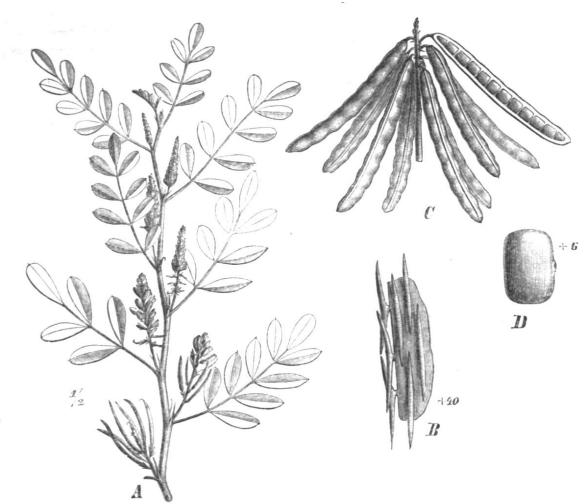
# Indigofera tinctoria

Chesley Ekelem
Deborah Montes
Alex Weickhardt

# True indigo, *Indigofera tinctoria*

- *I. tinctoria* is a dicot and member of the family Fabaceae (USDA)
- *Indigofera* genus is very large with ~700 spp (Takawira-Nyenya and Cardon, 2005).
- Annual to perennial shrub, grows to ~2 m in height (Takawira-Nyenya and Cardon, 2005).

(Takawira-Nyenya and Cardon, 2005)



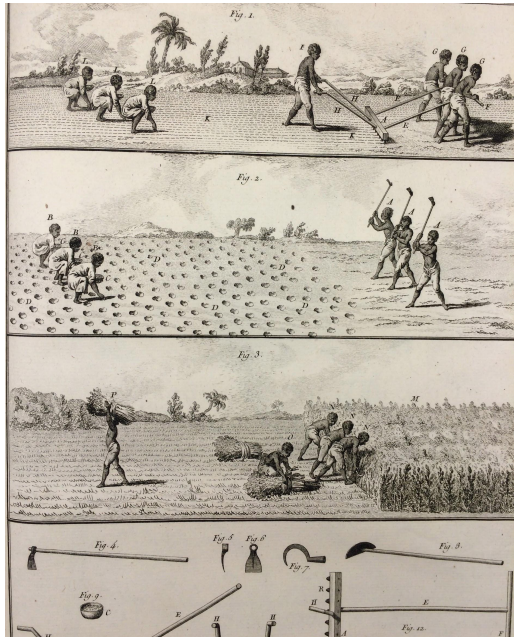

*I. tinctoria*

- The compound leaves are imparipinnate (pinnate with a terminal leaf) and arranged spirally (Takawira-Nyenya and Cardon, 2005)
- The leaflets contain indican, a colorless precursor to indigo dye (Jansen and Cardon, 2005).
- Inflorescence is a short, many-flowered axillary raceme (Takawira-Nyenya and Cardon, 2005).
- The legume is a linear pod that resembles a small green bean, shown on left, brown when ripe, typically contains 7-12 seeds (Takawira-Nyenya and Cardon, 2005)
- Seeds have a hard seed coat (Jansen and Cardon, 2005)

# Indigo Dye CAN BE made from *I. tinctoria*

- Before synthetic indigo production in 1897, *I. tinctoria* was the main source of indigo dye
- Today, almost all indigo dye is produced synthetically
- Indigo is called the ‘king of dyes’ because it can be combined with other natural dyes to make a wide range of colors (Jansen and Cardon, 2005)

(Balfour-Paul, 1998)



# The History of Indigo Dye Production from *I. tinctoria*

Eliza Lucas Pinckney


- In ancient times, indigo dye was traded from India to the Mediterranean region (Jansen and Cardon, 2005)
- Indigo dye produced from *I. tinctoria* was used on the Tellem Textiles, found in Mali, dating back to the 11th and 12th centuries (Takawira-Nyenya and Cardon, 2005)
- Large-scale cultivation of *I. tinctoria* began in the 16th century in India and Southeast Asia (Jansen and Cardon, 2005)
- In the 18th century, French and Spanish colonies in Central America and the Caribbean became major producers dye from of *I. tinctoria* (Jansen and Cardon, 2005)
- Eliza Lucas Pinckney took advantage of the growing demand for indigo dye in the British textile industry and developed *I. tinctoria* as a cash crop in South Carolina in the 1740s (Martin, 2007)
- In 1770, indigo dye produced from *I. tinctoria* on southern slave plantations was the 3rd most valuable export from the 13 colonies (Nash, 1992)
- By 1796, competition from the East India Company wiped out the U.S. indigo industry. For most of the 19th century, British planters exploited the peasants of Bengal to produce the majority of the world's indigo dye (Asiaticus, 1912)

# Cultivation of *I. tinctoria*

**Life cycle of a crop**

- Seeds germinate in about 4-5 days (Jansen and Cardon, 2005)
- Plants may start to flower 3-4 months after sowing (Jansen and Cardon, 2005)
- It has been grown as a ratoon crop, where the upper part of the shoot is cut off every 2-3 years (Jansen and Cardon, 2005). The roots and lower stem contain the root and shoot meristem necessary to grow a new plant (Galloway, 1989)

**Pest control**

- It contains 6 kinds of rotenoids, which have natural insecticide properties, (Takawira-Nyenya and Cardon, 2005)

**Distribution**

- *I. tinctoria* has been grown throughout the tropics and subtropics of Asia, Africa and the Americas (Takawira-Nyenya and Cardon, 2005)
- It also occurs in the wild, in seasonally flooded fields and in secondary forests, brushwood, riverbanks, sandy coasts (Takawira-Nyenya and Cardon, 2005)

But how do we get a blue dye from this:  I. tintorica leaves

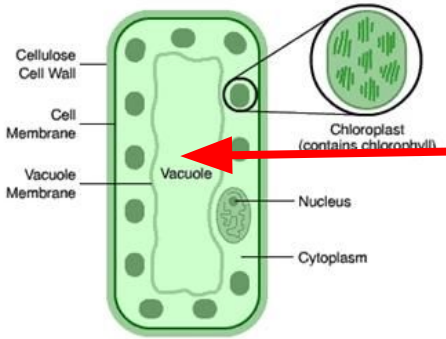
# *I. TINCTORIA* CONTAINS INDICAN, A PRECURSOR TO INDIGOTIN (INDIGO DYE)

**INDICAN**

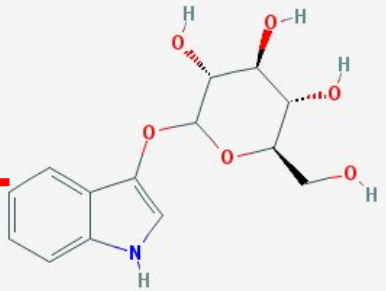
-Indican is a colorless precursor of indigo dye found in *I. tinctoria* and other plants used to make indigo (Jansen and Cardon, 2005).

-Its function in plants is still unknown (Warzech et al, 2006).

-Indican is most concentrated in the vacuoles of mesophyll cells in the leaflets (Minami et al, 1997).



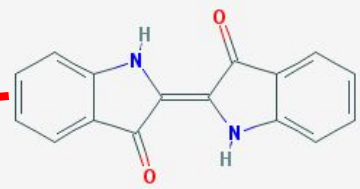

Palisade mesophyll cell



Indican

**INDIGOTIN**

-Indigotin, the blue pigment in indigo dye, can be produced as a blue powder from the indican present in the leaves of *I. tinctoria* (Clark et al, 1993) .



Indigotin

How was indican extracted from *I. tinctoria* and converted to indigotin?

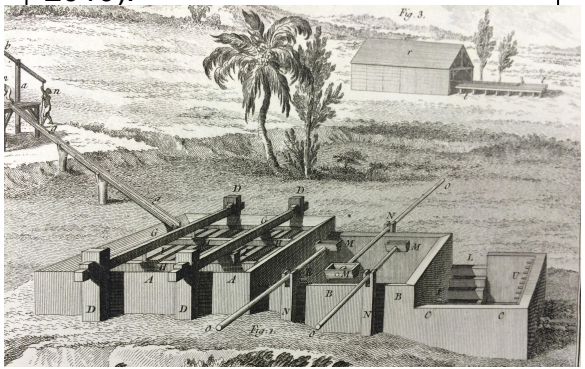
# Traditional indigotin processing from *I. tinctoria*

(this general method was used in the South, Central America, the Caribbean, and India)

**STEP 1: FERMENTATION**

-Immediately after harvesting the leaves, workers brought them to a nearby tub and covered them with water (Martin, 2007).

-Over the next 8-20 hours, workers pounded the leaves, causing indican to leach out into the water and be fermented by aerobic bacteria (Martin, 2007; Aino et al, 2010).

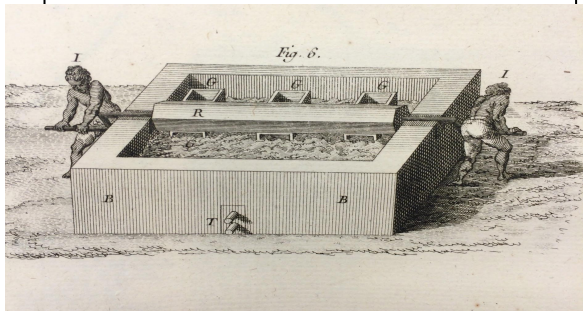


**STEP 2: SEDIMENTATION**

-Workers transferred the fermentation product to a beating vat, where they churned it with paddles (Martin, 2007).

-Exposure to oxygen converted the fermentation product into indigotin (Clark et al, 1993).

-The insoluble indigotin settled to the bottom as a sludge (Clark et al, 1993; Martin, 2007).




**STEP 3: DRYING**

-After siphoning off the water in the beating vat, the workers scraped up and strained indigotin-containing sludge (Clark et al, 1993; Martin, 2007).

-The strained sludge was formed into a cake and as it dried workers cut it into bricks (Martin, 2007).

-The bricks are left to dry for several weeks (Martin, 2007).

Cutting indigo bricks

# Traditional indigo dyeing method

## STEP 1: STORAGE AND TRANSPORTATION

-After drying, the bricks of indigotin powder are ready to be shipped (Martin, 2007)

-The bricks store well because indigotin is insoluble in water

## STEP 2: REDUCTION

-Since indigotin is not water soluble, it must be reduced before dyeing cloth (Clark et al, 1993) .

-The powder is mixed in a vat with water and a base, allowing anaerobic bacteria to reduce the indigotin into a colorless, water-soluble leuco-indigotin (Aino et al, 2010)

indigo reduction vat

## STEP 3: DIPPING

-The cloth is dipped in the vat and then dried (Jansen and Cardon, 2005).

-As the colorless leuco-indigotin is oxidized, it converts back into the blue indigotin (Clark et al, 1993)

-'Resist-dyeing' is done by tying, sewing or plaiting parts of cloth or covering them with starch pastes or wax (Jansen and Cardon, 2005)

cloth dyeing

(Balfour-Paul, 1998)

Adolf van Baeyer

# Synthetic Indigo

- Since the early 1900s, most indigo has been produced synthetically.
- Nobel Prize-winning German chemist Adolf van Baeyer and Heinrich Caro took up the challenge to synthesize indigo in 1856 and finally succeeded in 1897 (Balfour-Paul, 1998).
- When synthetic indigo came into commercial production in 1897, it was catastrophic to the the production of natural indigo (Jansen and Cardon, 2005).
- Although natural indigos have been largely replaced with synthetics, there is recent renewed interest in natural dyes because of increasing consumer concerns over sustainability and “all-natural” products (Takawira-Nyenya and Cardon, 2005).

# Additional uses of I. Tinctoria

- used in traditional medicine in Africa, has healing properties, particularly in regard to the liver/liver problems (Jansen and Cardon, 2005).
- in scientific studies, Indigtone, a bioactive fraction extracted from the indigo plant, “showed significant dose-related hepatoprotective activity against carbon tetracholoride induced liver injury in rats and mice” (Takawira-Nyenya and Cardon, 2005).
- has been used as a ‘green’ manure and as a cover crop in agriculture because it is an environmentally friendly nitrogen catch crop (Jansen and Cardon, 2005)
- used in craft dying, e.g. Batik in Indonesia, shown left (FAO)
- hardly of any value, so in Kenya it is sometimes fed to camels, sheep, and goats (Jansen and Cardon, 2005)
- in Cameroon twigs are used as a toothbrush and a root preparation is used to treat toothache (Jansen and Cardon, 2005)
- in India a watery root paste is applied to worm-infested wounds and used as an antidote against snake bites and insect stings (Jansen and Cardon, 2005)

# References


- Asiaticus, 1912. The Rise and Fall of the Indigo Industry in India. Econ. J. 22, 237. doi:10.2307/2221777
- Clark, R.J.., Cooksey, C.J., Daniels, M.A.., Withnall, R., 1993. Indigo, woad, and Tyrian Purple: important vat dyes from antiquity to the present. Endeavour 17, 191–199. doi:10.1016/0160-9327(93)90062-8
- Balfour-Paul, Jenny. "Indigo." *First published by British Museum Press: London* 4 (1998): 89-104.
- Galloway, J.H., 2005. The Sugar Cane Industry: an Historical Geography from Its Origins to 1914. Cambridge Univ Pr.
- “Indigofera tinctoria L.: True Indigo.” USDA (United States Department of Agriculture), http://plants.usda.gov/core/profile?symbol=INTI
- “Major Colourants and Dyestuffs Mainly Produced in Horticultural Systems”. FAO (Food and Agricultural Organization), http://www.fao.org/docrep/V8879E/v8879e09.htm
- Jansen, Paulos Cornelis Maria, and Dominique Cardon. *Dyes and tannins*. Vol. 3. Prota, 2005.
- Martin, E., 2007. Eliza Lucas Pinckney: Indigo in the Atlantic World, Social Biographies As World History: A Project of the UCSC Center for World History. University of California, Santa Cruz.
- Minami, Y., Takao, H., Kanafuji, T., Miura, K., Kondo, M., Hara-Nishimura, I., Nishimura, M., Matsubara, H., 1997. beta-Glucosidase in the indigo plant: intracellular localization and tissue specific expression in leaves. Plant Cell Physiol. 38, 1069–1074.
- Nash, R.C., 1992. South Carolina and the Atlantic Economy in the Late Seventeenth and Eighteenth Centuries. Econ. Hist. Rev. 45, 677. doi:10.2307/2597414
- Warzecha, H., Frank, A., Peer, M., Gillam, E.M.J., Guengerich, F.P., Unger, M., 2007. Formation of the indigo precursor indican in genetically engineered tobacco plants and cell cultures. Plant Biotechnol. J. 5, 185–191. doi:10.1111/j.1467-7652.2006.00231.x