DYEING AND PAINTING WITH NATURE: THE CHEMISTRY OF COCHINEAL

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Genspace, New York

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WORKSHOP PLAN

DAY 1

Cochineal History

Talk (30min)

Cochineal Lake Pigment

Hands-on work (1hr)

- Get comfortable in the lab
- Prepare materials
- Make pigment

Talk (30min)

- Lake pigment chemistry

Hands-on work (30min)

- Filter and wash pigment

Pigments vs. Dyes

Talk (30min) + *hands-on work*

- Difference between pigments and dyes
- *Preparation for dyeing*

DAY 2

Cochineal Dyeing

Hands-on work (1hr 30min)

- Dye textiles
- *Remove pigments from filters*

Talk (30min)

- Dye chemistry

Paints and Binding Media

Hands-on work + talk (1hr)

- Paint vs. pigment
- Role and types of binding media
- Paint out pigments
- Make tube of paint!

Cochineal: Color, Material, History

Red and Purple (and Pink)

Since antiquity and across cultures, the colors red and purple and pink have symbolized:

- Wealth
- Power
- Royalty
- Strength
- Force
- Life
- Blood

Red and Purple (and Pink)

The significance that these colors have taken on is directly tied to the ways humans obtain these colors from nature, notably in the coloring and dyeing of textiles.

The rarity, expense, and difficulty of production give importance to these colors.

PLINY THE ELDER, *NATURAL HISTORY*
1st century AD

CHAPTER 9.65

THE AMETHYST, THE TYRIAN, THE HYSGINIAN, AND THE CRIMSON TINTS.

But no sooner have we finished with one branch of this subject than we have to begin upon another, for we find that it is made quite a matter of sport to create expense; and not only this, but the sport must be doubled by making new mixtures and combinations, and falsifying over again what was a falsification of the works of Nature already; such, for instance, as staining tortoise-shell, alloying gold with silver for the purpose of making electrum, and then adding copper to the mixture to make Corinthian metal.

It was not sufficient to have borrowed from a precious stone the name of "amethyst" for a dye, but when we have obtained this colour we must drench it over again with Tyrian tints, so that we may have an upstart name compounded of both, and at the same moment a two-fold display of luxury; for as soon as ever people have succeeded in obtaining the conchyliated colour, they immediately begin to think that it will do better as a state of transition to the Tyrian hues.

PLINY THE ELDER, *NATURAL HISTORY*

CHAP. 60

THE NATURE OF THE MUREX AND THE PURPLE.

It is for this colour that the fasces and the axes of Rome make way in the crowd; it is this that assens the majesty of childhood; it is this that distinguishes the senator from the man of equestrian rank; by persons arrayed in this colour are prayers addressed to propitiate the gods; on every garment it sheds a lustre, and in the triumphal vestment it is to be seen mingled with gold.

PLINY THE ELDER, *NATURAL HISTORY*

CHAP.12

THE KERMES BERRY.

The helm oak, however, by its scarlet berry alone challenges competition with all these manifold productions. This grain appears at first sight to be a roughness on the surface of the tree, as it were, a small kind of the aquifolia variety of holm oak, known as the cusculium. To the poor in Spain it furnishes the means of paying one half of their tribute. We have already, when speaking of the purple of the murex, mentioned the best methods adopted for using it. It is produced also in Galatia, Africa, Pisidia, and Cilicia: the most inferior kind is that of Sardinia.

CHAP. 3.

EMPLOYMENT OF PLANTS FOR DYEING. EXPLANATION OF THE TERMS SAGMEN, VERBENA, AND CLARIGATIO.

We know, too, that from plants are extracted admirable colours for dyeing; and, not to mention the berries of Galatia, Africa, and Lusitania, which furnish the coccus, a dye reserved for the military costume of our generals, the people of Gaul beyond the Alps produce the Tyrian colours, the conchyliated, and all the other hues, by the agency of plants alone.

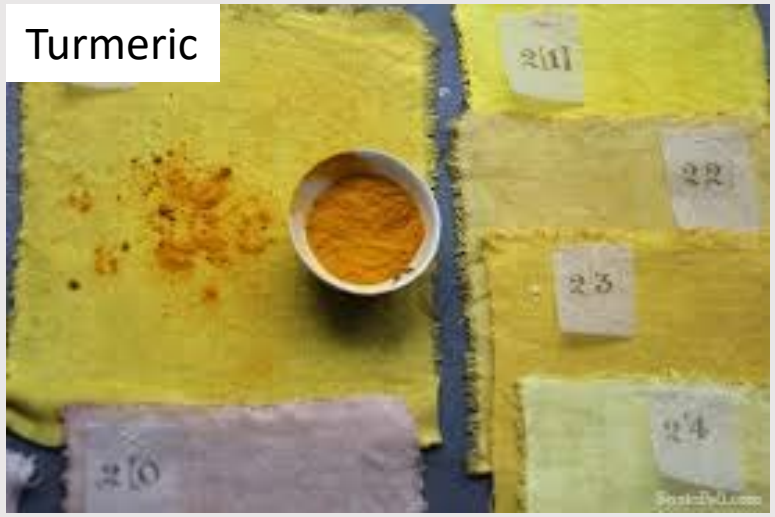
Natural colorants: dyes

Indigo

Cochineal

Weld

Turmeric

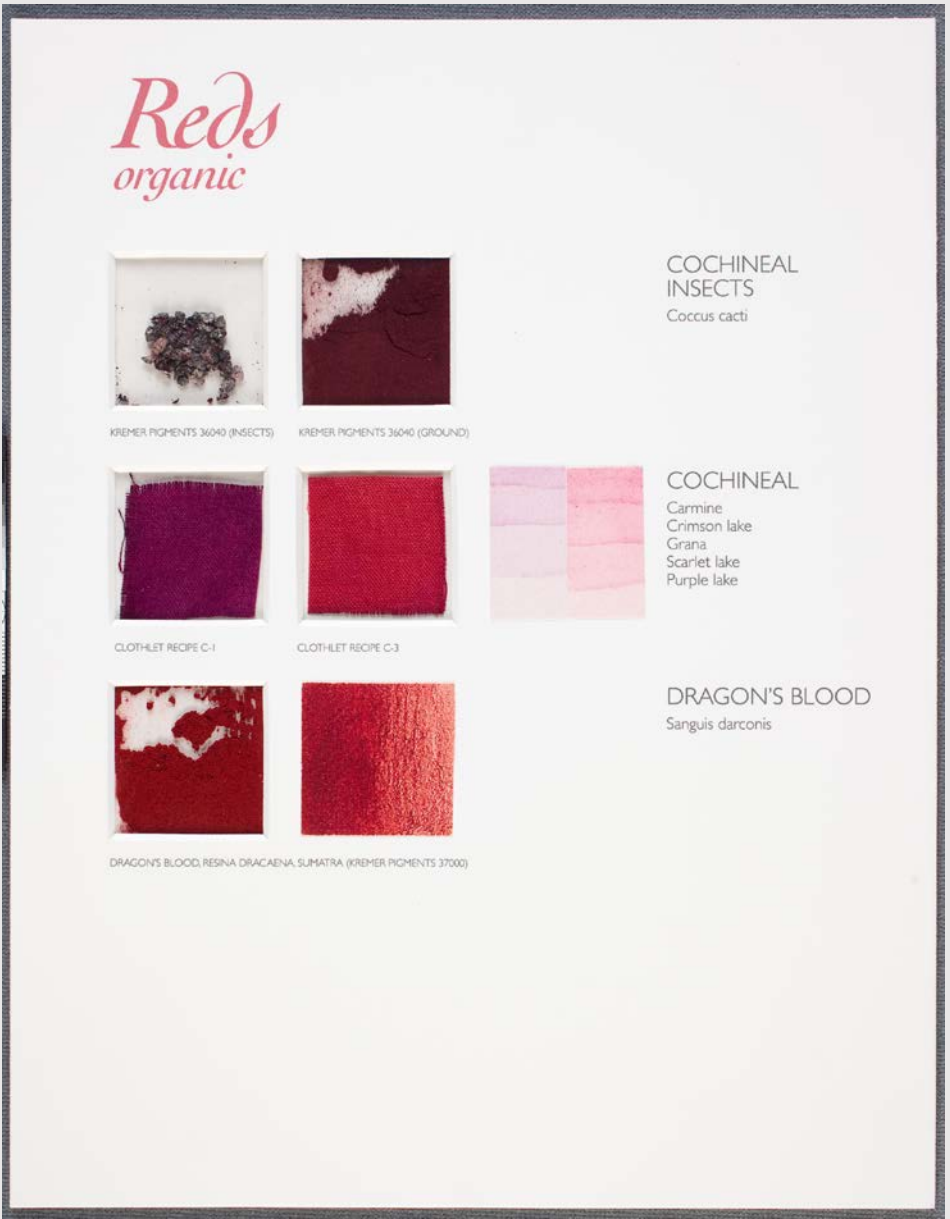


Madder

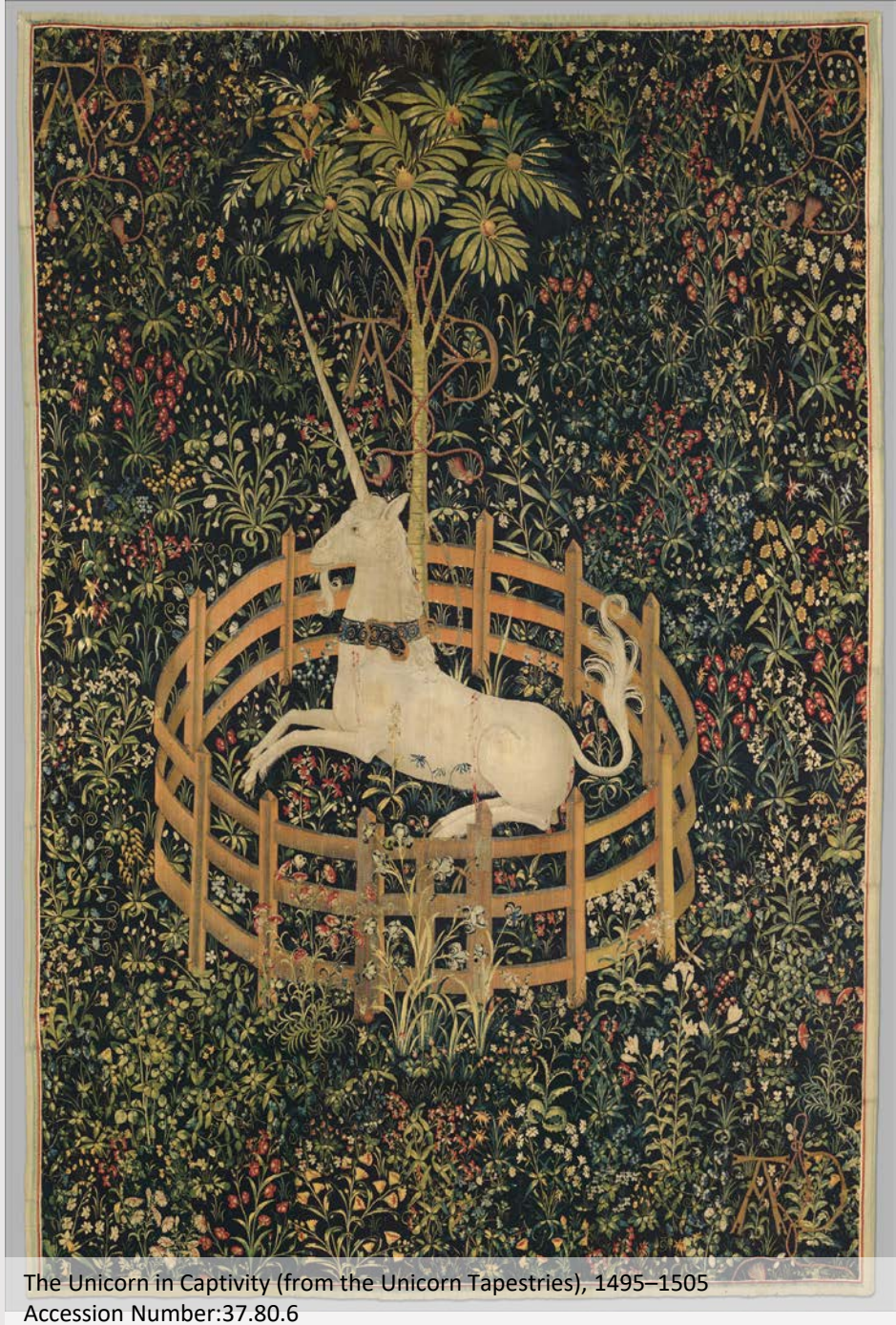
Logwood

https://travelingscriptorium.library.yale.edu/inks-and-pigments/

Natural colorants: pigments



Book of Hours, ca. 1530–35
Accession Number:2015.706
https://www.metmuseum.org/art/collection/search/684184



The Unicorn in Captivity (from the Unicorn Tapestries), 1495–1505
Accession Number:37.80.6
https://www.metmuseum.org/art/collection/search/467642

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.

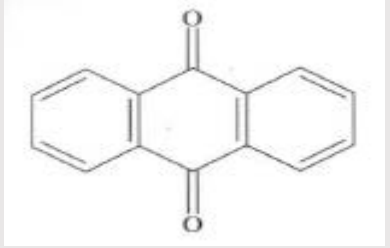
Leaves are used to obtain orange-red to brown colors.

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.)

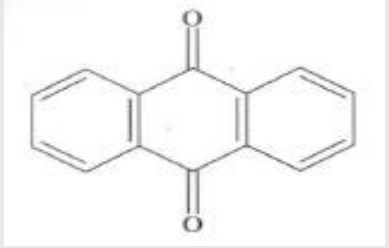
Secretes a protective coating that encloses itself in a sticky brown mass similar to resin, known as sticklac. When purified, this is known as shellac which was less economically important than the dye unlike today.

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

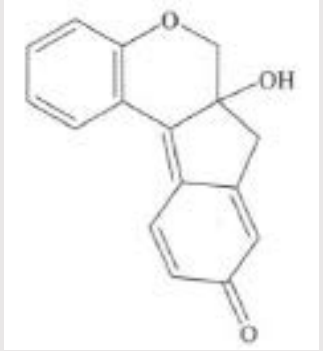
Egyptian (5th-8th century), linen and wool

http://collections.vam.ac.uk/item/O146101/jacket-unknown/

Iranian (ca. 1800-1870), cotton and silk

Redwoods

(sappanwood, brazilwood)



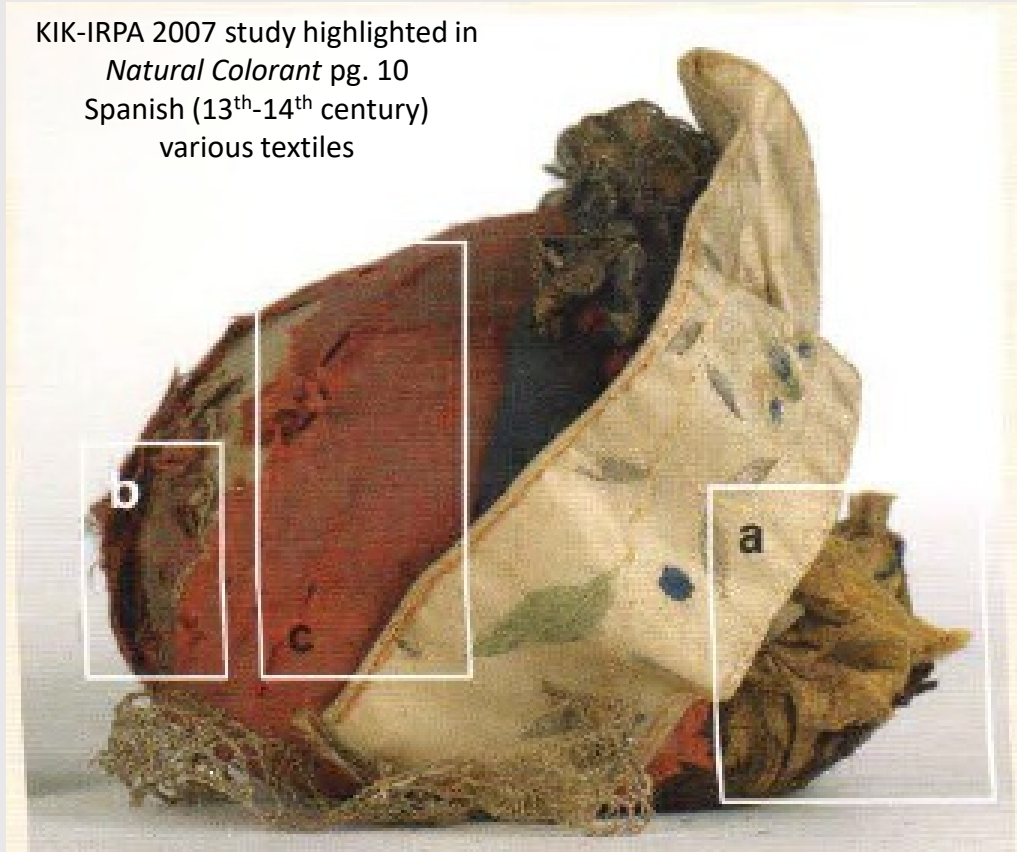
Chemical class: Brazilin, colorless until oxidized by air becoming orange-red braziliein (homoisoflavonoid)

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

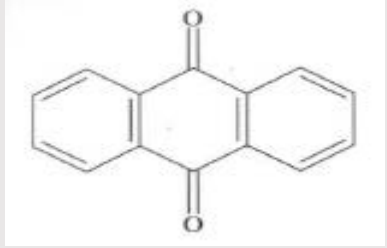


Logwood

Sappanwood

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

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

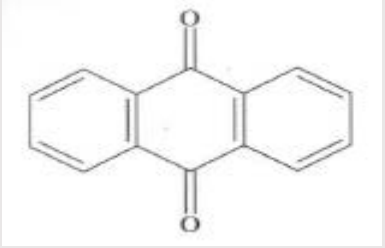
http://collections.vam.ac.uk/item/O264602/woven-silk-unknown/
Spanish (ca. 15th century), silk damask

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

Cochineal

Pass around cochineal and explore them:
What do they look like?
How do they smell?
Crush them in mortar & pestle:
How easily do they break down?
What color?
What texture?

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.

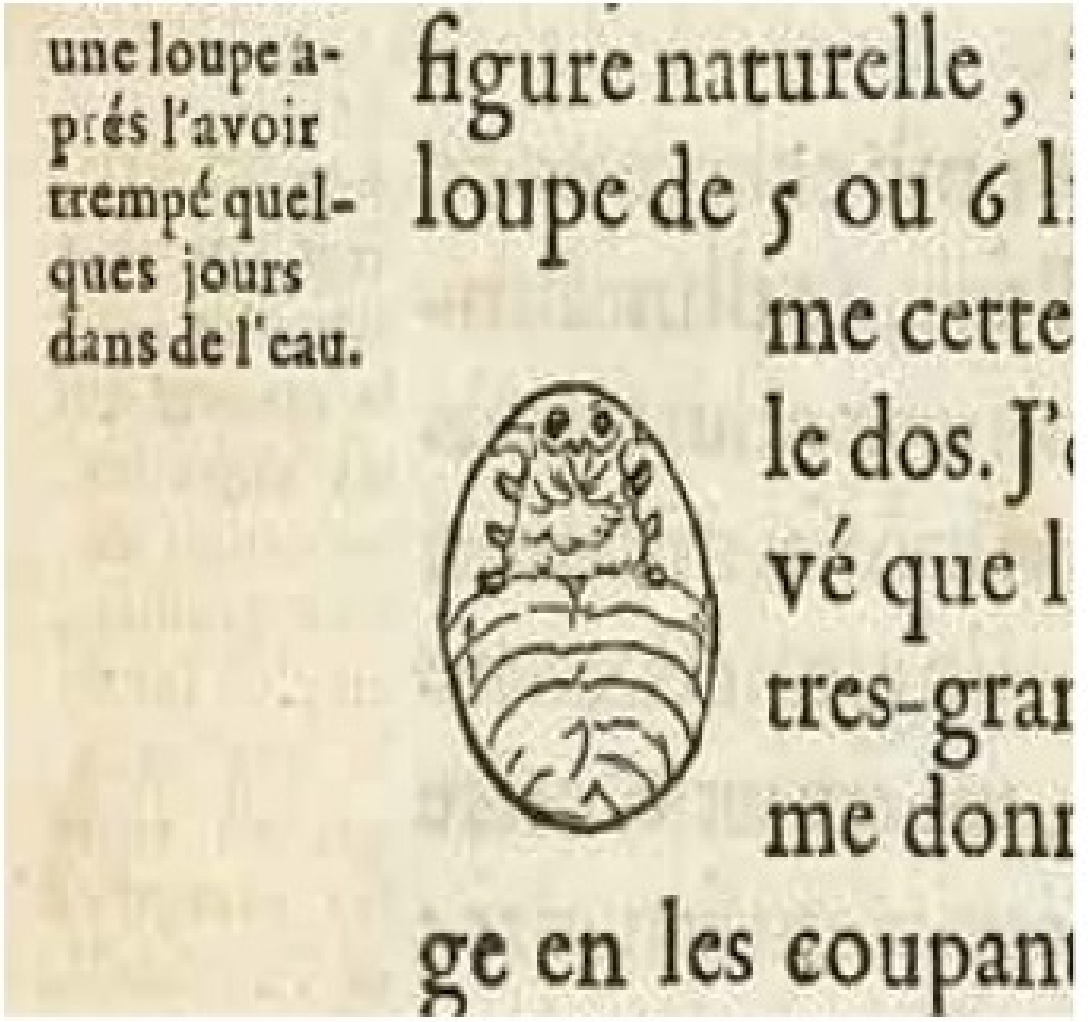
When Europeans did get hold of true Mexican cochineal, any attempts to bring them back to Europe failed, as the insects could not survive in the change of environment, often dyeing on the way back to Europe or perishing in Europe without access to nopal cacti.

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.


une loupe a-
prés l'avoir
trempé quel-
ques jours
dans de l'eau.
figure naturelle ,
loupe de 5 ou 6 l
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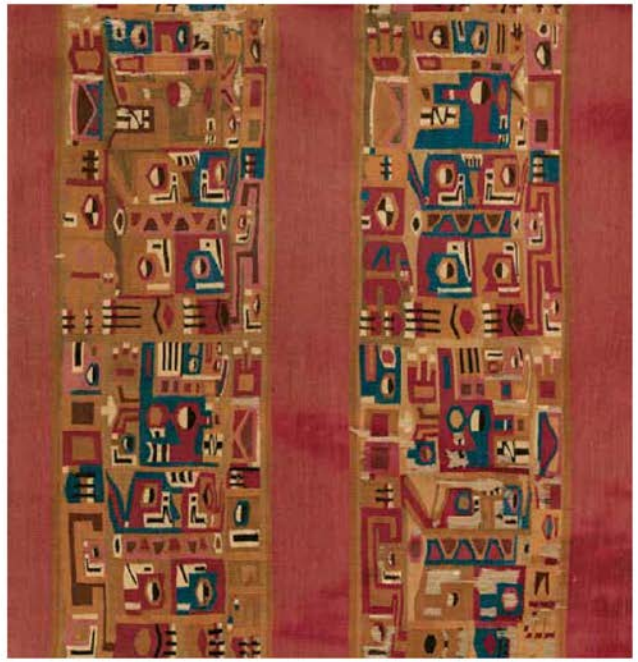
Nicolaas Hartsoeker’s representation and description of cochineal under a microscope. *Essay de Dioptrique* (Paris, 1694), sect. I, p. 52

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)



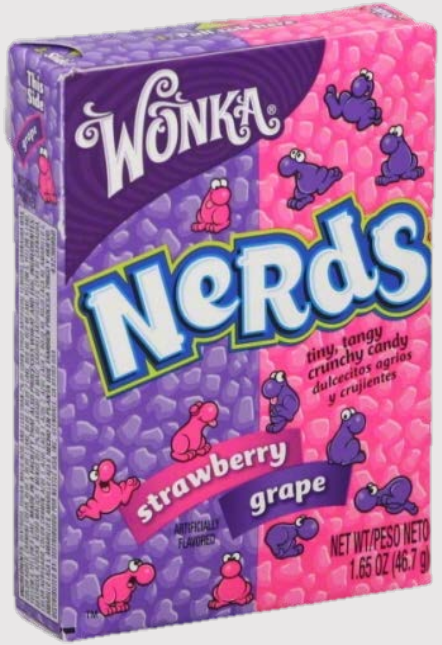
34. Tunic fragment (detail). Peru, Wari, 7th–9th century. Tapestry-weave cotton and cochineal-dyed camelid hair, 22½ x 80 in. (57.2 x 203.2 cm). The Metropolitan Museum of Art, Gift of George D. Pratt, 1930 (30.16.1)

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



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 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.

Cochineal

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

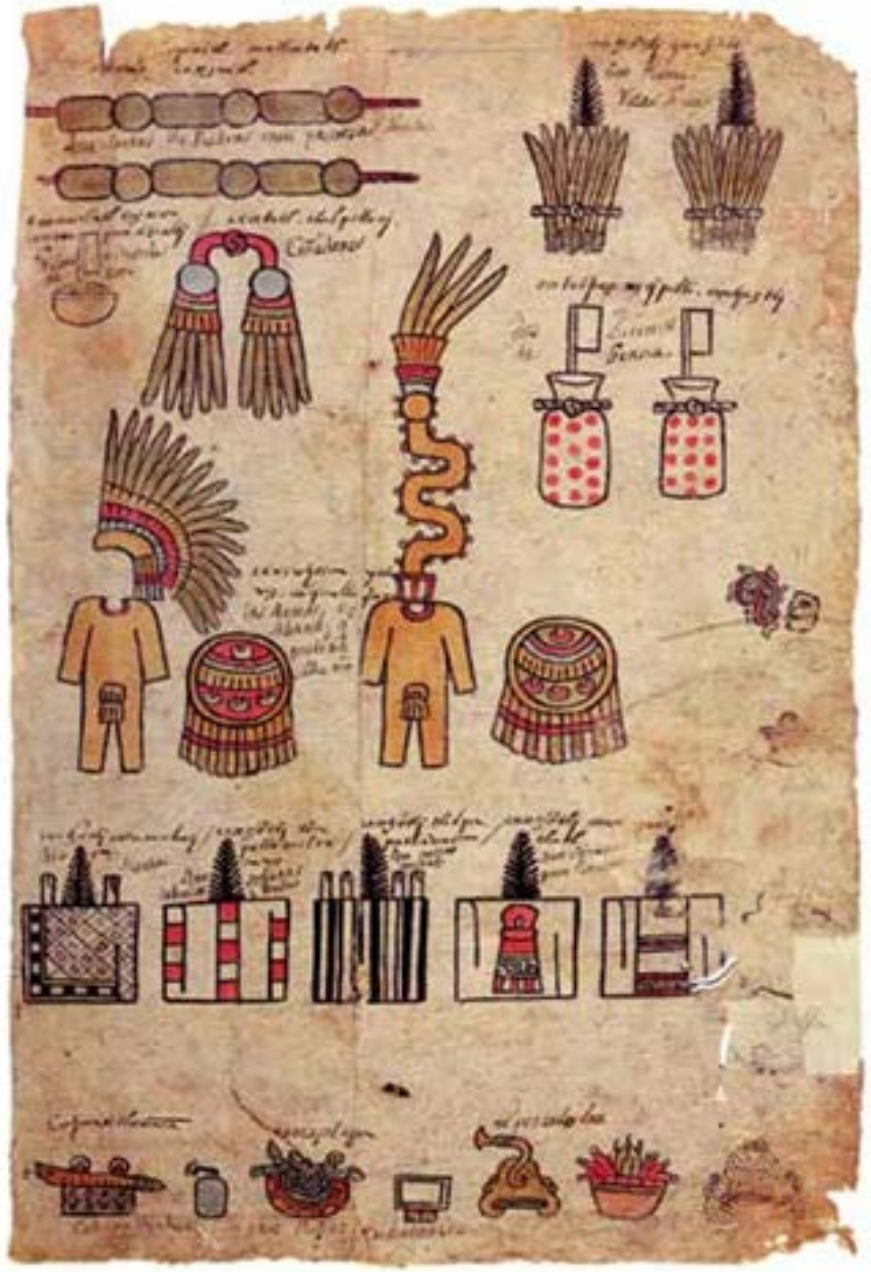
20. Samples of silk cloth dyed with cochineal, showing the many different hues that can be achieved by adding mordants and other modifiers to the dyebath

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

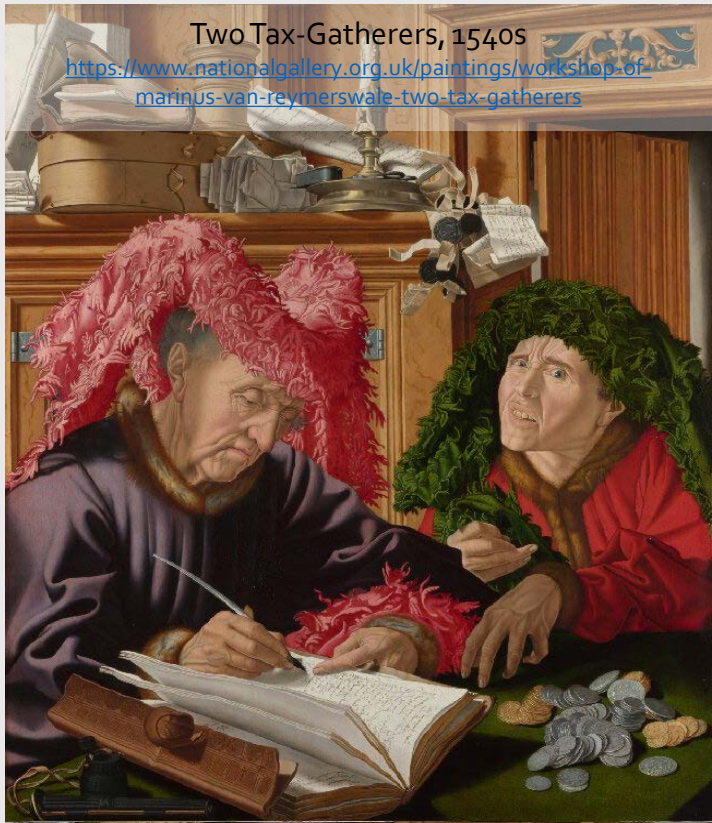
Cochineal

The Virgin and Child with a Pomegranate, ~1480-1500
https://www.nationalgallery.org.uk/paintings/workshop-of-sandro-botticelli-the-virgin-and-child-with-a-pomegranate



Matricula de tributos, early 16th-century, Mexico codex
Biblioteca Nacional de Antropologia y Historia (Codex 35-52)

Shoes, 1888, Vincent van Gogh
https://www.metmuseum.org/art/collection/search/436533



Two Tax-Gatherers, 1540s
https://www.nationalgallery.org.uk/paintings/workshop-of-marinus-van-reymerswale-two-tax-gatherers