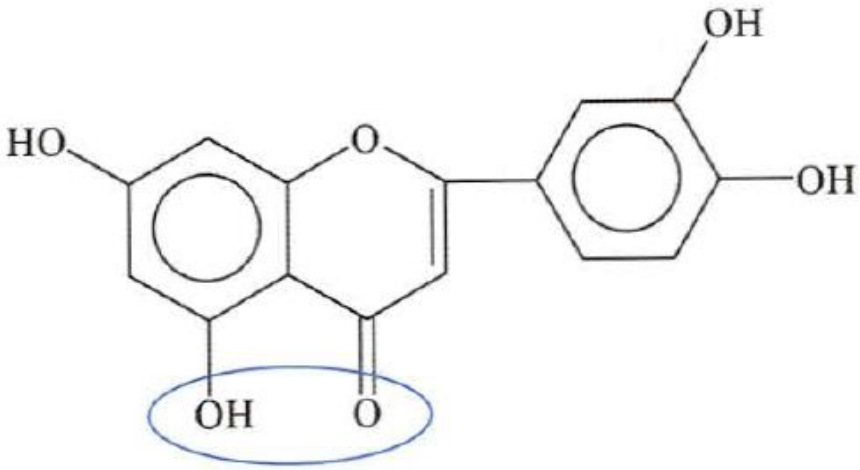
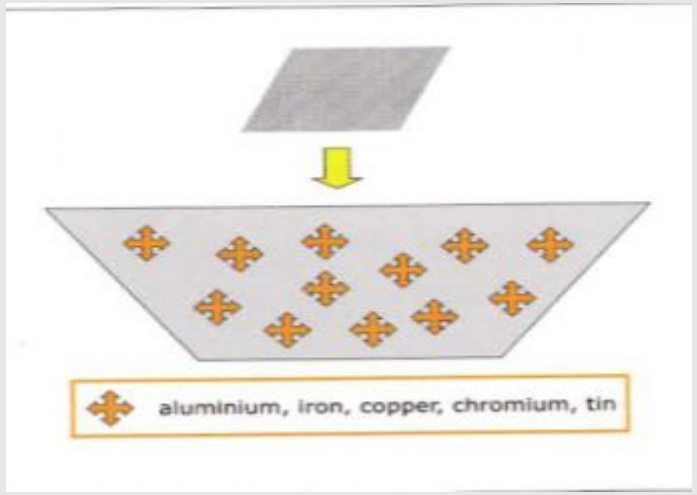


Figure 3 Probable position for coordination with aluminium ions taking luteolin as an example (Amat *et al.* 2010).

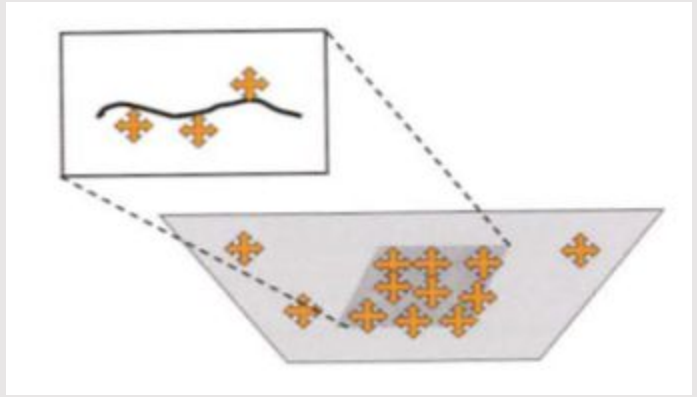
Jo Kirby et al, *Natural Colorants*, 25.

Mordant dye process

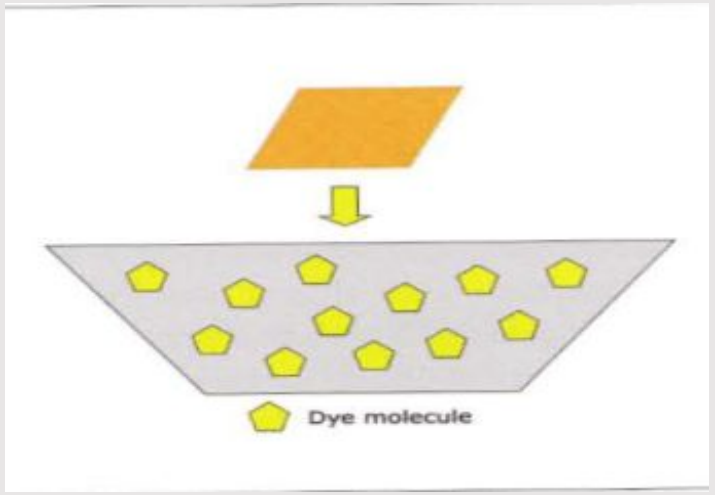
(1) Mordant bath is prepared by dissolving metal salts in water. Textile is then added



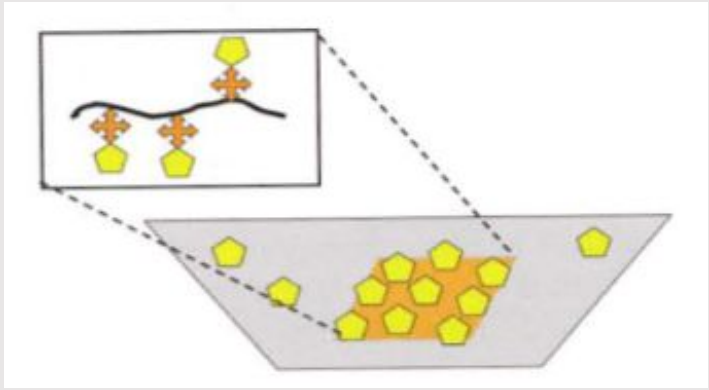
(2) Metal is bound to the textile



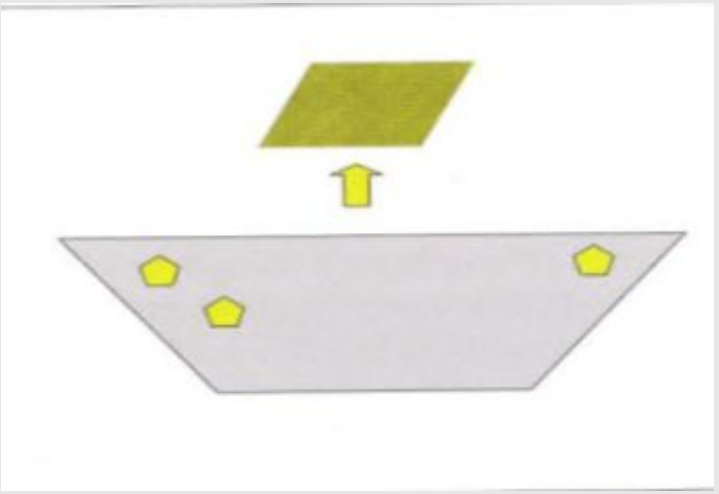
(3) Mordanted textile is added to dye bath



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



(5) Dyed textile is removed

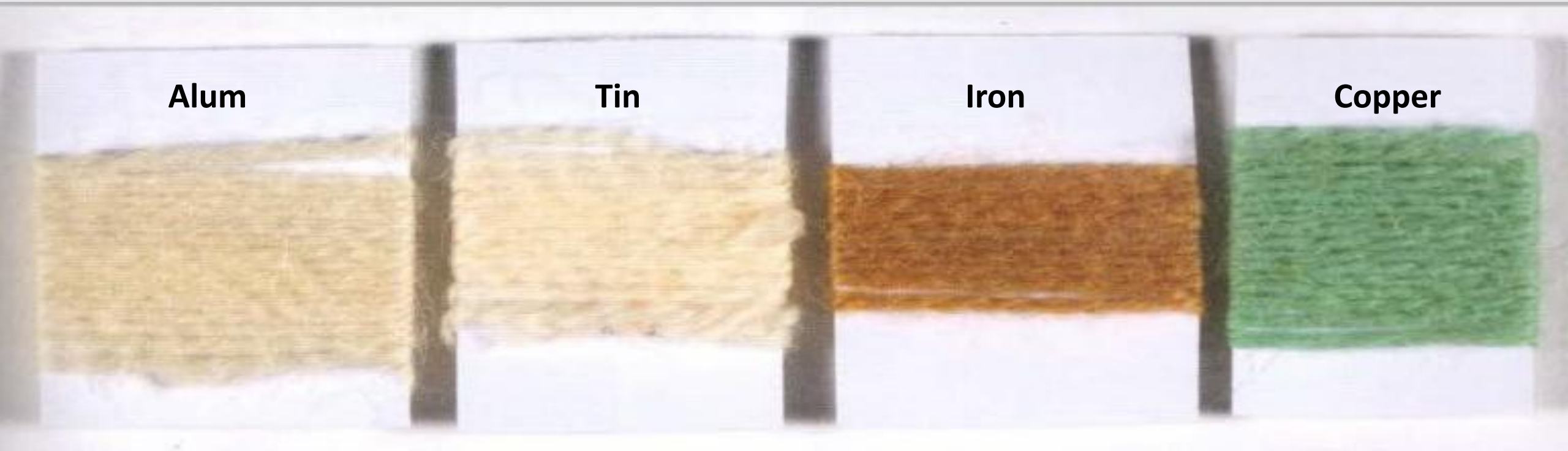


Adapted from Jo Kirby et al, *Natural Colorants for Dyeing and Lake Pigments: Practical Recipes and their Historical Sources* (Archetype, London, 2014), 27.

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

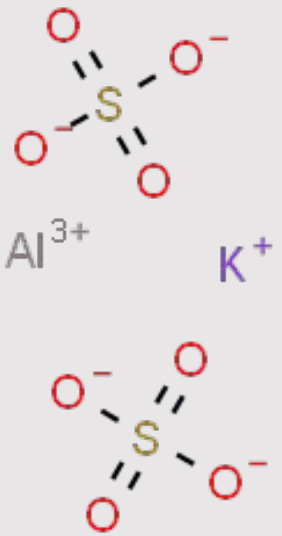
Used since antiquity.

Aluminum is the most important and most vastly used mordant.

https://www.amazon.com/Inoxia-Alum-Potassium-aluminium-sulphate/dp/B074G2V72X

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

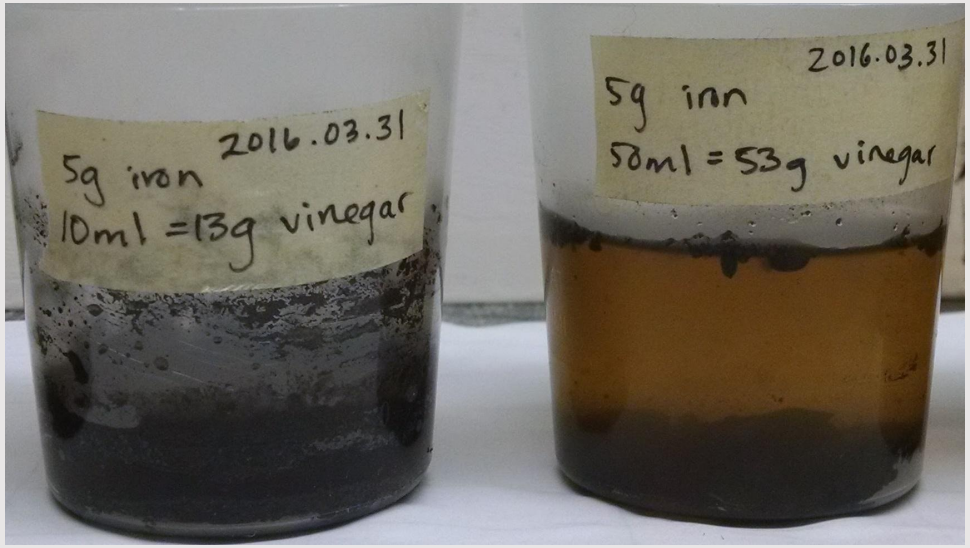
Also often called “potash alum”
(NOT to be confused with “potash”)

A white odorless powder with transparent crystals. Aluminum potassium sulfate occurs naturally in the minerals alunite and leucite**. It has been used since ancient times as a mordant in dyeing textiles and for tawing skins**. Aluminum potassium sulfate, or potash alum, is also used as a **filler in paper, cement, and paints**. It is used to harden gelatin, plaster, and cement. Potash alum has also been used as a substrate in the preparation of lake pigments.

Mordants: other metals used since antiquity

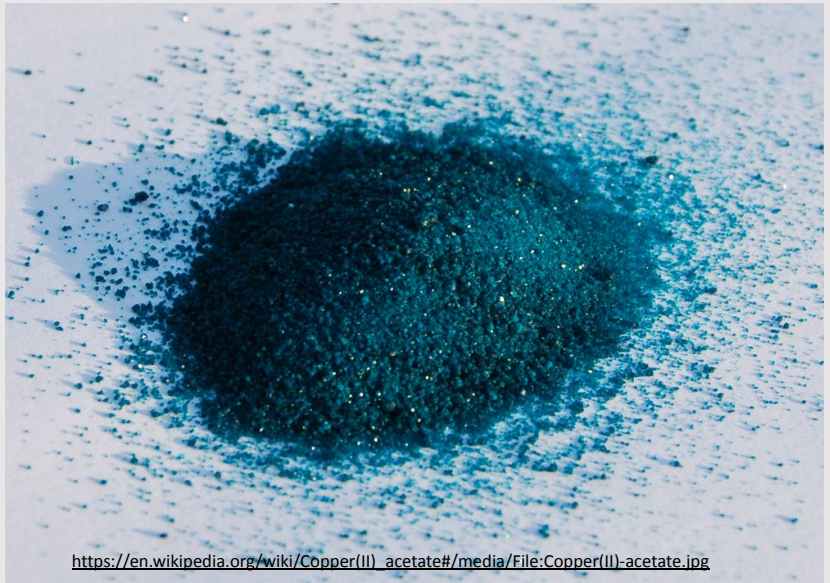
Iron

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



Copper

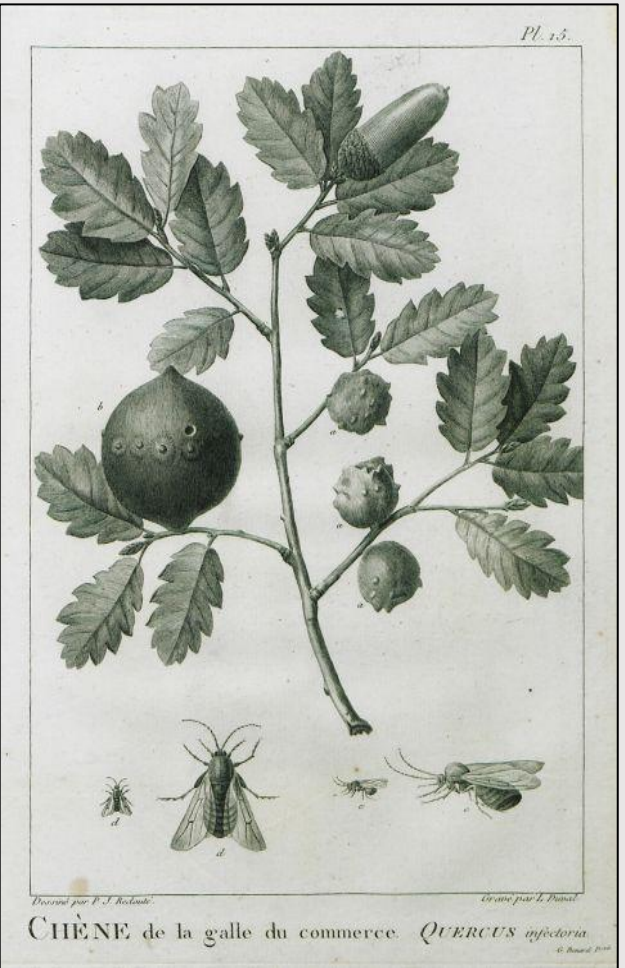
- Usually **copper(II) sulfate** (also known as cupric sulfate, blue vitriol, Roman vitriol), $CuSO_4 \cdot 5H_2O$
- Sometimes copper acetate, $Cu(CH_3COO)_2$



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:SumacFr

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

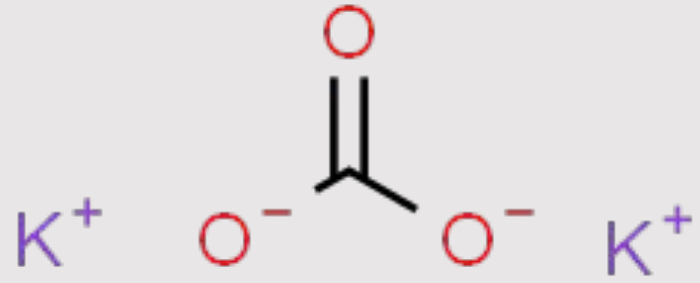
Classification of organic dyes

Additives

Additive: Potash = Potassium carbonate K_2CO_3

BASE
pH = 12

White deliquescent powder. **Potassium carbonate is used in the manufacture of glass, ceramics, smalt, and soap. It is also used in printing inks, process engraving, and lithography and in tanning and finishing leather.** In a closed environment, a saturated solution of potassium carbonate will form an equilibrium at a relative humidity of about 44% (20C).



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

Jo Kirby et al, *Natural Colorants*, 64–65.
http://cameo.mfa.org/wiki/Potassium_carbonate
http://www.chemspider.com/Chemical-Structure.10949.html

Mordant: None

Additive: None

Wool fleece

Silk taffeta and thread

Cotton twine

Linen, woven

Mordant:	None	Alum
Additive:	None	None
Wool fleece		
Silk taffeta and thread		
Cotton twine		
Linen, woven		


Mordant:
None
Alum
Alum
None
Additive:
None
None
Potash
Potash
Wool fleece
Silk taffeta and thread
Cotton twine
Linen, woven

Classification of organic dyes

Direct dyes
Mordant dyes
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.

http://www.mingei.com.au/mingei-story

https://www.averbforkeepingwarm.com/products/the-indigo-vat

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.

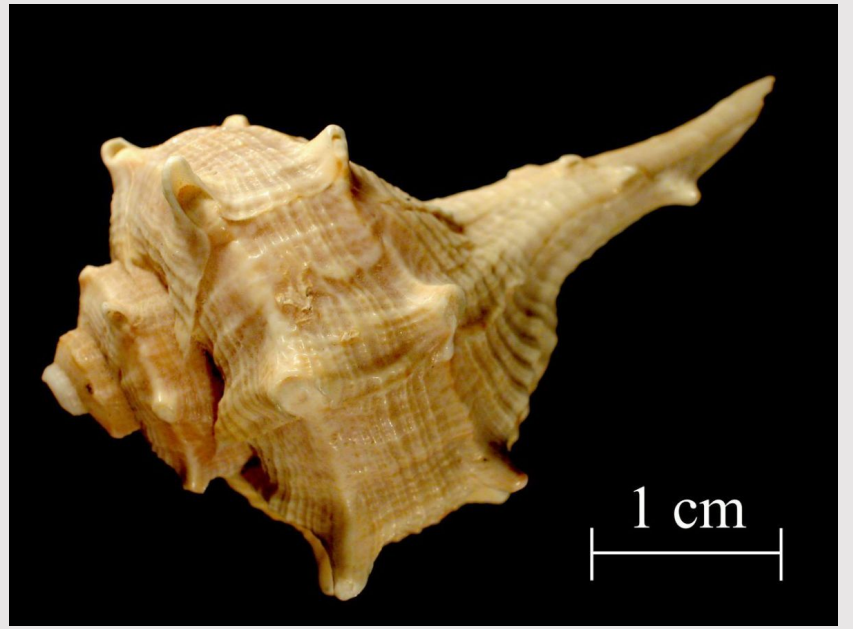
What creates, changes, or affects the color?

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

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

Natural colorants

Plant and Animal Dyes



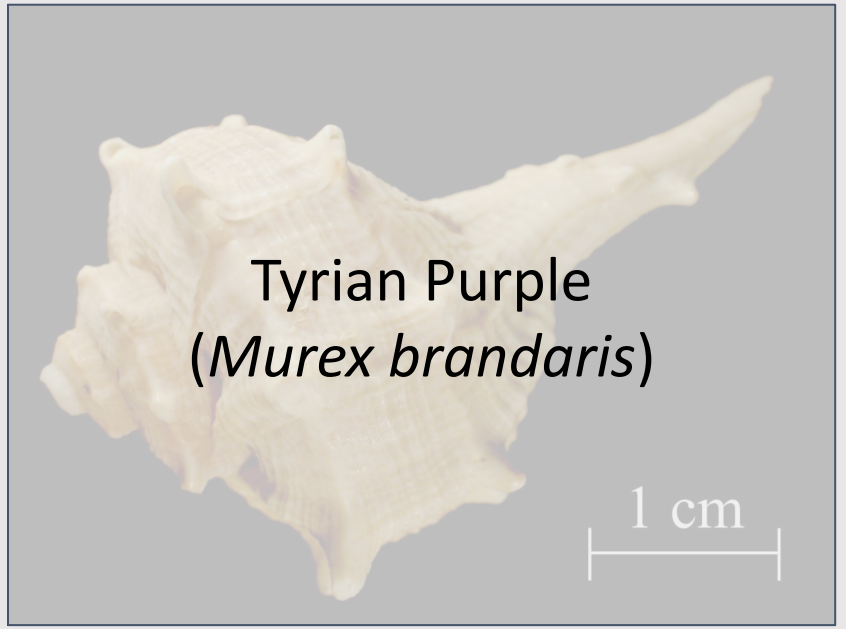
Plant and Animal Dyes

Madder (*Rubia tinctorum*)

Weld (*Reseda luteola*)

Annatto or *achiote* (*Bixa orellana*)

Tyrian Purple (*Murex brandaris*)



Buckthorn Berries (*Rhamnus frangula*)

Brazilwood (*Caesalpina echinata*)

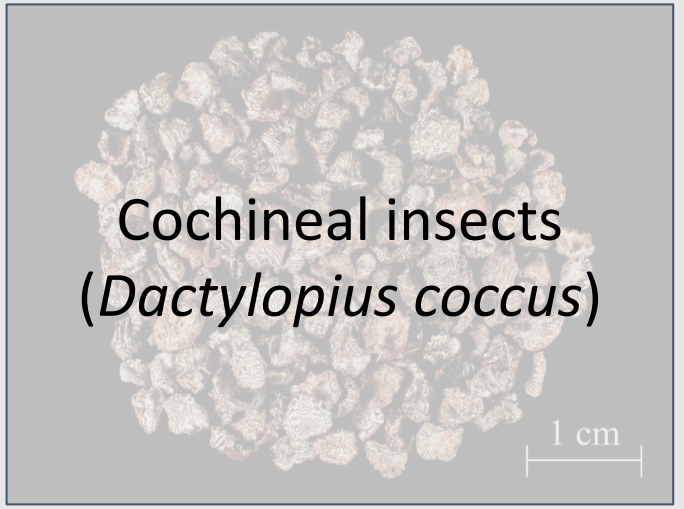
Indigo (*Indigofera tinctoria*)

Turmeric (*Curcuma domestica*)

Logwood (*Haematoxylum campechianum*)

Gall nuts (formed on *Quercus infectoria)*

Cochineal insects (*Dactylopius coccus*)



Plant and Animal Dyes










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

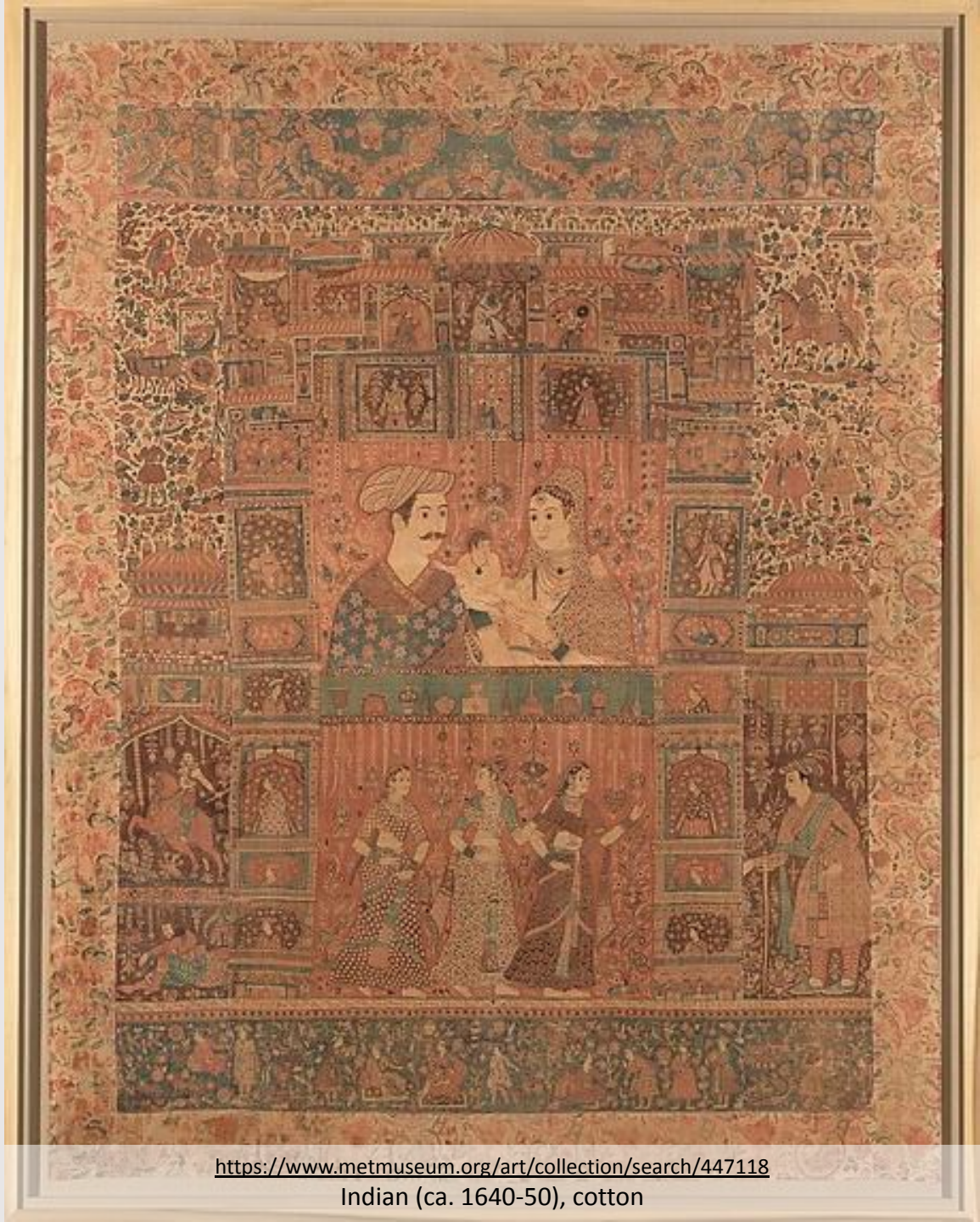
Chemical class: lawsone or isojuglone (naphthoquinone)

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.

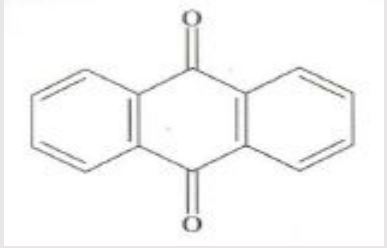
http://www.tropicos.org/Name/19200244



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.)

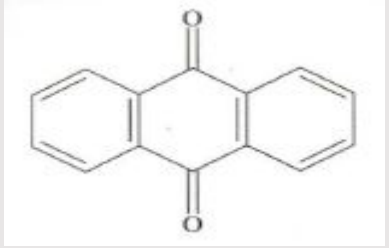
Secretes a protective coating that encloses itself in a sticky brown mass similar to resin, known as sticklac. When purified, this is known as shellac which was less economically important than the dye unlike today.

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.

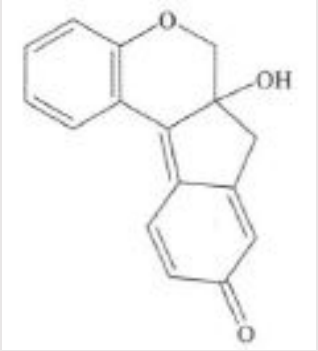
Range of red-orange-brown dyes obtained from the roots of a bedstraw.

http://thedomesticsoundscape.com/wordpress/?attachment_id=7451

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



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

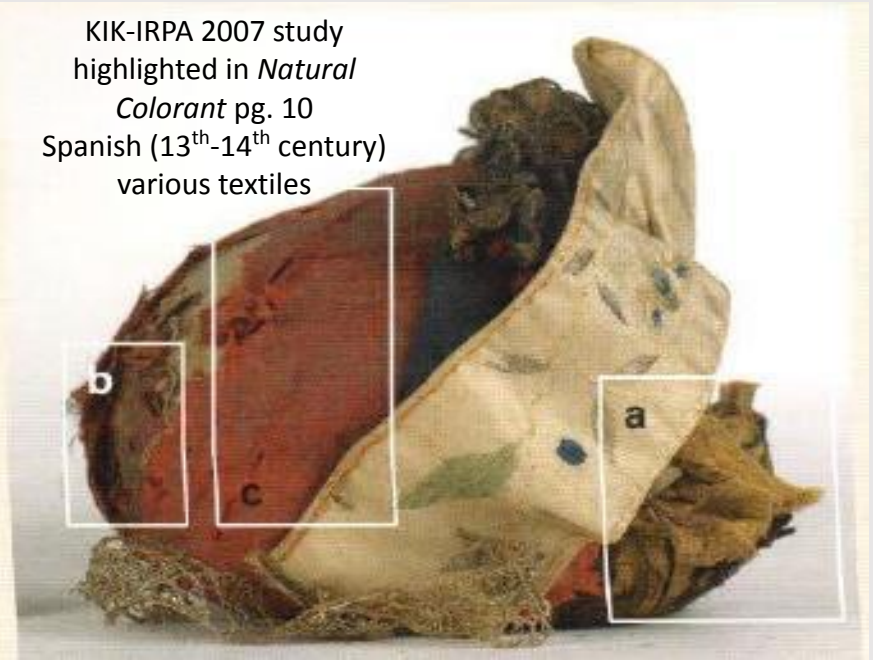
Dye type: Mordant dye.

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

Sappanwood

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

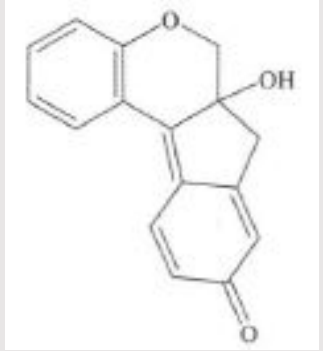


Brazilwood

Sappanwood

http://www.tropicos.org/Image/62816

Logwood



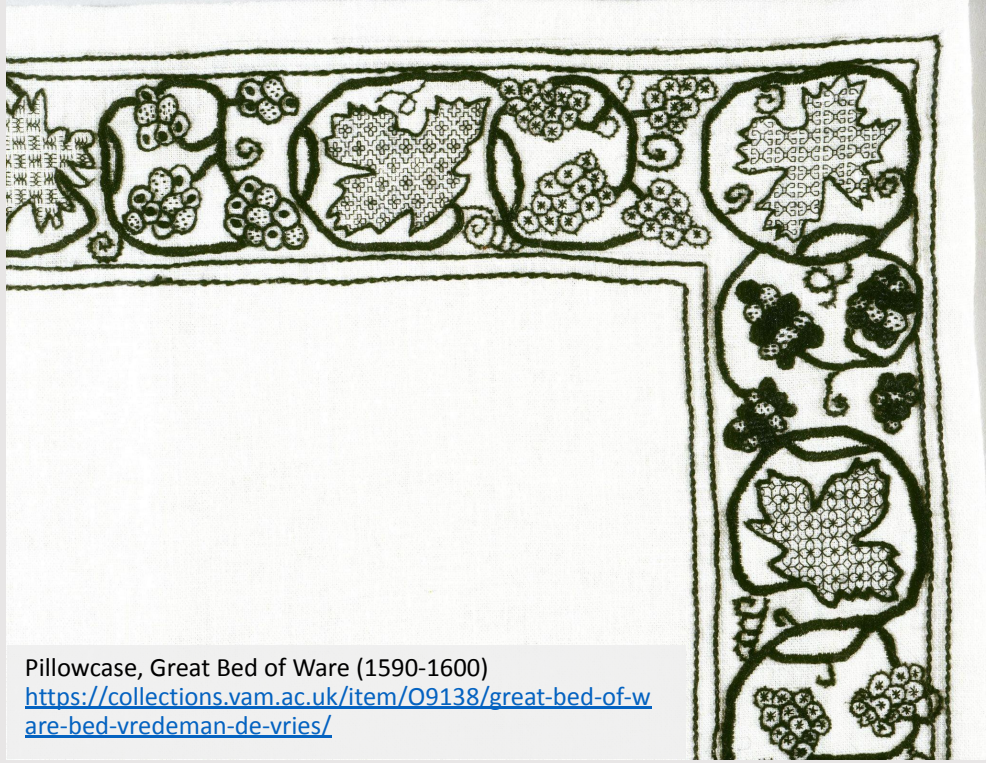
Botanical name: *Haematoxylon campechianum*

Chemical class: Hematoxylin (neo-flavonoid)

Region: Central America, Mexico, and the West Indies.

Dye type: Mordant dye.

Range of orange, red, brown, dark purple, and black dyes obtained from the heartwood of the tree. Also known as ***Árbol de campeche***.

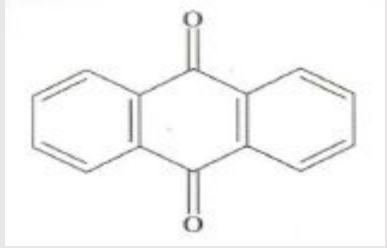


Pillowcase, Great Bed of Ware (1590-1600)
https://collections.vam.ac.uk/item/O9138/great-bed-of-ware-bed-vredeman-de-vries/

No mordant	Alum	Alum	No mordant
Logwood	Logwood	Logwood & potash	Logwood & potash

Logwood

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

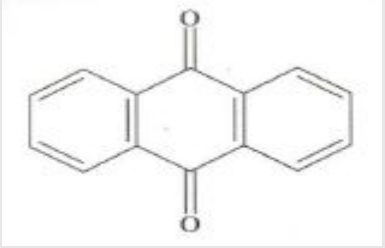
Cochineal

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.

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.)).

Dye is extracted from females with unhatched eggs.

Cochineal, covered in a white excretion that acts as a protective layer, on a nopal pad (Altadena, CA, 2022)

Collecting cochineal and killing cochineal, 1777, ink on paper.
José Alzate y Ramírez, *Memoria sobre la naturaleza, cultivo y beneficio de la grana* (Mexico City: Archivo General de la Nación, 1991).

Collecting cochineal in Altadena, CA (2021), Naomi Rosenkranz
https://drive.google.com/file/d/14GSA4udPcEdfN1LjDYzq984McLY5G5K8/view?usp=sharing

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 widespread confusion about what cochineal actually was
3. The monopoly maintained by the Spanish over cochineal cultivation

Cochineal in the Americas

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.

Coca Bag , 5th–7th century
Moche culture of Peru
Camelid hair, cotton
The Metropolitan Museum of Art, 1994.35.88

Terminology and Domestication

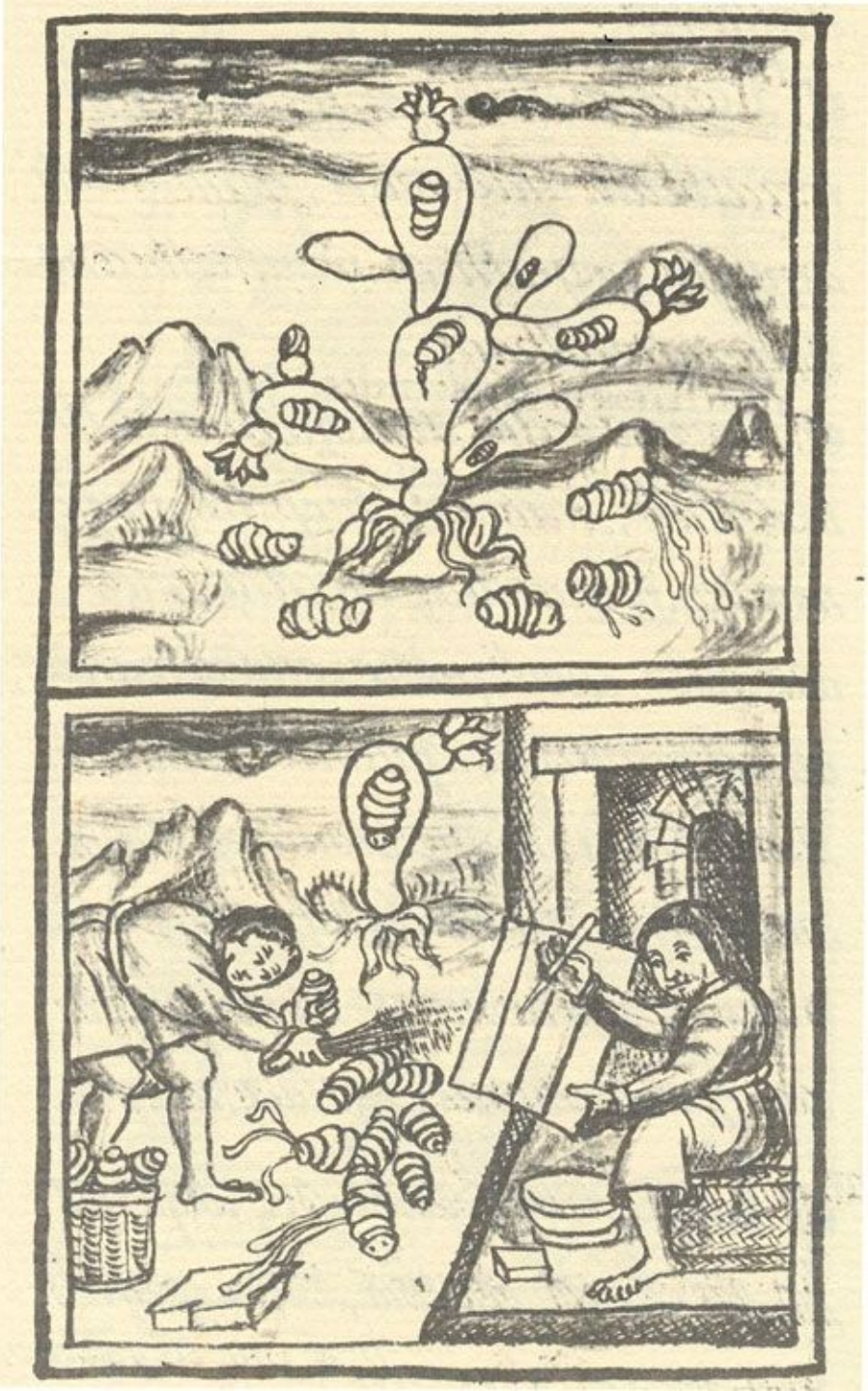
The cactus is known as ***nopalli*** or ***nochpalli*** in Náhuatl and ***tuna*** in Spanish from the Carib word for fruit or seed, ***tun***.

The fruit of the nopal is ***nochlti*** (Náhuatl) or ***tunal*** (Spanish).

Cochineal was known as ***nocheztli***, translating to “blood of the nopal fruit.”

Cochineal was also known as ***grana***, were selectively bred by Pre-Columbian peoples to create larger insects that could produce more color, the most potent source of red color in nature.

These domesticated varieties are known as ***grana fina***, as opposed to wild, less potent species known as ***grana silvestre***.

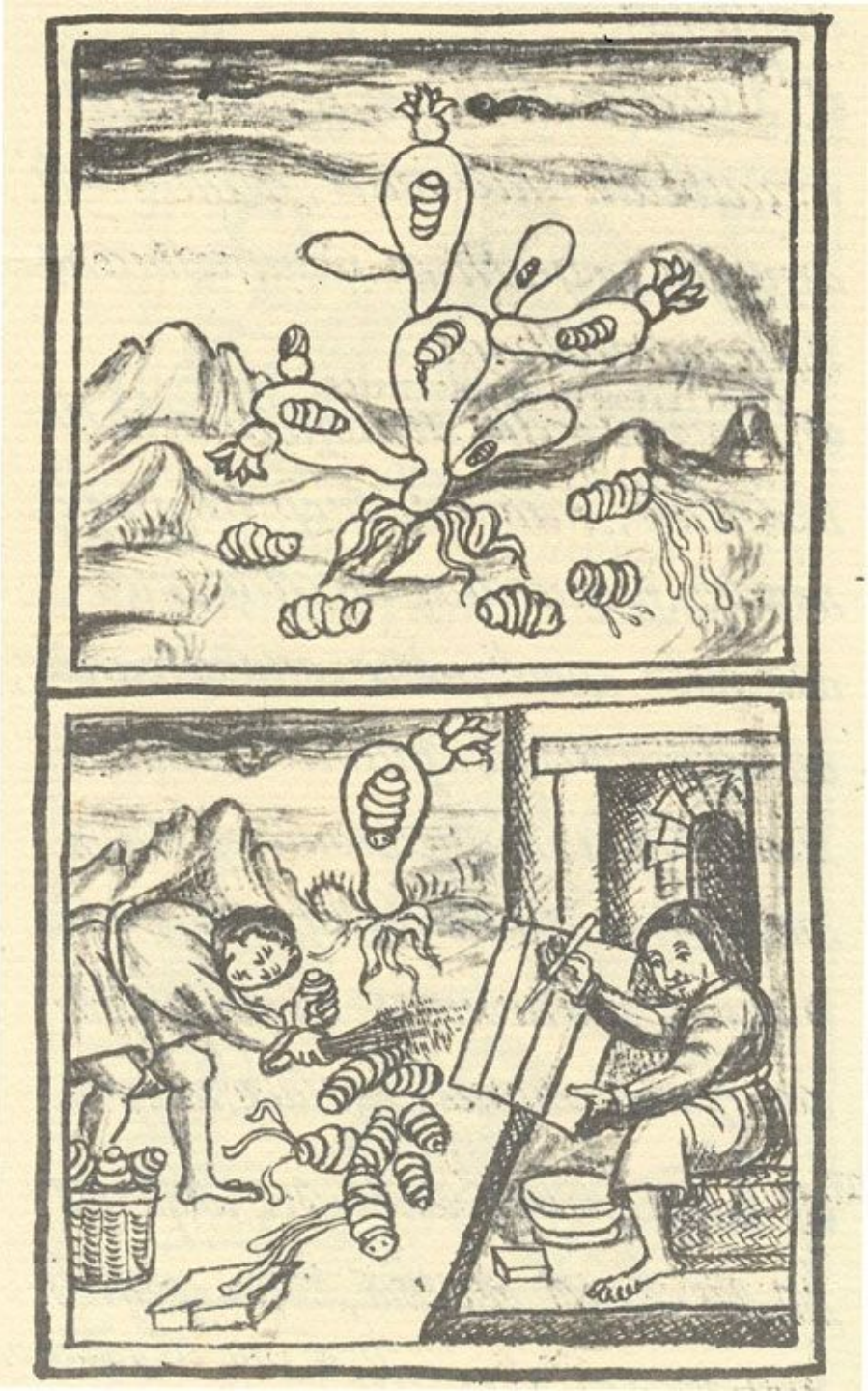


Cochineal harvest, folio 368v. Bernadino de Sahagún (Spanish, 1499-1590), *Historia general de las cosas de Nueva España* [or *The Florentine Codex*] (Mexico, ca. 1540-85). Biblioteca Medicea Laurenziana, Florence (Mediceo Palatino 220, book 11). Ink on European paper, 12 ⅝ x 8 11/16 in.

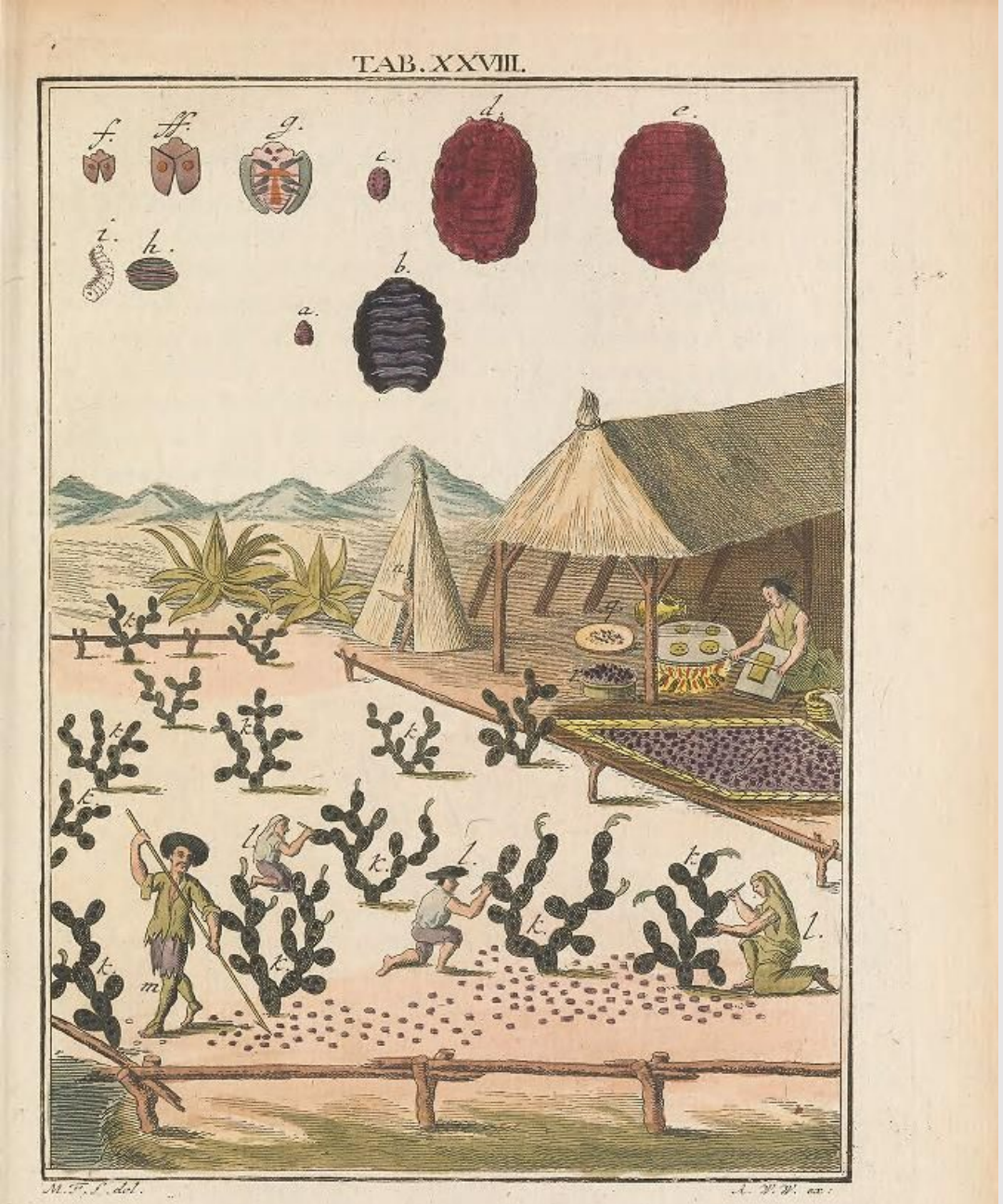
Etymology of cochineal

- **Forms:** 1500s–1700s **cochenille**, **cochinelle**, 1600s–1700s **cochineel**, **cochinele**, **cocheneal**, **cochenile**, 1600s– **cochineal**; also 1600s **cochenel(le**, **cochanele**, **cochoneel**, **cochinella**, **cochonillio**; 1500s **cuchinilla**, 1600s **cuchineel**, **cuchinile**, **cucheneale**, **cuchanel**, **coucheneele**, **couchenille**; 1500s–1600s **cutchenele**, 1600s **cutcheneale**, **cutchineale**, **cutchyneale**, **cutchaneale**, **cutchanel(e**, **cutchoneal(e**; (1600s **quitchineel**, **chochineel**, **scutchenel**, etc.).
- **Etymology:** < French *cochenille*, < Spanish *cochinilla* or Italian *cocciniglia*. The latter is evidently a derivative of Italian *coccino*, Latin *coccinum* scarlet robe or vesture, Italian *coccineo*, Latin *coccineus* scarlet-coloured, < *coccum* scarlet, 'grain', originally 'berry', in Italian *cocco* 'graine to dye scarlet with' (Florio). Spanish has also *cochinilla* 'woodlouse', diminutive of *cochina* 'sow', and it has been said that *cochinilla* 'cochineal' is the same word, from the resemblance of the dried cochineal insects to woodlice in the same state; but this is apparently a secondary association arising out of the fortuitous identity of the words.

"cochineal, n.". OED Online. March 2023. Oxford University Press. https://www.oed.com/view/Entry/35307?redirectedFrom=cochineal (accessed March 29, 2023).

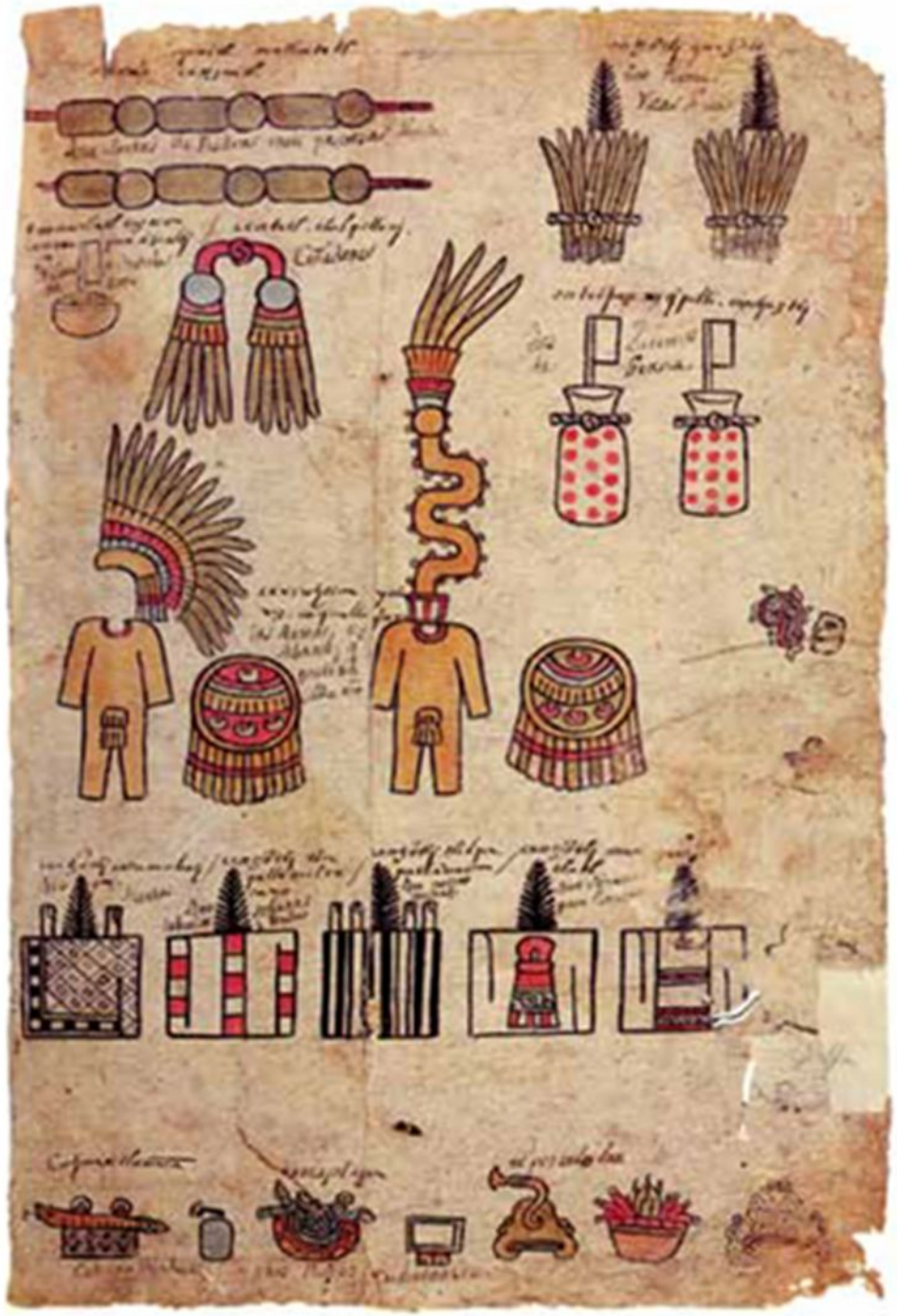


Cochineal harvest, folio 368v. Bernadino de Sahagún (Spanish, 1499-1590), *Historia general de las cosas de Nueva España* [or *The Florentine Codex*] (Mexico, ca. 1540-85). Biblioteca Medicea Laurenziana, Florence (Mediceo Palatino 220, book 11). Ink on European paper, 12 ⅝ x 8 11/16 in.



Michael van der Gucht, *The manner of propagating, gathering & curing the Grana or Cochineel, done by an Indian in the Bishoprick of Guaxaca in the Kingdom of Mexico in America*, engraving, plate 190, in volume 2, *Hans Sloane, Voyage to ... Jamaica* (London, 1725), NLM Digital Collections, http://resource.nlm.nih.gov/101456797.

Martin Frobenius Ledermüller, *Mikroskopische Gemüths- und Augen-Ergötzung* (*Microscopic Delights for the Soul and Eyes*), 3 vols. (Nuremberg: Gedruckt auf Kosten des Verlegers von Christian de Launoy, 1760-63), https://doi.org/10.5962/bhl.title.148700. Ink on paper.



Aztec Empire

Early 16th-century Mexican codex, *Matricula de tributos,* documents tributes to be made to the ruler of the Aztec Empire:

- From the Mixtec people: 40 sacks of cochineal every year, 2,000 mantles and 400 cloths of various types, 20 jade belts, 800 quetzal feathers, bags of gold, and more.
- From the Zapotec people: 20 sacks of cochineal every 80 days, 400 woven covers, 800 plain mantles, and 20 gold disks.

Inca Empire

Red was a symbol of royalty and nobility.

Certain textiles, such as the red royal fringe, *mascaypacha*, could only be worn by the king.

Other official garments incorporated red cochineal, such as the decorations worn by the royal army.

Tassel from an Inca bag with designs of llamas, reminiscent of the royal Inca *mascaypacha*.
Peru, Inca, 11th-16th century
Cotton and camelid hair
The Metropolitan Museum of Art, 28.171 .4

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.

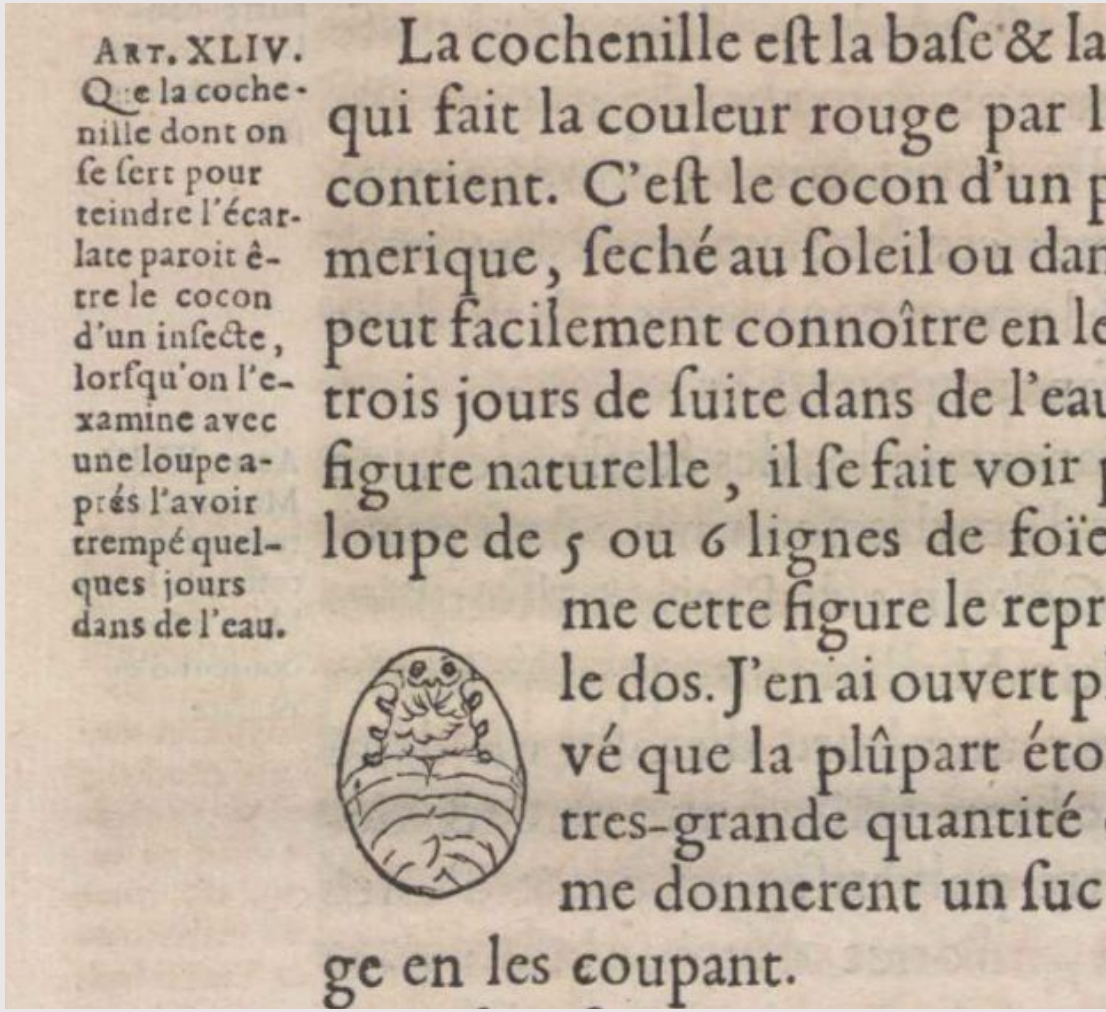
When Europeans did get hold of true Mexican cochineal, any attempts to bring them back to Europe failed, as the insects could not survive in the change of environment, often dying on the way back to Europe or perishing in Europe without access to nopal cacti.

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.


ART. XLIV.
Que la cochenille dont on ſe ſert pour teindre l'écarlate paroit être le cocon d'un inſecte, lorſqu'on l'examine avec une loupe aprés l'avoir trempé quelques jours dans de l'eau.

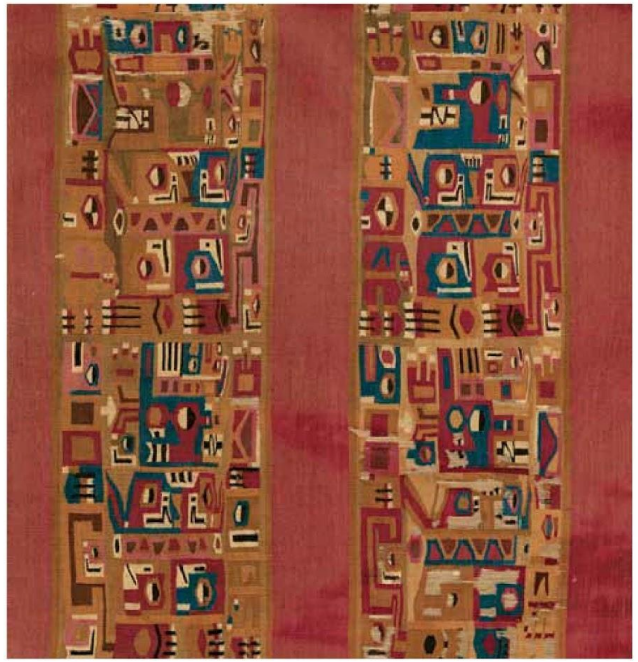
La cochenille eſt la baſe & la
qui fait la couleur rouge par l
contient. C'eſt le cocon d'un p
merique, ſeché au ſoleil ou dan
peut facilement connoître en le
trois jours de ſuite dans de l'eau
figure naturelle, il ſe fait voir
loupe de 5 ou 6 lignes de foïe
me cette figure le repr
le dos. J'en ai ouvert p
vé que la plûpart éto
tres-grande quantité
me donnerent un ſuc
ge en les coupant.

Description and illustration of cochineal under a microscope, 1694, printed book, Biblioteca Nazionale Centrale - Firenze, record number UFIE002882.
Nicolas Hartsoeker, *Essay de dioptrique par Nicolas Hartsoeker* (Paris, France, 1694), https://www.proquest.com/docview/2090352984/citation/37B74A983B42B1PQ/1, 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)



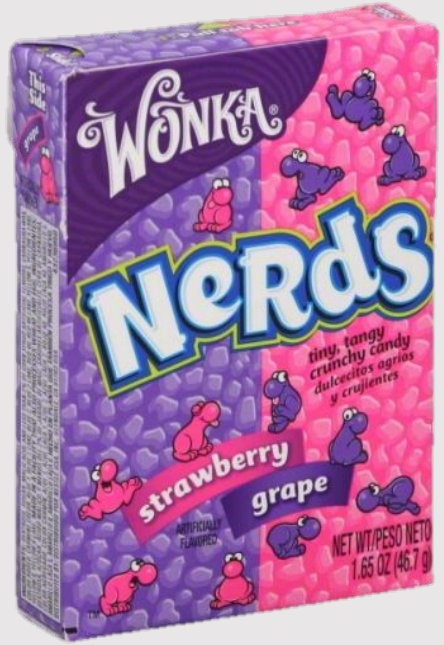
34. Tunic fragment (detail). Peru, Wari, 7th–9th century. Tapestry-weave cotton and cochineal-dyed camelid hair, 22½ x 80 in. (57.2 x 203.2 cm). The Metropolitan Museum of Art, Gift of George D. Pratt, 1930 (30.16.1)

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.

Why Tiny Cactus Bugs In Red Food Dye Are A $35 Billion Industry | Big Business | Insider Business https://youtu.be/iBNySB2jpVg

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

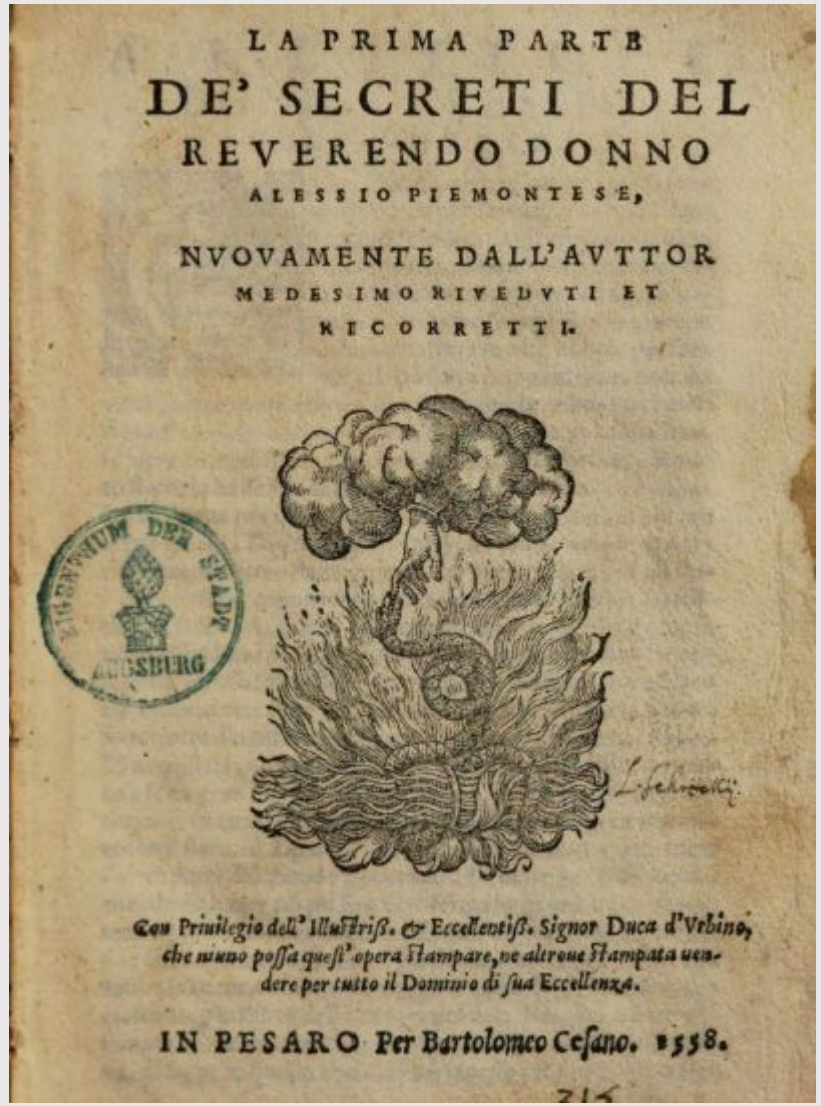
https://www.metmuseum.org/art/collection/search/320804
Peruvian (ca. 16th-17th century), camelid hair and cotton

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

Dyeing recipes

Recipe Example: To Dye Silk Carmine

To dye silk carmine. First, you will rasp or scratch hard soap very finely, and let them [the soap shavings] dissolve in plain water; after that put your silk in a small bag made of linen or fine canvas, and put it in a kettle with the aforesaid soap and water. Let this boil for half an hour, moving it around regularly so it does not burn, then take it from the fire, wash it in salt water, and after that in sour water. Take also to every pound of silk a pound or more of rock alum dissolved in cold water, and be sure there is enough water; wherein you will put your silk without any bag, and let it lay therein without fire for eight hours. Then take it out, wash it in fresh water, then in salt water, and then again in fresh water, and do not let it dry but put it all wet into a kettle with the carmine well pestled and sieved, that is, three ounces for each pound of silk… And when it starts boiling then put in the silk prepared as above, and let it boil for a quarter of an hour. At last you will take it from the fire, and let it dry in the shade, and you will have a very excellent dyeing.


LA PRIMA PARTE
DE' SECRETI DEL
REVERENDO DONNO
ALESSIO PIEMONTESE,
NVOVAMENTE DALL'AVTTOR
MEDESIMO RIVEDVTI ET
RICORRETTI.

Con Priuilegio dell' Illuſtriſs. & Eccellentiſs. Signor Duca d'Vrbino, che niuno poſſa queſt' opera ſtampare, ne altroue ſtampata uendere per tutto il Dominio di ſua Eccellenza.

IN PESARO Per Bartolomeo Cesano. 1558.

***De' secreti del reverendo signore Alessio Piemontese* (1558)**
as translated from the Dutch in Jo Kirby et al, *Natural Colorants*, 37–38.

https://www.nuovorinascimento.org/cinquecento/secreti/Secreti06VariantiPesaroCesano1558.html

Recipe Example: To Dye Silk Carmine

To dye silk carmine. First, you will rasp or scratch hard soap very finely, and let them [the soap shavings] dissolve in plain water; after that put your silk in a small bag made of linen or fine canvas, and put it in a kettle with the aforesaid soap and water. Let this boil for half an hour, moving it around regularly so it does not burn, then take it from the fire, wash it in salt water, and after that in sour water. Take also to every pound of silk a pound or more of rock alum dissolved in cold water, and be sure there is enough water; wherein you will put your silk without any bag, and let it lay therein without fire for eight hours. Then take it out, wash it in fresh water, then in salt water, and then again in fresh water, and do not let it dry but put it all wet into a kettle with the carmine well pestled and sieved, that is, three ounces for each pound of silk… And when it starts boiling then put in the silk prepared as above, and let it boil for a quarter of an hour. At last you will take it from the fire, and let it dry in the shade, and you will have a very excellent dyeing.

***De' secreti del reverendo signore Alessio Piemontese* (1558)**
as translated from the Dutch in Jo Kirby et al, *Natural Colorants*, 37–38.

“Sour water” or bran water

Giovanventura Rosetti, *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*, ed. Sidney M Edelstein and Hector C Borghetty, translation of the first edition of 1548 (Cambridge: M.I.T. Press, 1969), p 191.

The use of a solution of bran helped cleanse the goods of its impurities and made it more amenable to the absorption of the alum and subsequently the dyestuff.

Kirby, *Natural Colorants*, p 40.
'Sour water: also called 'bran water· or 'strong water' (not to be confused with aqua regia, Scheidwasser in German and sometimes also referred to as 'strong water') is an acid bath, obtained by fermentation of wheat bran.

http://www.elizabethancostume.net/dyes/lyteldyebook/branwater.html

From experiments with madder dyeing, bran water (although slightly acidic) adds a bluer cast to madder red dyes. In addition, it softens the harsh feeling given to wool by madder. Use of bran to soften water for madder dyeing is discussed at length in James Haigh.s *Dyer.s Assistant* (1796). Haigh also says that bran can be used to counteract water with a high alkaline/chalk/mineral content when dyeing, by throwing a large bag of bran into the vat and boiling it for a while.

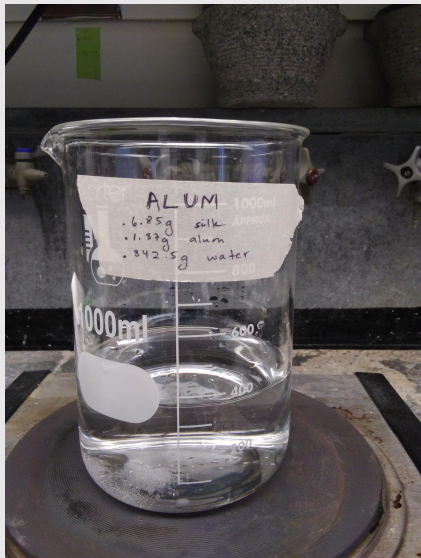
https://botanicalcolors.com/shop/mordants/wheat-bran-mordant-assist/

Experiments with soaking wool for long periods of time in fermented bran water (in the middle east, this technique is used when dyeing yarn for carpets) show that, when examined under an electron microscope, the sticky substance between the wool scales is eaten away, allowing deeper penetration of the dye stuffs. This results in brighter colors with much better resistance to sunbleaching.

We like to use wheat bran mordant assist with aluminum acetate. It contains minerals that help enhance the aluminum acetate mordant and brighten dye colors. Complete instructions are available here. Wheat bran baths can be used several times before discarding. Their enzymes are also useful to remove starch from fibers.

Recipe Example: To Dye Silk Carmine

To dye silk carmine. First, you will rasp or scratch hard soap very finely, and let them [the soap shavings] dissolve in plain water; after that put your silk in a small bag made of linen or fine canvas, and put it in a kettle with the aforesaid soap and water. Let this boil for half an hour, moving it around regularly so it does not burn, then take it from the fire, wash it in salt water, and after that in sour water. **Take also to every pound of silk a pound or more of rock alum dissolved in cold water, and be sure there is enough water;** wherein you will put your silk without any bag, and let it lay therein without fire for eight hours. Then take it out, wash it in fresh water, then in salt water, and then again in fresh water, and do not let it dry but put it all wet into a kettle with the carmine well pestled and sieved, that is, three ounces for each pound of silk… And when it starts boiling then put in the silk prepared as above, and let it boil for a quarter of an hour. At last you will take it from the fire, and let it dry in the shade, and you will have a very excellent dyeing.



***De' secreti del reverendo signore Alessio Piemontese* (1558)**
as translated from the Dutch in Jo Kirby et al, *Natural Colorants*, 37–38.

Recipe Example: To Dye Silk Carmine

To dye silk carmine. First, you will rasp or scratch hard soap very finely, and let them [the soap shavings] dissolve in plain water; after that put your silk in a small bag made of linen or fine canvas, and put it in a kettle with the aforesaid soap and water. Let this boil for half an hour, moving it around regularly so it does not burn, then take it from the fire, wash it in salt water, and after that in sour water. Take also to every pound of silk a pound or more of rock alum dissolved in cold water, and be sure there is enough water; **wherein you will put your silk without any bag, and let it lay therein without fire for eight hours.** Then take it out, wash it in fresh water, then in salt water, and then again in fresh water, and do not let it dry but put it all wet into a kettle with the carmine well pestled and sieved, that is, three ounces for each pound of silk… And when it starts boiling then put in the silk prepared as above, and let it boil for a quarter of an hour. At last you will take it from the fire, and let it dry in the shade, and you will have a very excellent dyeing.

***De' secreti del reverendo signore Alessio Piemontese* (1558)**
as translated from the Dutch in Jo Kirby et al, *Natural Colorants*, 37–38.

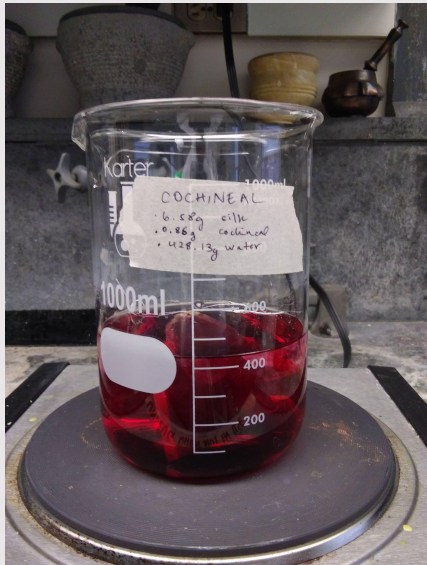
Recipe Example: To Dye Silk Carmine

To dye silk carmine. First, you will rasp or scratch hard soap very finely, and let them [the soap shavings] dissolve in plain water; after that put your silk in a small bag made of linen or fine canvas, and put it in a kettle with the aforesaid soap and water. Let this boil for half an hour, moving it around regularly so it does not burn, then take it from the fire, wash it in salt water, and after that in sour water. Take also to every pound of silk a pound or more of rock alum dissolved in cold water, and be sure there is enough water; wherein you will put your silk without any bag, and let it lay therein without fire for eight hours. **Then take it out, wash it in fresh water, then in salt water, and then again in fresh water,** and do not let it dry but put it all wet into a kettle with the carmine well pestled and sieved, that is, three ounces for each pound of silk… And when it starts boiling then put in the silk prepared as above, and let it boil for a quarter of an hour. At last you will take it from the fire, and let it dry in the shade, and you will have a very excellent dyeing.

***De' secreti del reverendo signore Alessio Piemontese* (1558)**
as translated from the Dutch in Jo Kirby et al, *Natural Colorants*, 37–38.

Recipe Example: To Dye Silk Carmine

To dye silk carmine. First, you will rasp or scratch hard soap very finely, and let them [the soap shavings] dissolve in plain water; after that put your silk in a small bag made of linen or fine canvas, and put it in a kettle with the aforesaid soap and water. Let this boil for half an hour, moving it around regularly so it does not burn, then take it from the fire, wash it in salt water, and after that in sour water. Take also to every pound of silk a pound or more of rock alum dissolved in cold water, and be sure there is enough water; wherein you will put your silk without any bag, and let it lay therein without fire for eight hours. Then take it out, wash it in fresh water, then in salt water, and then again in fresh water, **and do not let it dry but put it all wet into a kettle with the carmine well pestled and sieved, that is, three ounces for each pound of silk**… And when it starts boiling then put in the silk prepared as above, and let it boil for a quarter of an hour. At last you will take it from the fire, and let it dry in the shade, and you will have a very excellent dyeing.



***De' secreti del reverendo signore Alessio Piemontese* (1558)**
as translated from the Dutch in Jo Kirby et al, *Natural Colorants*, 37–38.

Recipe Example: To Dye Silk Carmine

To dye silk carmine. First, you will rasp or scratch hard soap very finely, and let them [the soap shavings] dissolve in plain water; after that put your silk in a small bag made of linen or fine canvas, and put it in a kettle with the aforesaid soap and water. Let this boil for half an hour, moving it around regularly so it does not burn, then take it from the fire, wash it in salt water, and after that in sour water. Take also to every pound of silk a pound or more of rock alum dissolved in cold water, and be sure there is enough water; wherein you will put your silk without any bag, and let it lay therein without fire for eight hours. Then take it out, wash it in fresh water, then in salt water, and then again in fresh water, and do not let it dry but put it all wet into a kettle with the carmine well pestled and sieved, that is, three ounces for each pound of silk… **And when it starts boiling then put in the silk prepared as above, and let it boil for a quarter of an hour.** At last you will take it from the fire, and let it dry in the shade, and you will have a very excellent dyeing.

***De' secreti del reverendo signore Alessio Piemontese* (1558)**
as translated from the Dutch in Jo Kirby et al, *Natural Colorants*, 37–38.

Recipe Example: To Dye Silk Carmine

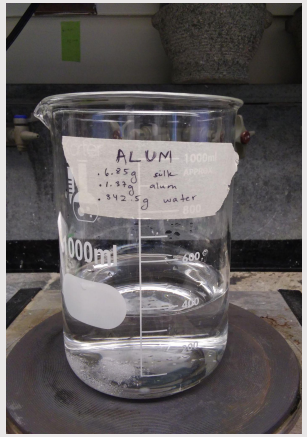
To dye silk carmine. First, you will rasp or scratch hard soap very finely, and let them [the soap shavings] dissolve in plain water; after that put your silk in a small bag made of linen or fine canvas, and put it in a kettle with the aforesaid soap and water. Let this boil for half an hour, moving it around regularly so it does not burn, then take it from the fire, wash it in salt water, and after that in sour water. Take also to every pound of silk a pound or more of rock alum dissolved in cold water, and be sure there is enough water; wherein you will put your silk without any bag, and let it lay therein without fire for eight hours. Then take it out, wash it in fresh water, then in salt water, and then again in fresh water, and do not let it dry but put it all wet into a kettle with the carmine well pestled and sieved, that is, three ounces for each pound of silk… And when it starts boiling then put in the silk prepared as above, and let it boil for a quarter of an hour. **At last you will take it from the fire, and let it dry in the shade, and you will have a very excellent dyeing.**

***De' secreti del reverendo signore Alessio Piemontese* (1558)**
as translated from the Dutch in Jo Kirby et al, *Natural Colorants*, 37–38.

Dyeing with Natural Colorants

Prepare mordant bath

Such as alum



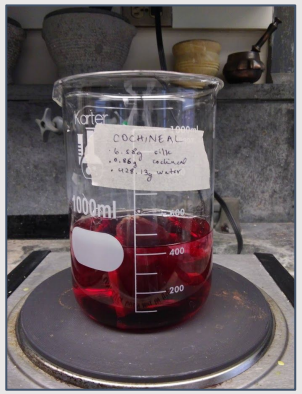
Dissolve in water

Add textile

Wash textile

Prepare dye bath

Crush cochineal



Extract in water

Add textile

Wash textile

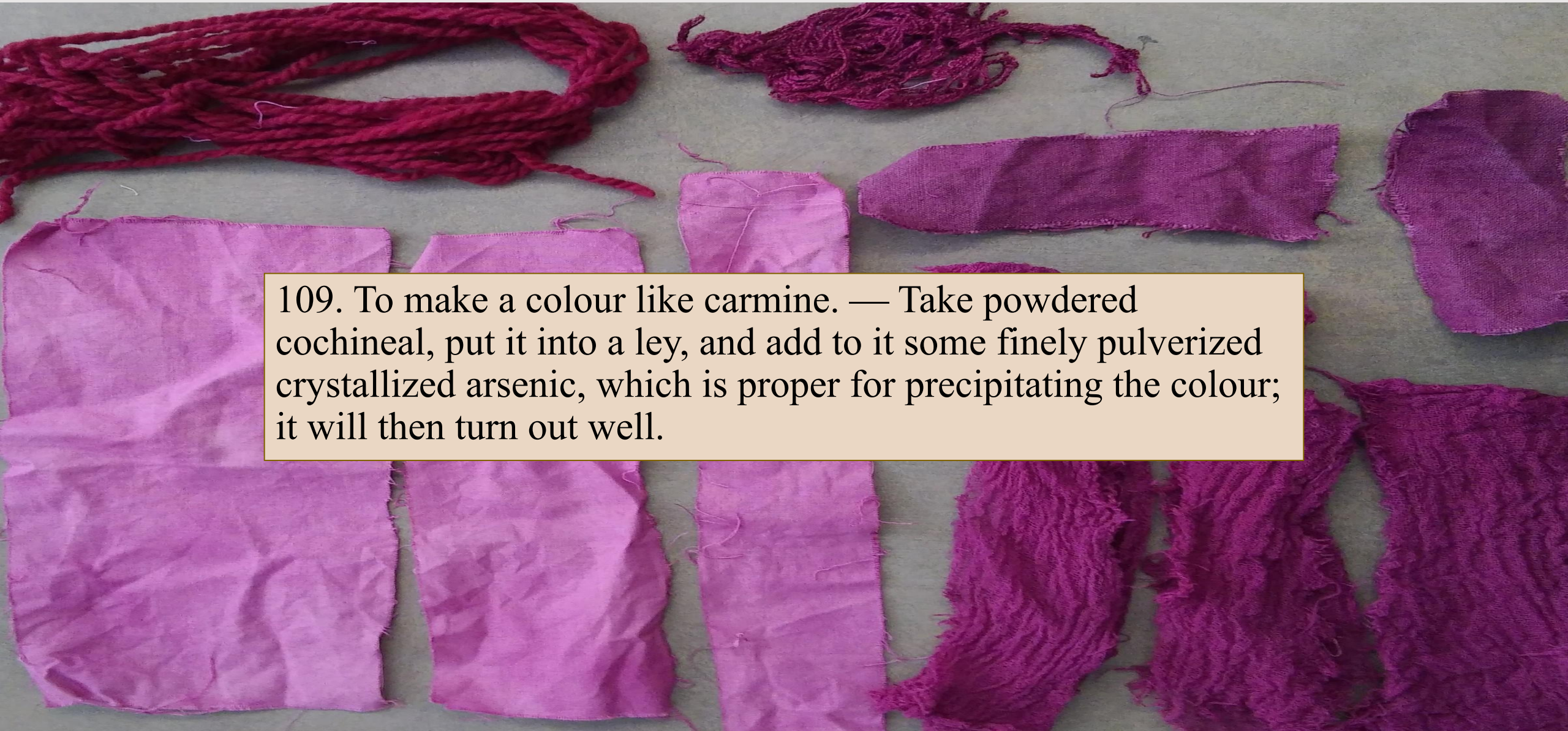
Neueroffneter curioser Schatz-Kasten (Anon. 1706: 556, translated)

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)

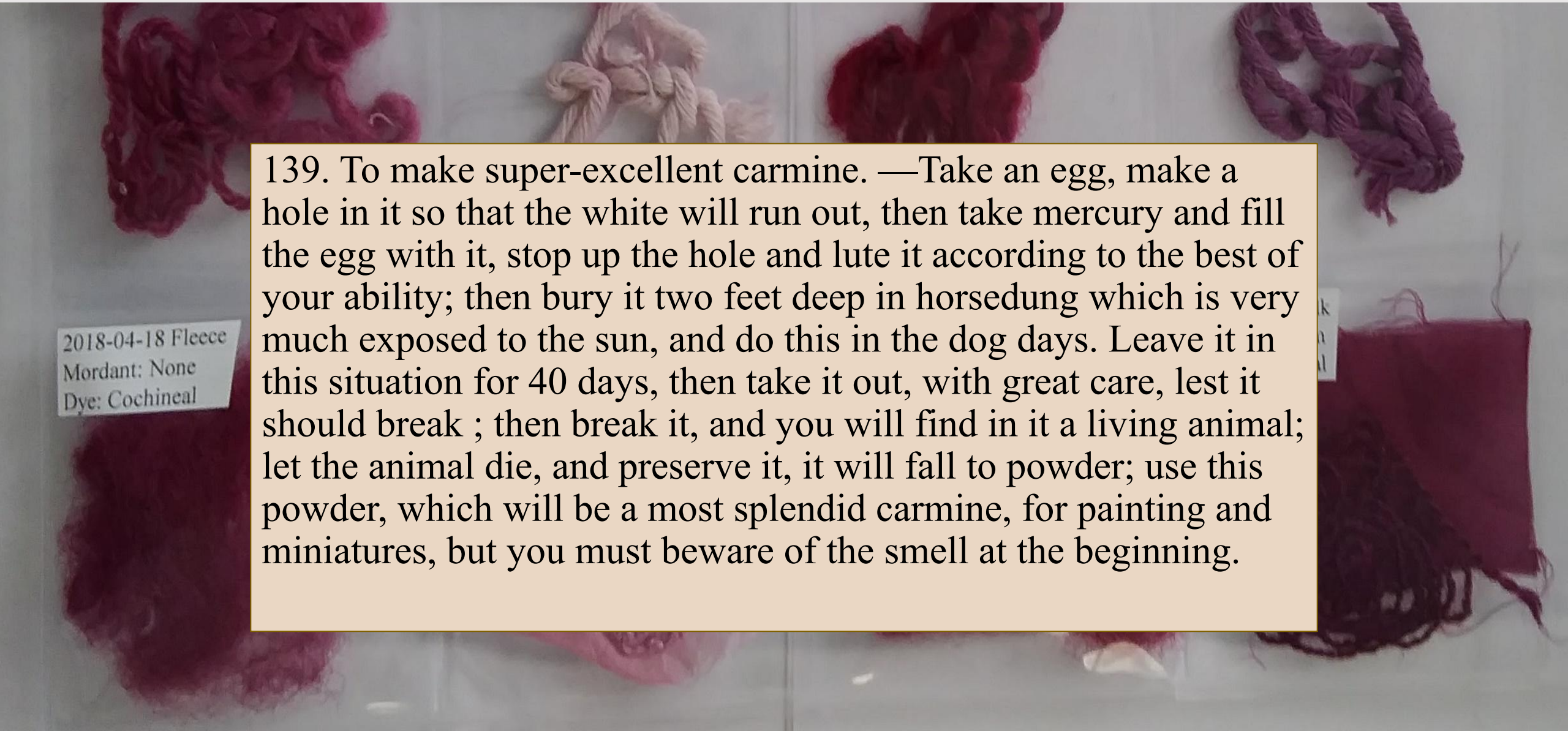
Original Treatises, Dating from the XIIth to XVIIIth Centuries, on the Arts of Painting in Oil, Miniature, Mosaic, and on Glass of Gilding, Dyeing, and the Preparation of Colours and Artificial Gems by Mary P. Merrifield (1804)



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)



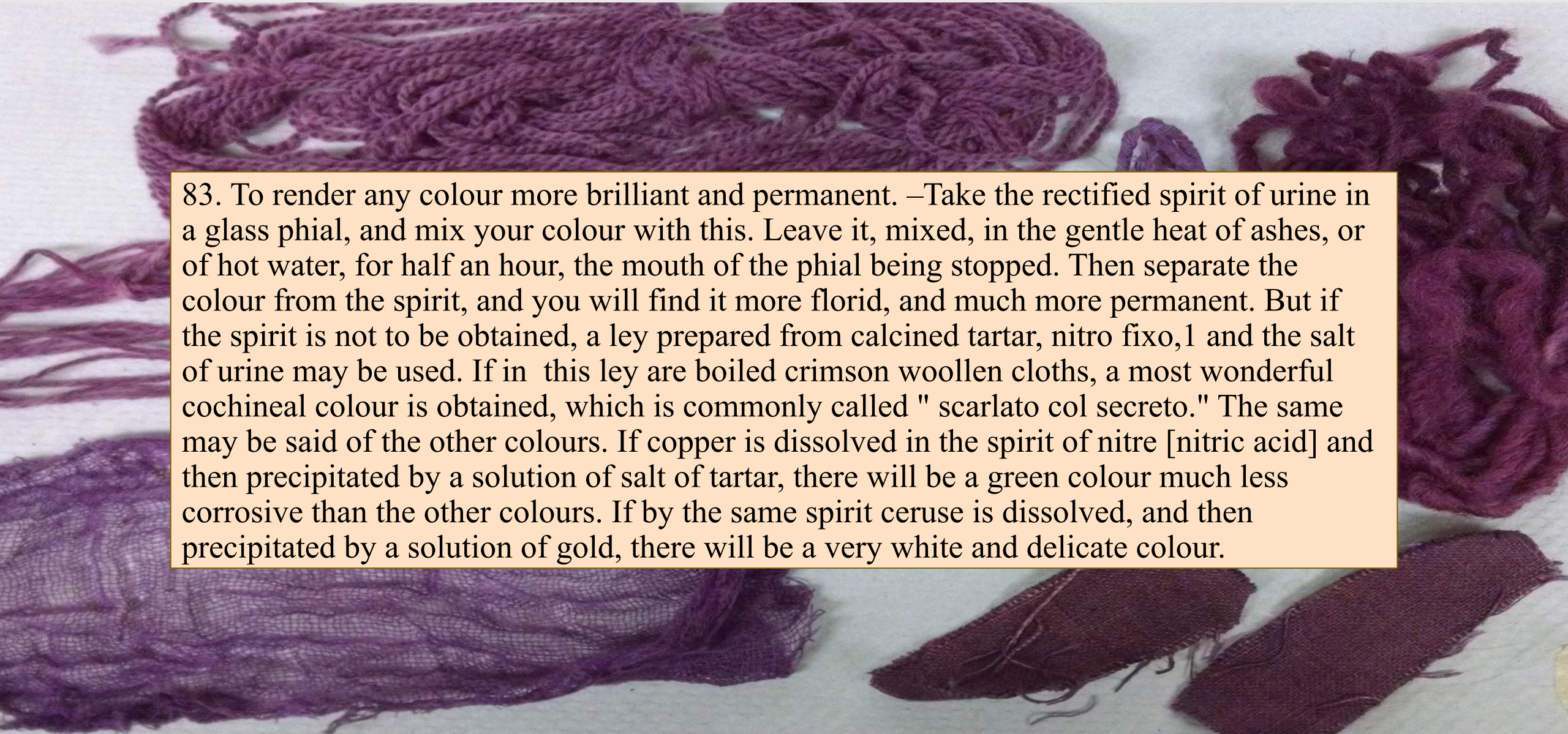
139. To make super-excellent carmine. —Take an egg, make a hole in it so that the white will run out, then take mercury and fill the egg with it, stop up the hole and lute it according to the best of your ability; then bury it two feet deep in horsedung which is very much exposed to the sun, and do this 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)

Paduan Manuscript (pg. 682-684)

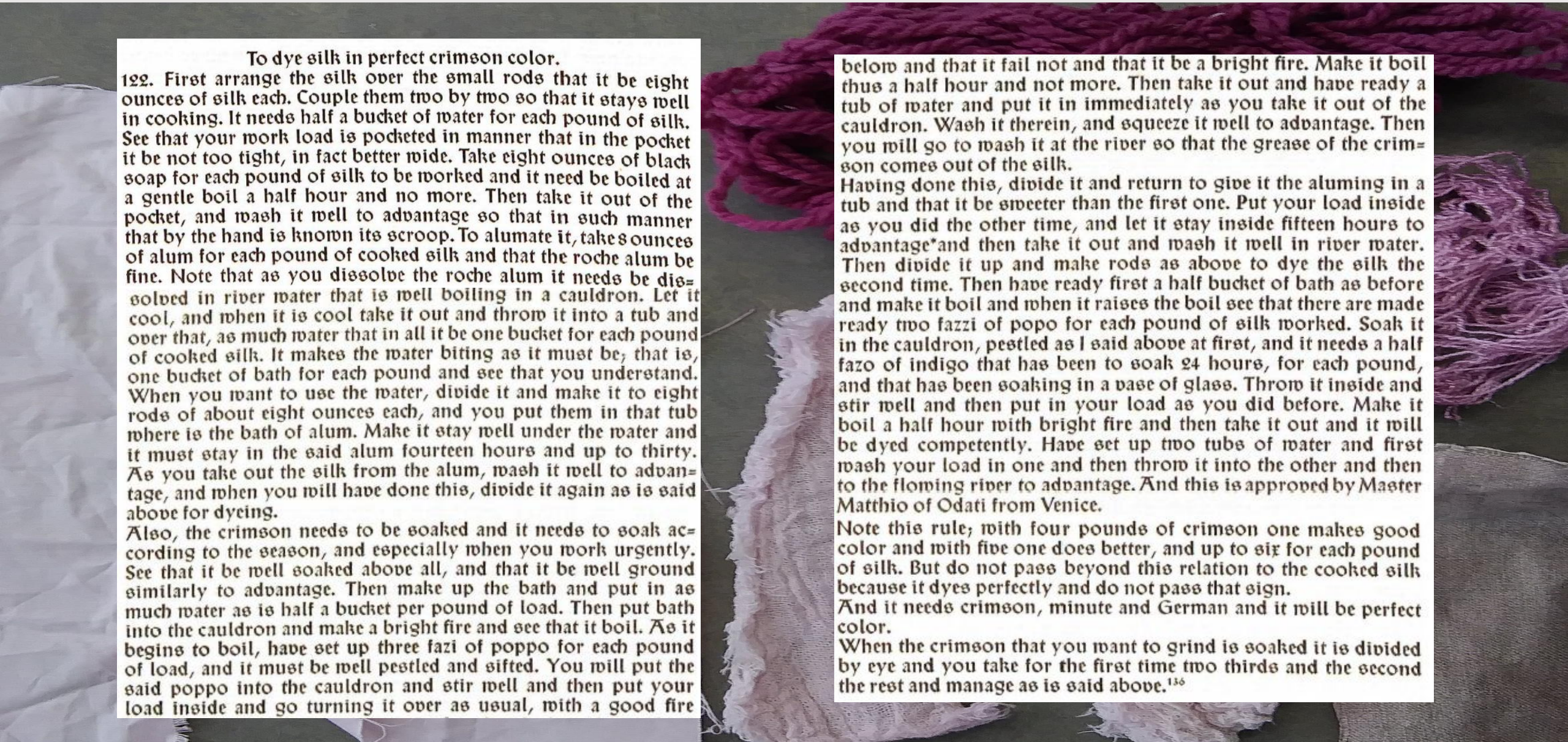
Original Treatises, Dating from the XIIth to XVIIIth Centuries, on the Arts of Painting in Oil, Miniature, Mosaic, and on Glass of Gilding, Dyeing, and the Preparation of Colours and Artificial Gems by Mary P. Merrifield (1804)



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]

Dyeing at home

Dyestuffs in your kitchen

Onion Skins

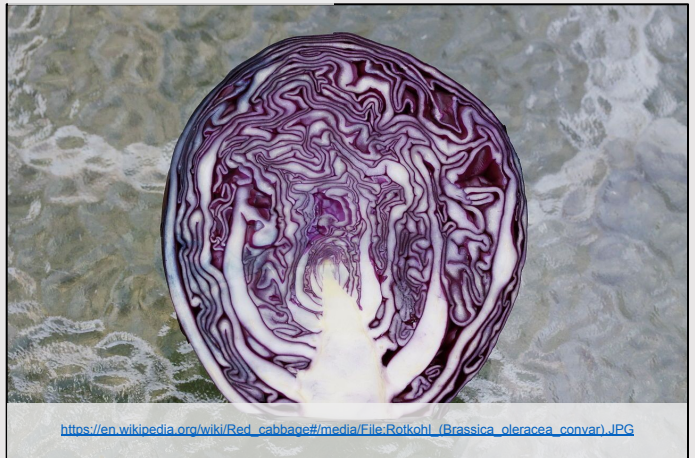
(Credit: Annika Cunningham, M&K high school intern)

https://cu-mkp.github.io/sandbox/docs/su22_fld_cunningham_annika_onion-skin-dyeing.html

Annatto (achiote)

Turmeric

Red cabbage



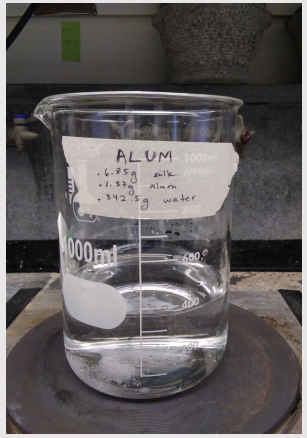
https://en.wikipedia.org/wiki/Red_cabbage#/media/File:Rotkohl_(Brassica_oleracea_convar).JPG

Get creative!

Dyeing with Natural Colorants

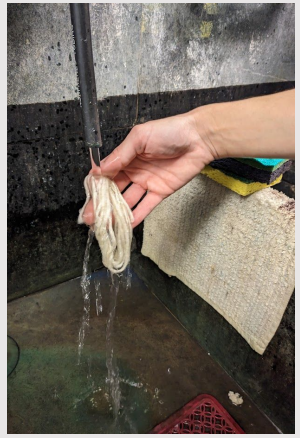
Prepare mordant bath

Such as alum



Dissolve in water

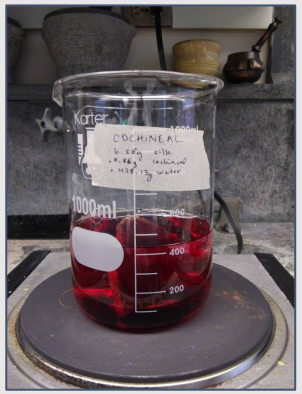
Add textile



Wash textile

Prepare dye bath

Crush cochineal

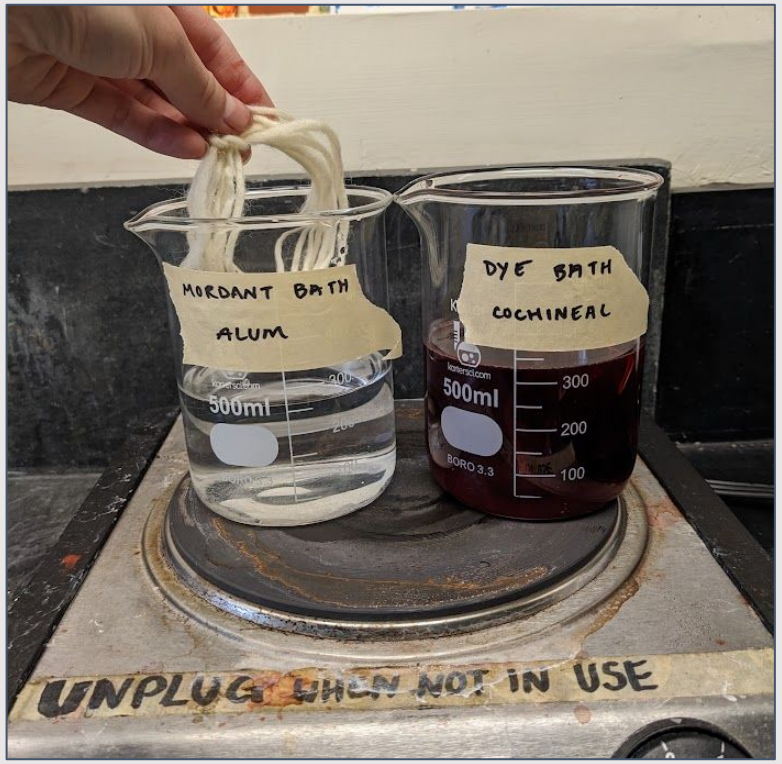


Extract in water

Add textile

Wash textile

Practical tip



Mordant the textile while you extract the dye.

Dissolve mordant and add the textile in one bath and, at the same time, add crushed cochineal to water and extract over heat.

Alternative methods to beakers and hotplates: pots

Alternative methods to beakers and hotplates: “bain marie”

Glass jars with your mordant baths and dye baths, sitting inside pots of water

This method uses a water bath or bain-marie
(see this cooking blog for more information about bain-maries:
https://www.thekitchn.com/technique-how-to-make-and-use-70190)

Process

- On your stove at home, prepare your mordant and dye baths in mason jars (or other glass jars that can withstand prolonged heating such as pickling or jam jars).
- Place the jars in a large cooking pot (the pot's material doesn't matter – can use steel, ceramic, etc)
- BE CAREFUL ABOUT USING THESE POTS TO PREPARE FOODS AFTER YOU HAVE DYED WITH THEM IF YOU ARE WORKING WITH MATERIALS THAT ARE NOT FOOD SAFE
- Fill the pot with enough water to come up past the solutions in your mason jars, being careful not to contaminate the baths inside your jars
- Heat the pot on your stove and follow the procedure for mordanting or dyeing the textiles

Advantages and Notes

- This is one way to dye at home without beakers or other shock-resistant containers
    - Beakers, Pyrex, and other borosilicate glass is specially formulated to withstand direct high heat (like when placed directly on a hot plate) as well as shocks or sudden changes in temperature (like placing a hot glass vessel with your bath onto a cold surface like a counter)
    - Regular glass, including mason jars, are not formulated in this way, and so it can be very dangerous (and messy) if used in the same way as beakers – direct high heat or sudden change can cause the glass to shatter
- This method also allows for easier dyeing without a thermometer
    - The temperature of your baths is determined by the temperature of the water in the pot
    - You will know the baths have approximately reached the desired temperature range of 70-90 ° C when the water in the pot is beginning to gather bubbles just before simmering
    - Because water boils and begins to evaporate at 100 °C, your baths will never exceed 100 °C, the temperature where your baths and textiles can begin to degrade. This is an easy way to prepare baths without a thermometer and ensure you are not reaching high temperature levels
    - If the water in the pot begins to boil or simmer violently, your jars will start to shake and move around the pot. If this happens, it is a sign to turn your heat down

Reference books with recipes

- Kirby, Jo, Maartin van Bommel, André Verhecken, and Marika Spring. *Natural Colorants for Dyeing and Lake Pigments: Practical Recipes and Their Historical Sources*. London: Archetype Publications, 2014.
- Dean, Jenny. *Wild Color the Complete Guide to Making and Using Natural Dyes*. Watson-Guptill, 2010.
- Vejar, Kristine, and Sara Remington. *The Modern Natural Dyer: a Comprehensive Guide to Dyeing Silk, Wool, Linen, and Cotton at Home*. Stewart, Tabori & Chang, an Imprint of Abrams, 2015.

Material sourcing (general)

- **Kremer Pigments**
  - http://shop.kremerpigments.com/en/
  - Order online or visit the New York storefront
- **Natural Pigments**
  - https://www.naturalpigments.com/
  - Order online
- **Maiwa**
  - https://maiwa.com/
  - Order online or visit retail locations in Vancouver, Canada
- **Dick BLICK Art Materials**
  - https://www.dickblick.com
  - Order online or visit numerous locations in USA
- **Michaels Art and Craft Supplies**
  - https://www.michaels.com
  - Order online or visit numerous locations in USA
- **TALAS Bookbinding, Archival & Conservation Supplies**
  - http://www.talasonline.com/
  - Primarily a mail order business, but storefront located: 330 Morgan Ave, Brooklyn, NY 11211
- **Test Fabrics**
  - http://testfabrics.com/index.php
  - Order online
- **Vendors for chemicals from Amazon.com**
  - Loudwolf, https://www.loudwolf.com/
  - Alpha Chemicals, https://alphachemicals.com/
- **Knitty City specialty yarn and craft store**
  - http://www.knittycitynyc.com/
  - Stock sometimes includes undyed raw materials (and they are happy to order specialty yarns or wool on your behalf)
  - Storefront: 208 West 79th St, New York, NY 10024
- **Local textile-making or fiber arts communities**
- **Find dyestuffs in your garden, local park, or even the grocery store**
  - Please collect responsibly - respect our natural world!

SOME TEXTILES:		
Name	**Description and Link**	**Appearance**
Wool #1	100% wool, undyed from LB Collection® Pure Wool Yarn	Thick, roving/woolen (not tightly spun, fuzzy texture) yarn
Wool #2	100% wool, undyed from Catskills Merino Sheep, New York	Thin, worsted (tightly spun), slightly curly/crimped yarn
Wool #3	100% baby alpaca, undyed from Island Alpaca Company, Martha's Vineyard	Thin, worsted (tightly spun), straight and smooth yarn
A+W	A+W = "alpaca" + "wool" Knitty City - Cascade Yarns "Eco Highland Duo", Col. 2204, Lot. 7A8897, made in Peru, CAS-0805-2204 70% undyed baby alpaca, 30% undyed Merino wool	Thin, worsted (tightly spun), straight and smooth yarn
W+N	W+N = "wool" + "nylon" Knitty City - MountainTop by Classic Elite Yarns "Mohawk Wool", Color 3316, Lot 831, made in USA, CE-3316-3 undyed: 60% merino wool, 30% Romney wool, 10% nylon	Thin, roving/woolen (not tightly spun, fuzzy texture) yarn
Cotton	100% cotton, undyed twine (butcher's string)	Thick, worsted yarn
Cheesecloth	100% cotton, undyed	Loosely woven textile, mesh-like
Linen	100% linen Utrecht Unprimed Belgian Linen Canvas Type 185	Rectangular pieces, woven linen threads
Silk	Jaquard Silk Scarf, 100% chinese silk, hand rolled hems, ready to dye, Habotai 8mm x 15" x 60"	Rectangular pieces, woven linen threads
	Jaquard Silk Scarf Habotai	Close woven, very thin and light, white strips
	See also sister company "silkconnection" with same information	
	Silk yarn, 100% Tussah silk, 2 ply lace weight, Undyed and Natural (Lace Weight) Ready to Dye	Thread
Cascade Eco wool	Cascade yarns, ecological wool, 100% undyed peruvian highland wool (col. 8010, Lot 7C1211), purchased at Knitty City NYC	Chunky, worsted (tightly spun)
Fleece	Ashford Corriedale, 100% corriedale wool, color: 091 "natural white"; undeyed, probably unbleached, from Knitty City NYC	Unspun, fluffy white wool
TestFabrics	Conservation-quality fabrics from Test Fabrics	Various (silk taffeta, silk satin)

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**

References and Links

- Kirby, Jo, Maartin van Bommel, André Verhecken, and Marika Spring. *Natural Colorants for Dyeing and Lake Pigments: Practical Recipes and Their Historical Sources*. London: Archetype Publications, 2014.
- Phipps, Elena. *Cochineal Red: the Art History of a Color*. New York (N.Y.: The Metropolitan Museum of Art, 2010. Print.)
  - Full pdf available for free download here: https://www.metmuseum.org/art/metpublications/cochineal_red_the_art_history_of_a_color
- Achim, Miruna. "Cochineal." In *New World Objects of Knowledge: A Cabinet of Curiosities*, edited by Mark Thurner, Juan Pimentel, and University of London, 177–82. London: Institute of Latin American Studies, School of Advanced Study, University of London, 2021. https://doi.org/10.14296/2104.9781908857835.
- Merrifield, Mary P. *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; Preceded by a General Introd., with Translations, Prefaces, and Notes*. J. Murray, 1849.
- CAMEO: Conservation & Art Materials Encyclopedia Online: http://cameo.mfa.org/wiki/Main_Page
  - CAMEO is a searchable information resource developed by the Museum of Fine Arts, Boston. The MATERIALS database contains chemical, physical, visual, and analytical information on historic and contemporary materials used in the production and conservation of artistic, architectural, archaeological, and anthropological materials.
- http://shop.kremerpigments.com/en/
- https://maiwa.com/pages/natural-dyes
- Greenfield, Amy Butler. *A Perfect Red Empire, Espionage, and the Quest for the Color of Desire*. Harper Perennial, 2006.
- Padilla, Carmella. *Red like No Other - How Cochineal Colored the World*. Rizzoli International Publicat, 2015.
- Cardon, Dominique. *Natural Dyes: Sources, Tradition, Technology and Science*. Archetype, 2007.
- Gettens, Rutherford J., and George L. Stout. *Painting Materials: a Short Encyclopedia*. Dover Publications, 1966.
- Vejar, Kristine. *The Modern Natural Dyer a Comprehensive Guide to Dyeing Silk, Wool, Linen, and Cotton at Home*. Abrams, 2015.
- Short History of Cochineal Red: https://artechne.wp.hum.uu.nl/short-history-of-the-cochineal-red/
- 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

Dye sustainability resources

- Chávez-Moreno, C. K., et al. “The Opuntia (Cactaceae) and Dactylopius (Hemiptera: Dactylopiidae) in Mexico: a Historical Perspective of Use, Interaction and Distribution.” *Biodiversity and Conservation*, vol. 18, no. 13, 2009, pp. 3337–3355., doi:10.1007/s10531-009-9647-x.
- Baliarsingh, Sasmita, et al. “Exploring Sustainable Technique on Natural Dye Extraction from Native Plants for Textile: Identification of Colourants, Colourimetric Analysis of Dyed Yarns and Their Antimicrobial Evaluation.” *Journal of Cleaner Production*, vol. 37, 2012, pp. 257–264., doi:10.1016/j.jclepro.2012.07.022.
- Bechtold, T, et al. “Natural Dyes in Modern Textile Dyehouses — How to Combine Experiences of Two Centuries to Meet the Demands of the Future?” *Journal of Cleaner Production*, vol. 11, no. 5, 2003, pp. 499–509., doi:10.1016/s0959-6526(02)00077-x.
- Bechtold, Thomas. *Handbook of Natural Colorants*. Wiley, 2010.
    - 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
- FAO/WHO, Major colourants and dyestuffs mainly produced in horticultural systems, in Natural Colourants and Dyestuffs, Non-Wood Forest Products Series, Rome, 1995
- Kant, Rita. “Textile Dyeing Industry an Environmental Hazard.” *Natural Science*, vol. 04, no. 01, 2012, pp. 22–26., doi:10.4236/ns.2012.41004.
- Chequer, Farah Maria Drumond, et al. “Textile Dyes: Dyeing Process and Environmental Impact | IntechOpen.” *Intech Open*, IntechOpen, 16 Jan. 2013, www.intechopen.com/books/eco-friendly-textile-dyeing-and-finishing/textile-dyes-dyeing-process-and-environmental-impact.
- Mizener, Sarah M., and Catherine Amoroso Leslie. “This Is How We Do It: Understanding Financially Successful Apparel Companies' Adoption of Sustainable Initiatives over Time.”
- Samanta, Ashis Kumar. “Fundamentals of Natural Dyeing of Textiles: Pros and Cons.” *Current Trends in Fashion Technology & Textile Engineering*, vol. 2, no. 4, 2018, doi:10.19080/ctftte.2018.02.555593.
- “Textiles and Clothing Sustainability.” *Textile Science and Clothing Technology*, 2017, doi:10.1007/978-981-10-2146-6.
- Shahid, Mohammad, et al. “Recent Advancements in Natural Dye Applications: a Review.” *Journal of Cleaner Production*, vol. 53, 2013, pp. 310–331., doi:10.1016/j.jclepro.2013.03.031.
- Yusuf, Mohd, et al. “Natural Colorants: Historical, Processing and Sustainable Prospects.” *Natural Products and Bioprospecting*, vol. 7, no. 1, 2017, pp. 123–145., doi:10.1007/s13659-017-0119-9.

Popular articles

- Yardley, Jim. “Bangladesh Pollution, Told in Colors and Smells.” *The New York Times*, The New York Times, 15 July 2013, www.nytimes.com/2013/07/15/world/asia/bangladesh-pollution-told-in-colors-and-smells.html.
- “A Monstrous Mess: Toxic Water Pollution in China.” *Greenpeace International*, www.greenpeace.org/international/story/6846/a-monstrous-mess-toxic-water-pollution-in-china/.
- “These Truly Organic Bed Sheets Are Made With Cotton, Rainwater and Wind.” *Interesting Engineering*, 10 Mar. 2018, https://interestingengineering.com/organic-bed-sheets-cotton-rainwater-and-wind.
- “Wear The Change You Want To See In The World.” *Ayo*, https://madebyayo.shop/blogs/let-s-go-ayo/wear-the-change-you-want-to-see-in-the-world.
- “Dye Industry.” *:: WorstPolluted.org : Reports*, www.worstpolluted.org/projects_reports/display/105
- www.fibre2fashion.com. “Indian Dyes & Dye Intermediates Future, Indian Dyestuff Industry, Indian Dyes Sector Growth, Indian Dyestuffs.” *Fibre2Fashion*, www.fibre2fashion.com/industry-article/5118/the-future-of-indian-dyes-and-dye-intermediates?page=1.
- “Environmental Pollution Control in Textile Industry.” *Fashion2Apparel*, http://fashion2apparel.blogspot.com/2017/08/environmental-pollution-control-textile.html.
- “The Case for Natural Dyes.” *Avani E-Store*, https://avani-earthcraft.com/blogs/blog/the-case-for-natural-dyes.
- Todd, Elliot. “Reflections on the Journey of Fashion and Sustainability.” *Centre for Sustainable Fashion*, 22 May 2018, http://sustainable-fashion.com/blog/reflections-on-the-journey-of-fashion-and-sustainability/.
- “Gujarat's Troubling Environmental Record.” *USAPP*, 6 Dec. 2016, http://blogs.lse.ac.uk/southasia/2014/04/04/gujarats-troubling-environmental-record/.
- “V&A · Fashioned from Nature.” *Introduction to 20th-Century Fashion*, Victoria and Albert Museum, Cromwell Road, South Kensington, London SW7 2RL. Telephone +44 (0)20 7942 2000. Email Vanda@Vam.ac.uk, www.vam.ac.uk/exhibitions/fashioned-from-nature.
- Kimani, Natalie. “Dye Off: Natural vs. Synthetic.” *The Designers Studio*, 19 Nov. 2016, http://tdsblog.com/dye-off-natural-vs-synthetic/.