

American Chemical Society

Symposium on Chemistry & Culture

43rd IUPAC World Chemistry Congress

San Juan, Puerto Rico

Monday, August 1, 2011



Protochemistries are the Bridge

Roald Hoffmann

Protochemistries

Transformations of matter accomplished before there were professional chemists

Protochemistries

Transformations of matter accomplished before there were professional chemists

winning metals from their ores

cooking, preserving food, fermentation, distillation

medicines

ceramics, glass, and other container materials

dyes, textile preparation

cosmetics

jewelry

pigments

tanning

soap, other cleaning agents

mummification



Heather Lechtman



Moche, Chimú, Inca







Figure 30.55 Photomicrograph of an etched cross section removed from a tab underneath the base of the Loma Negra seated man illustrated in figure 30.20. Note the large grain size of the annealed copper, the spherical oxide inclusions, and the grain boundary corrosion. At the surface of the copper sheet the electrochemically deposited gold layer is just visible.

Heather Lechtman

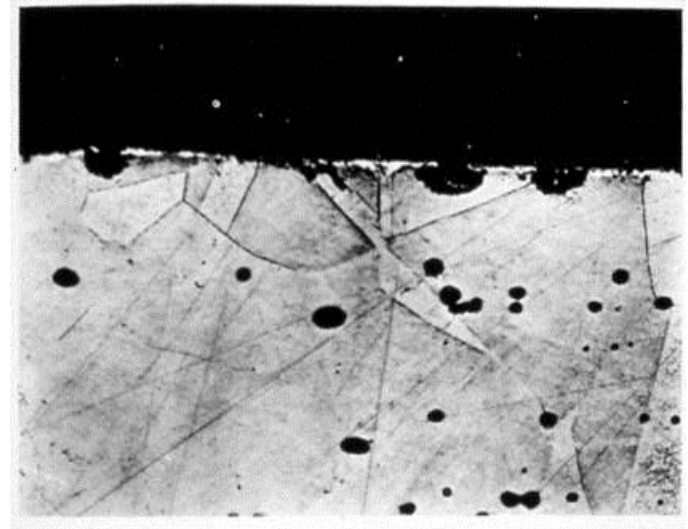
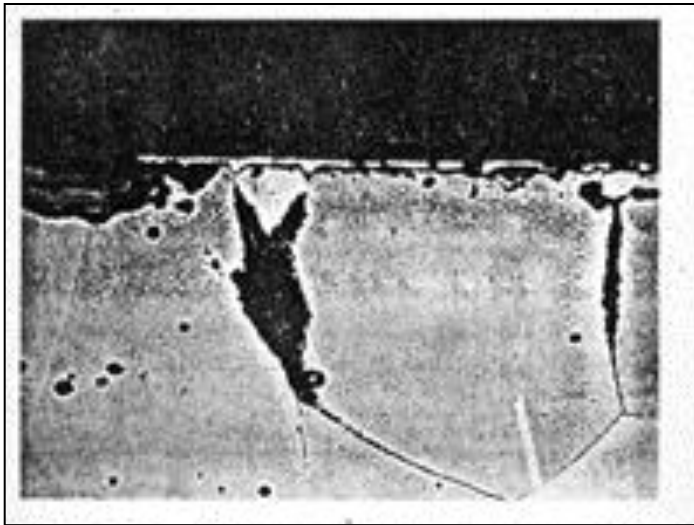
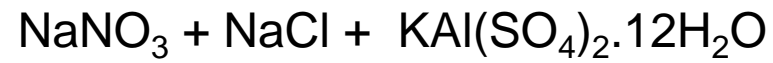
Aqua regia = HCl + HNO₃ 3 volumes to 1



Aqua regia = HCl + HNO₃ 3 volumes to 1



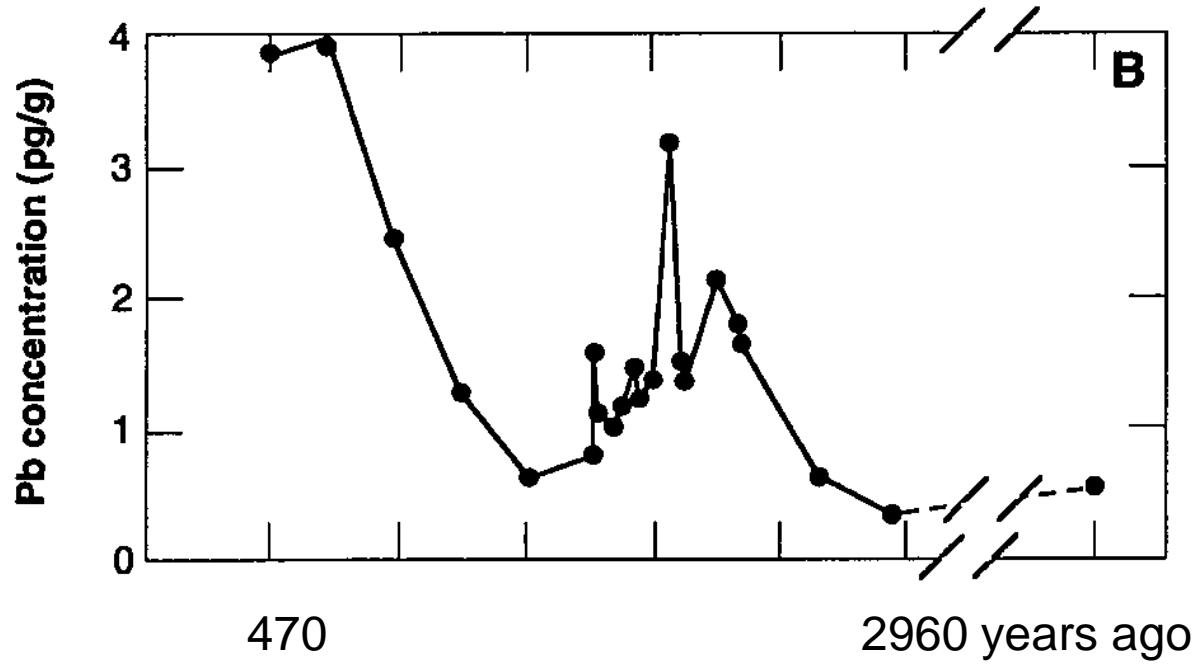
Chile saltpeter + salt + alum



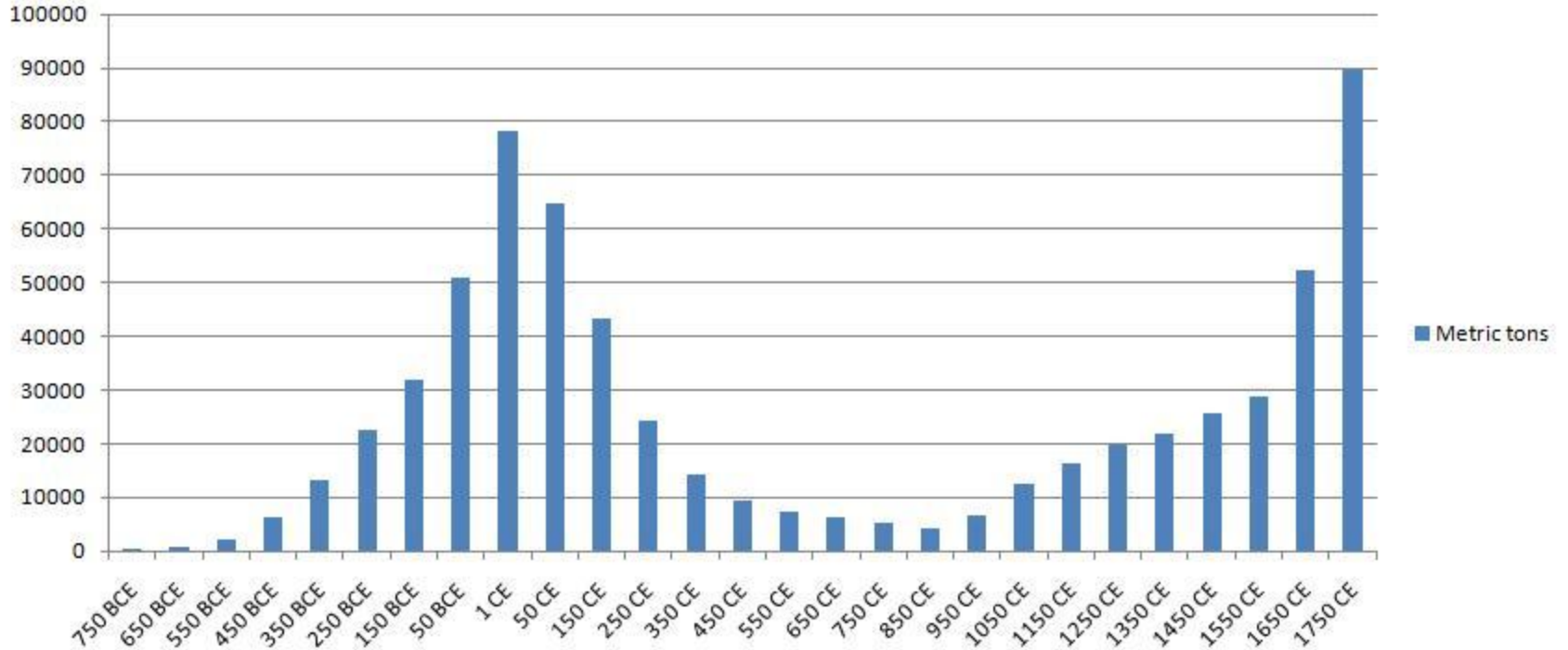
Greenland Ice Evidence of Hemispheric Lead Pollution Two Millennia Ago by Greek and Roman Civilizations

Sungmin Hong, Jean-Pierre Candelone, Clair C. Patterson,
Claude F. Boutron*

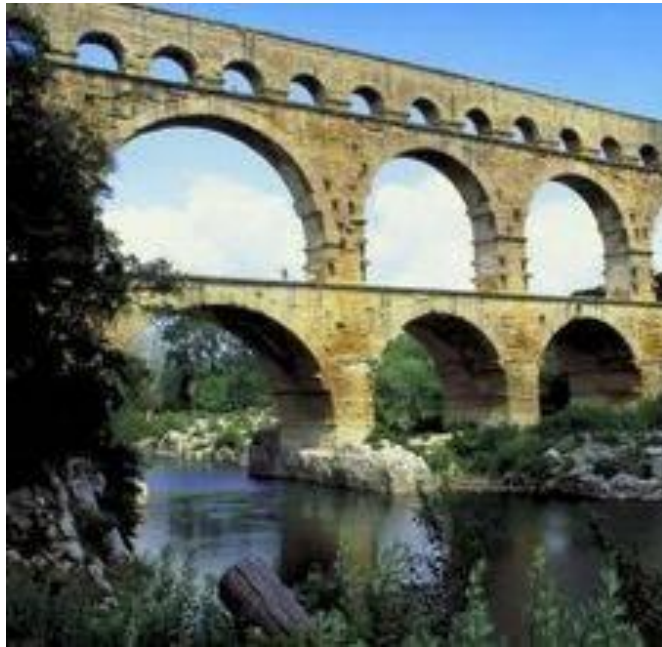
Science, 265, 1841 (1994)



World Lead Production



Rank	Country	World Mine Production Of Lead In Concentrate, By Country (Metric tons, lead content)
1	China	1,500,000
2	Australia	641,000
3	United States	444,000
4	Peru	329,154
5	Mexico	120,000
6	Poland	85,000
7	Canada	82,000
8	India	77,600
9	Sweden	62,100
10	Ireland	54,100



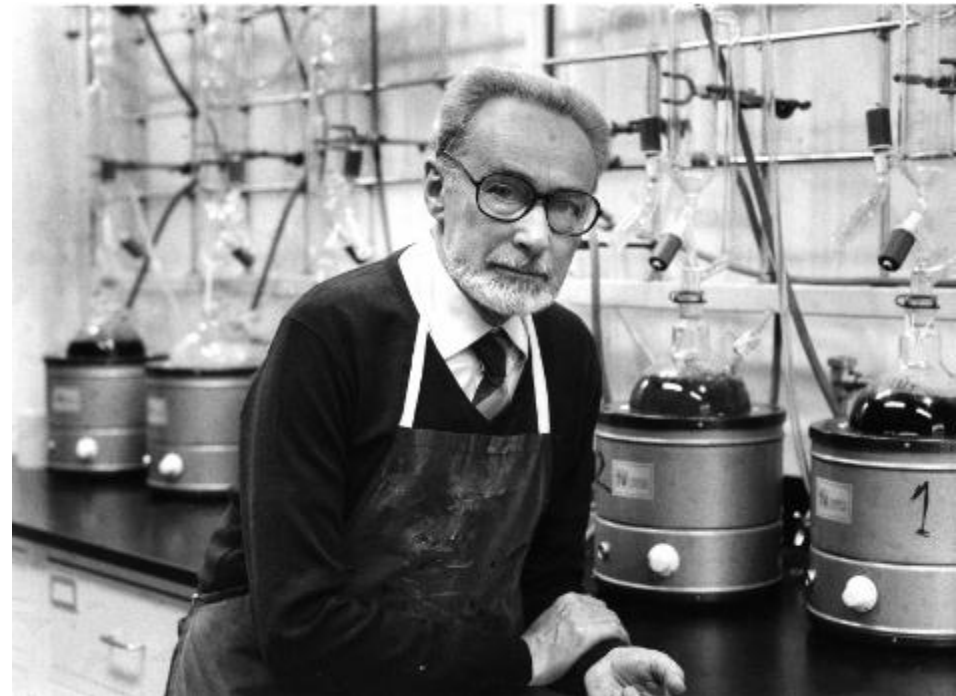
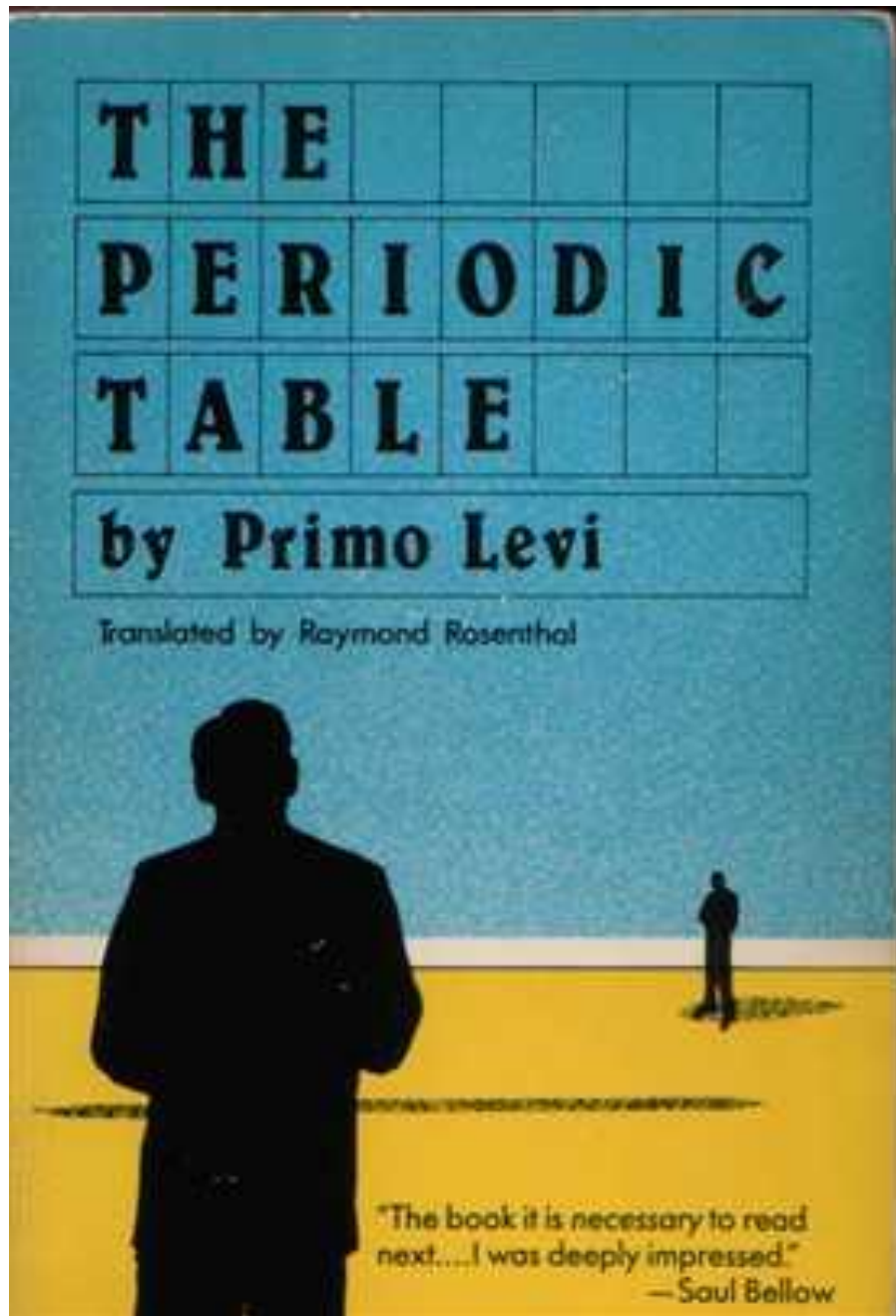


Greenland Ice Evidence of Hemispheric Lead Pollution Two Millennia Ago by Greek and Roman Civilizations

Sungmin Hong, Jean-Pierre Candelone, Clair C. Patterson,
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Analysis of the Greenland ice core covering the period from 3000 to 500 years ago—the Greek, Roman, Medieval and Renaissance times—shows that lead is present at concentrations four times as great as natural values from about 2500 to 1700 years ago (500 B.C. to 300 A.D.). These results show that Greek and Roman lead and silver mining and smelting activities polluted the middle troposphere of the Northern Hemisphere on a hemispheric scale two millennia ago, long before the Industrial Revolution. Cumulative lead fallout to the Greenland Ice Sheet during these eight centuries was as high as 15 percent of that caused by the massive use of lead alkyl additives in gasoline since the 1930s. Pronounced lead pollution is also observed during Medieval and Renaissance times.

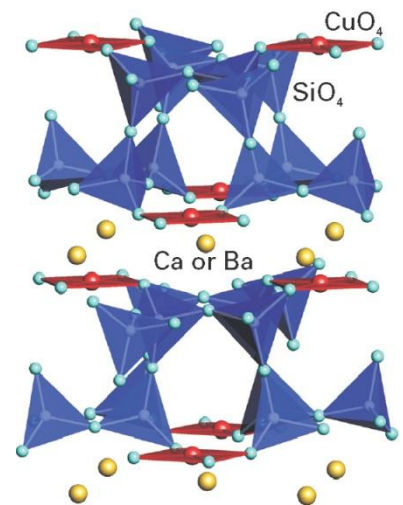
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Lapis lazuli = ultramarine

Egyptian blue





Tyrian purple

24 If this was done unwittingly, through the inadvertence of the community, or the herd, or the property, or they have their community, it has. 27 I shall shall who him and ritual



of the with its. 25 The ity and or they RD and ommu- ren, for gly, he e priest person ion for israelites ave one

30 But the person, be he citizen or stranger, who acts defiantly^a against the LORD; that person shall be cut off from among his people. 31 Because he has spurned the word of the LORD and violated His commandment, that person shall be cut off—he bears his guilt.

32 Once, when the Israelites were in the wilderness, they came upon a man gathering wood on the sabbath day. 33 Those who found him as he was gathering wood brought him before Moses, Aaron, and the whole community. 34 He was placed in custody, for it had not been specified what should be done to him. 35 Then the LORD said to Moses, "The man shall be put to death: the whole community shall pelt him with stones outside the camp." 36 So the whole community took him outside the camp and stoned him to death—as the LORD had commanded Moses.

37 The LORD said to Moses as follows: 38 Speak to the Israelite people and instruct them to make for themselves fringes on the

^a Lit. "with upraised hand"

corners of their garments throughout the ages; let them attach a cord of blue to the fringe at each corner. 39 That shall be your fringe; look at it and recall all the commandments of the LORD and observe them, so that you do not follow your heart and eyes in your lustful urge. 40 Thus you shall be reminded to observe all My commandments and to be holy to your God. 41 I the LORD am your God, who brought you out of the land of Egypt to be your God: I, the LORD your God.

קרח

16 Now Korah, son of Izhar son of Kohath son of Levi, ^abetook himself, ^balong with Dathan and Abiram sons of Eliab, ^cand On son of Peleth—descendants of Reuben^d—to rise up against Moses, together with two hundred and fifty Israelites, chieftains of the community, chosen in the assembly, men of repute. 3 They combined against Moses and Aaron and said to them, "You have gone too far! For all the community are holy, all of them, and the LORD is in their midst. Why then do you raise yourselves above the LORD'S congregation?"

4 When Moses heard this, he fell on his face. 5 Then he spoke to Korah and all his company, saying, "Come morning, the LORD will make known who is His and who is holy, and will grant him access to Himself; He will grant access to the one He has chosen. 6 Do this: You, Korah and all your^e band, take fire pans, ^fand tomorrow put fire in them and lay incense on them before the LORD. Then the man whom the LORD chooses, he shall be the holy one. You have gone too far, sons of Levi!"

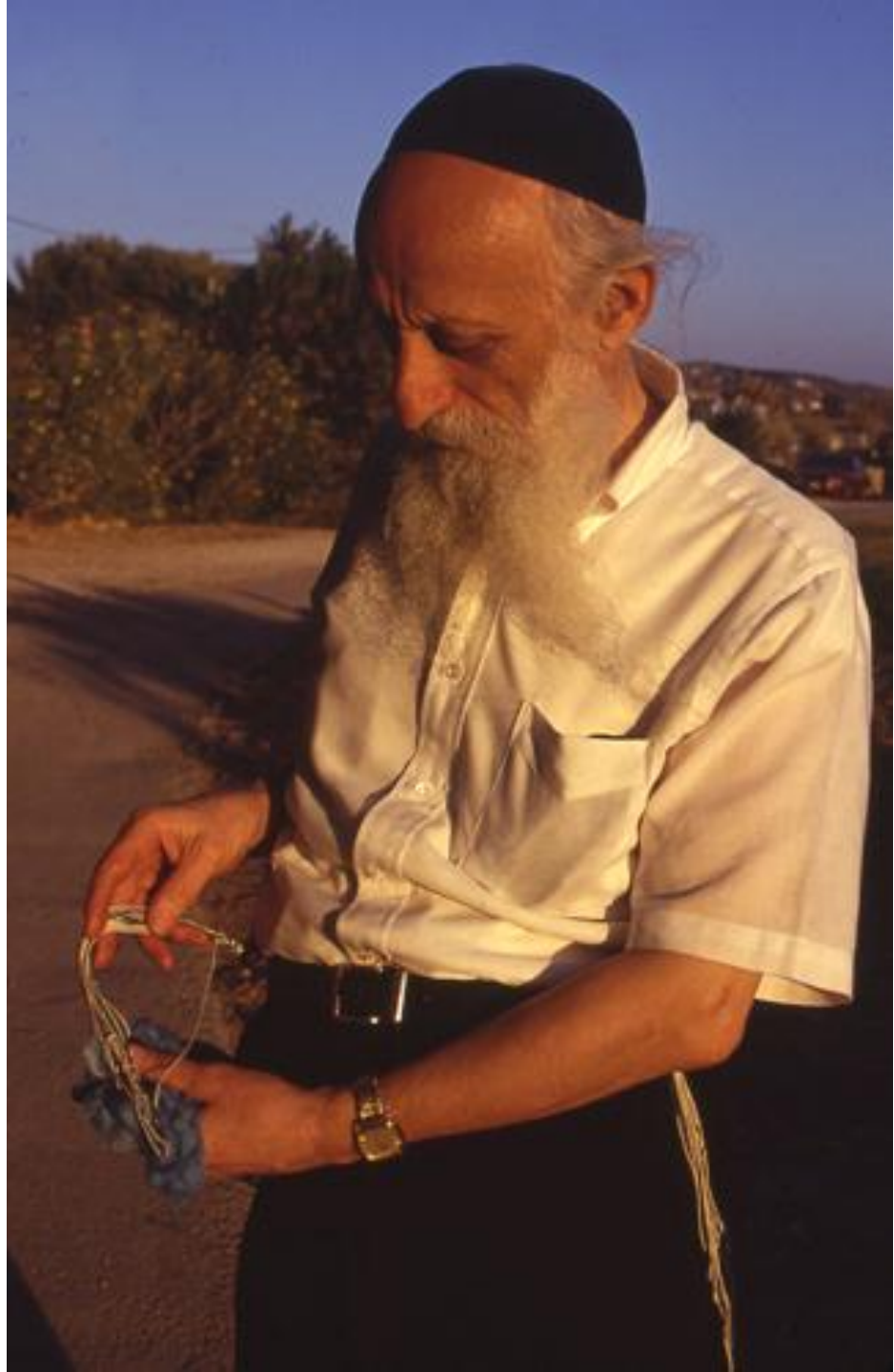
7 Moses said further to Korah, "Hear me, sons of Levi. 8 Is it not enough for you that the God of Israel has set you apart from the community of Israel and given you access to Him, to perform the duties of the LORD'S Tabernacle and to minister to the community and serve them? 9 Thus He has advanced you and all your fellow Levites with you; yet you seek the priesthood too! 10 Truly, it is against the LORD that you and all your company have banded together. For who is Aaron that you should rail against him?"

^a Lit. "took"; Heb. obscure

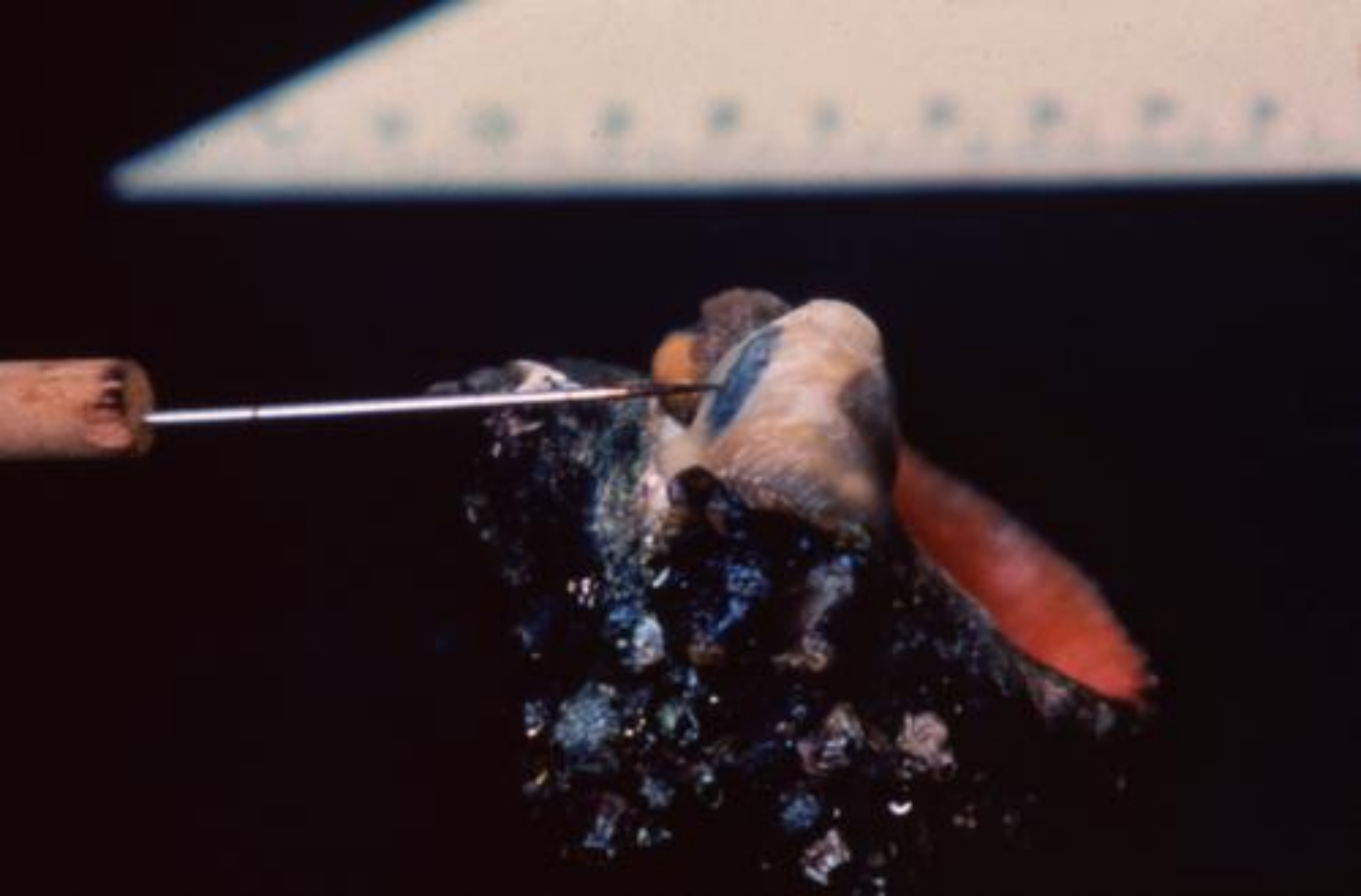
^b According to Nu. 26:3, 8-9, Eliab was son of Pallu, son of Reuben

^c Perhaps in the sense of "his face fell"

^d Lit. "his"

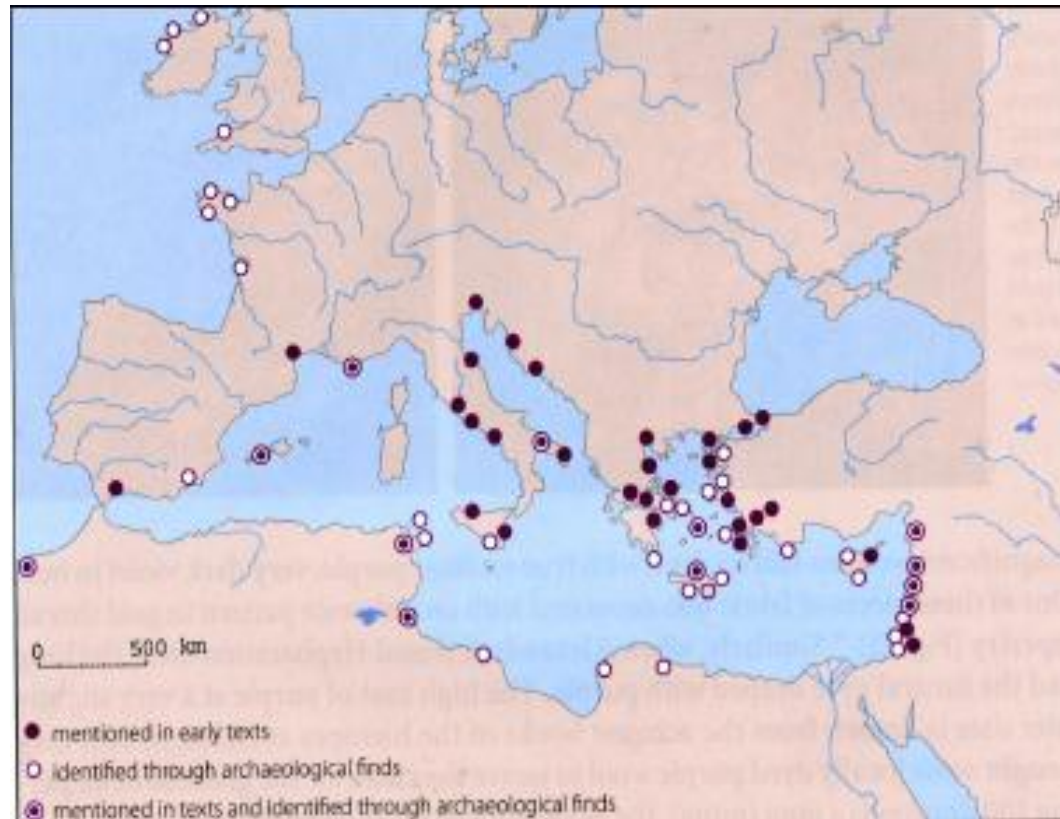
















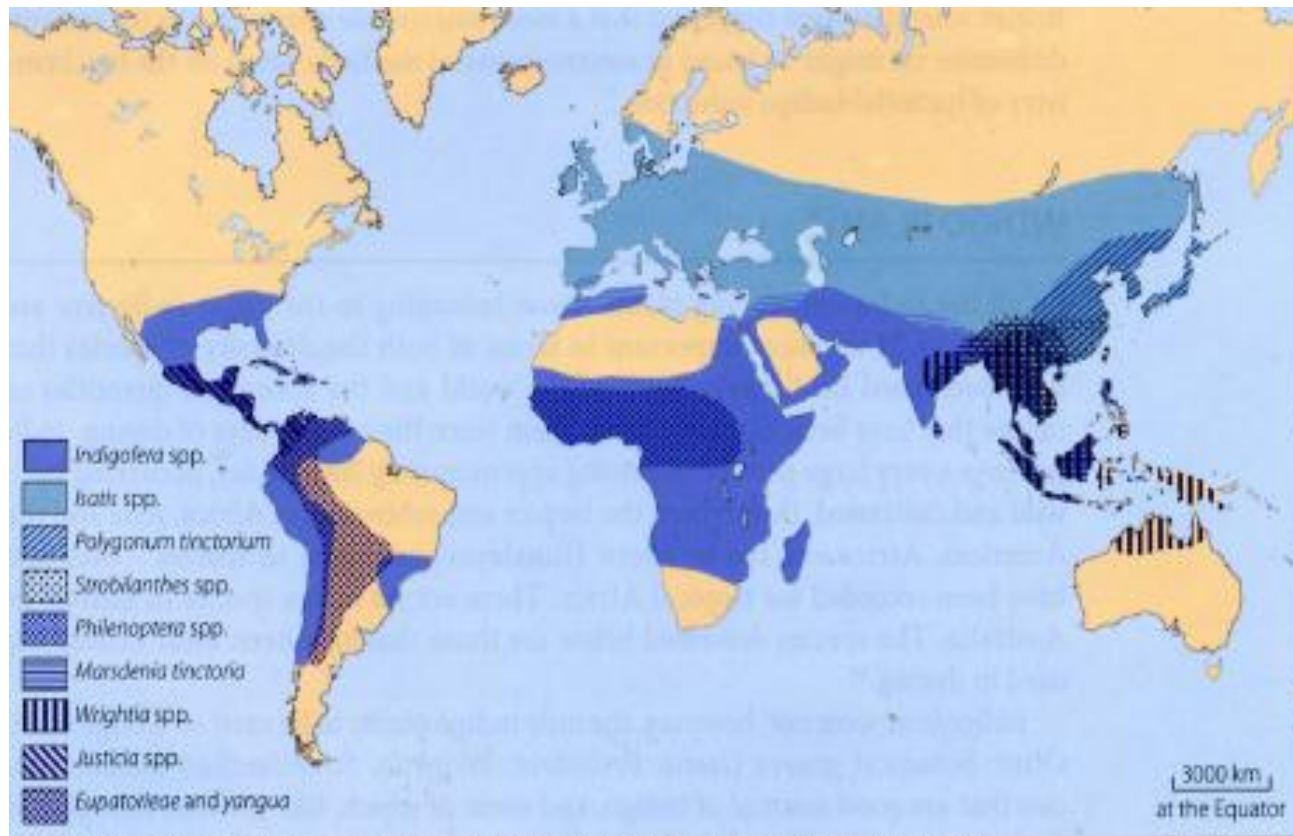


Figure 25 Indigo plants of the world and American blue vat dyes. (Map: D. Augerd/ D. Cardon, CNRS)



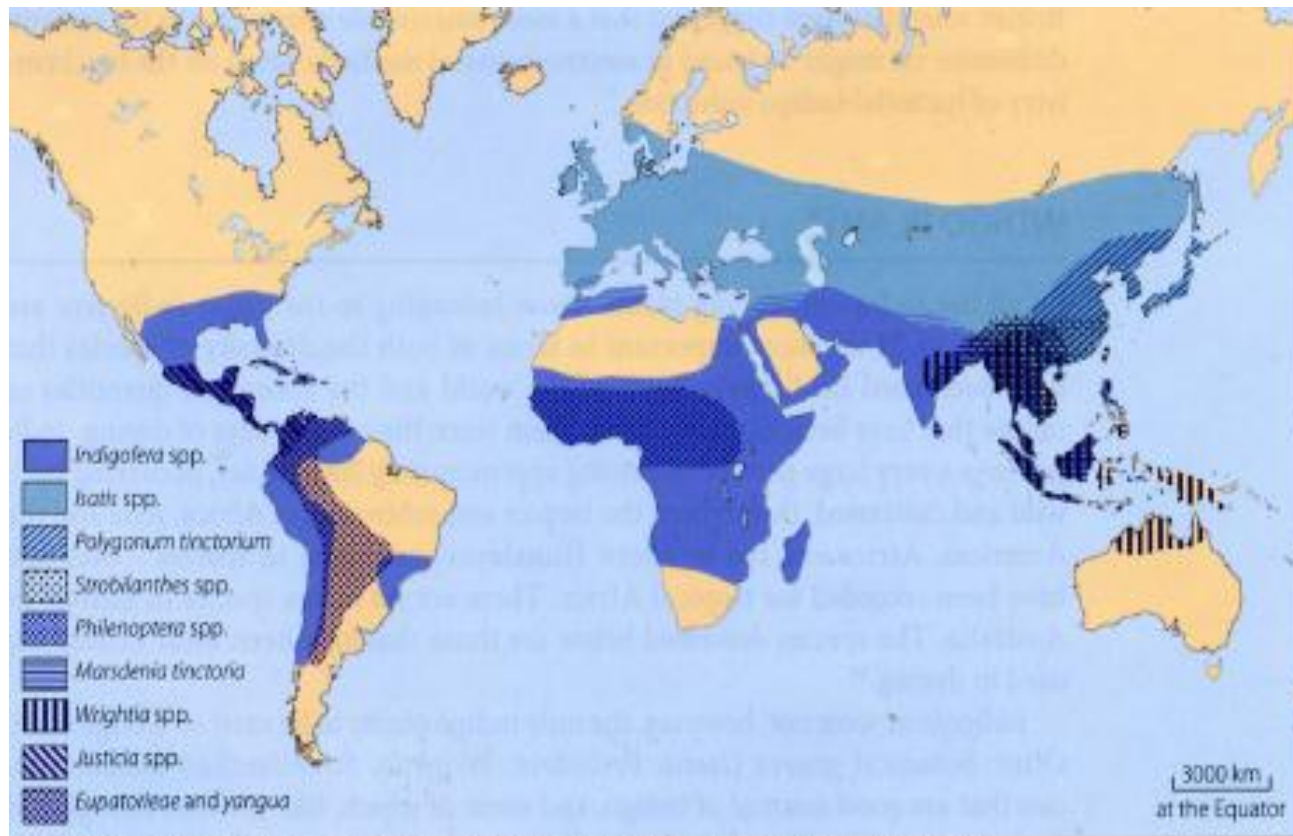


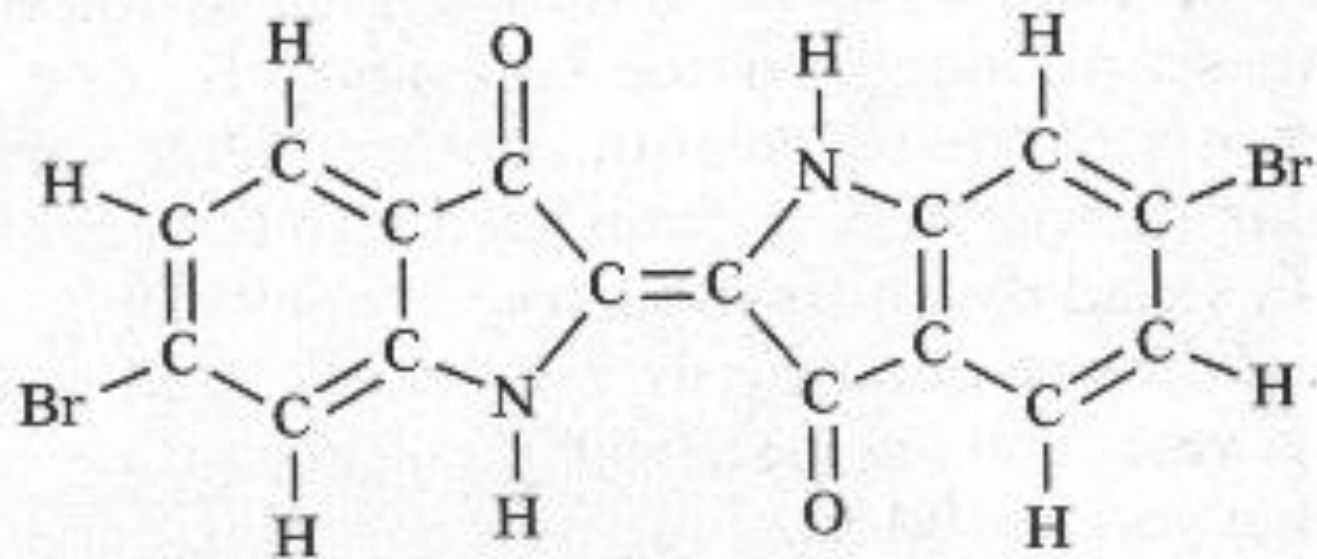
Figure 25 Indigo plants of the world and American blue vat dyes. (Map: D. Augerd/ D. Cardon, CNRS)





Diderot et D'Alembert





Historic Dye Labels of BASF Indigo since 1890







105. Dyeing in Dark Blue.

Put about a talent of woad in a tube, which stands in the sun and contains not less than 15 metretes, and pack it in well. Then pour urine in until the liquid rises over the woad and let it be warmed by the sun, but on the following day get the woad ready in a way so that you (can) tread around in it in the sun until it becomes well moistened. One must do this, however for 3 days together.

Stockholm Papyrus

Accounts Chem. Res. 1990, 23, 152-8

Royal Purple Dye: The Chemical Reconstruction of the Ancient Mediterranean Industry

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Royal purple, 6,6'-dibromoindigotin (DBI, structure III in Figure 1, X = Br), is the most renowned of ancient dyes.¹ Even before Nero issued a decree in the first century A.D. that gave the emperor the exclusive right

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Rudolph H. Michel was born in Landau, Germany, in 1925 and came to the U.S. in 1936. He was trained as a physical organic chemist, receiving his B.S. from the City College of New York and his Ph.D. from the University of Notre Dame. He investigated various aspects of polymer chemistry, including the syntheses of many new materials, in his professional career at E. I. du Pont de Nemours & Co., from which he retired as a Research Fellow in 1985. Soon afterward and continuing to the present, he volunteered his considerable chemical expertise to begin a new "career" in archaeochemical research at MASCA.

to wear royal purple garments, the association of this dye with royalty and high ecclesiastics was well established. As one example, biblical texts² incorporating Iron Age traditions prescribed that the tabernacle curtains and the high priest's vestments were to be dyed with royal purple.

The sociopolitical and religious significance of royal purple was closely tied to its economic value. In some periods, it was worth as much as 10-20 times its weight in gold.³ This circumstance can be traced to the fact that the precursors of DBI, which convert to the dye in air and light (see Figure 1), are found in nature only in the hypobranchial secretions of certain marine mollusks (Figure 2).⁴ As many as 10 000 animals are

(1) Brunello, F. *The Art of Dyeing in the History of Mankind*; Neri Pozza Editore: Venice, 1973; pp 13, 57, 79.

(2) See: Exod. 26:1, 31; 28:4-6; 39:1, 28-29. 1 Kings 5:1-12; 7:13-14; 9:10-14, 26-28; 10:11, 22. 2 Chron. 2:7, 14; 3:14. Ezek. 27:7, 16, 24.

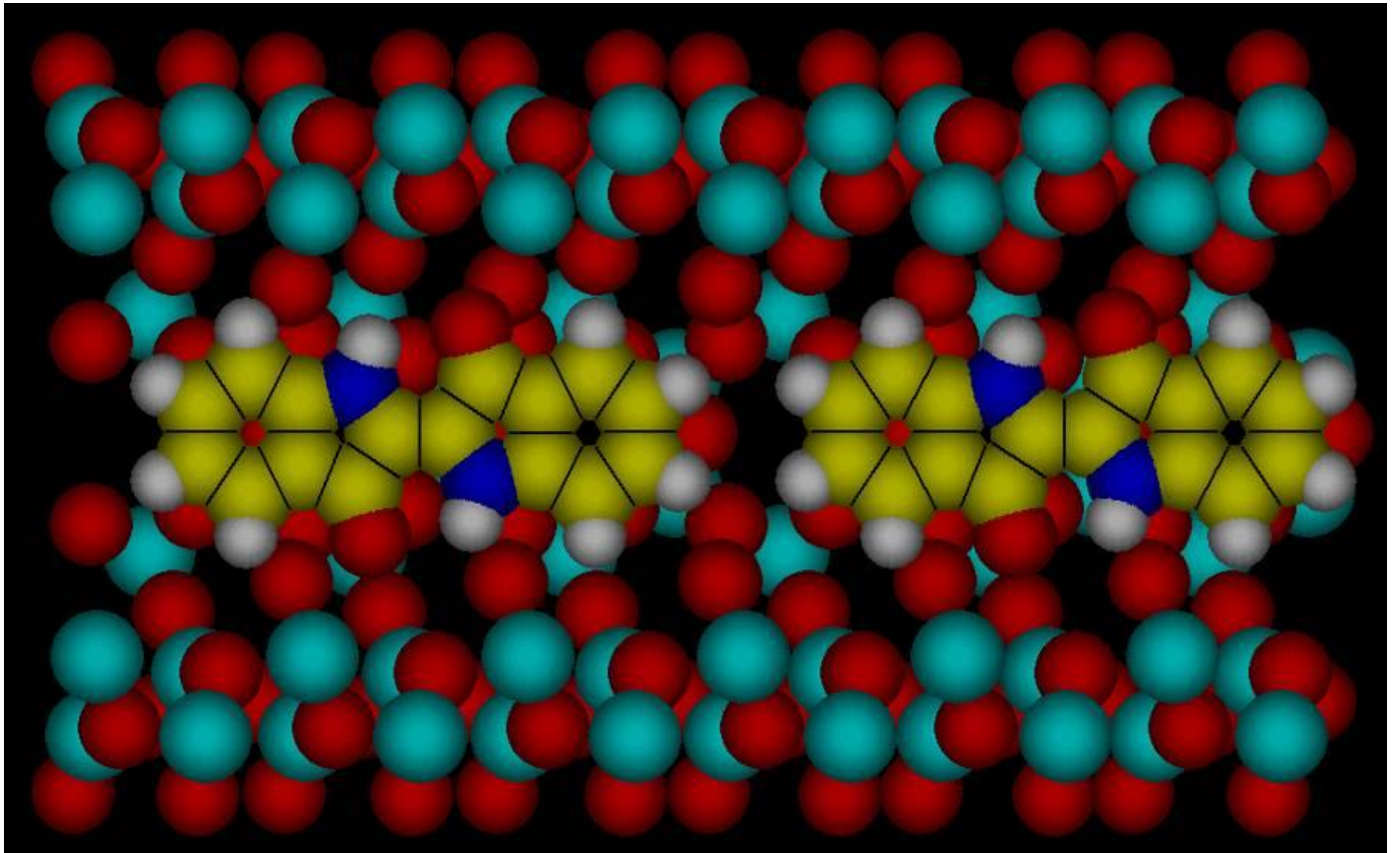
(3) Born, W. *Ciba Rev.* 1937, 1, 106-111, 124-128.















Patrick McGovern

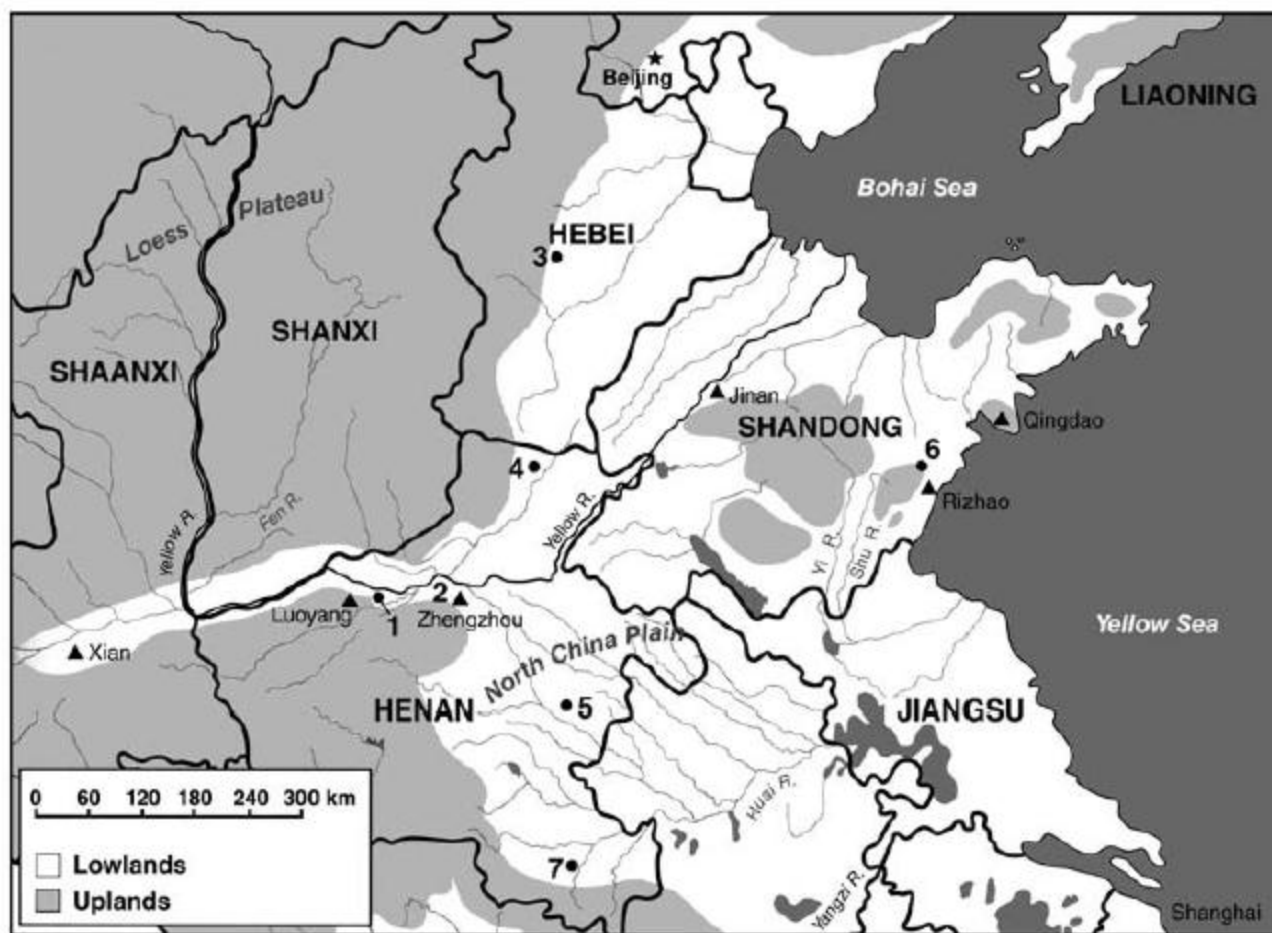


Fig. 1. Archaeological sites discussed in the text. 1 = Erlitou, 2 = Zhengzhou, 3 = Taixi, 4 = Anyang, 5 = Jiahu, 6 = Liangchengzhen, 7 = Tianhu.



~7000 BC



*Chemical Identification and Cultural Implications
of a Mixed Fermented Beverage from Late
Prehistoric China*



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FENGSHI LUAN, GRETCHEN R. HALL, HAIGUANG YU,
CHEN-SHAN WANG, FENGSHU CAI, ZHIJUN ZHAO,
AND GARY M. FEINMAN

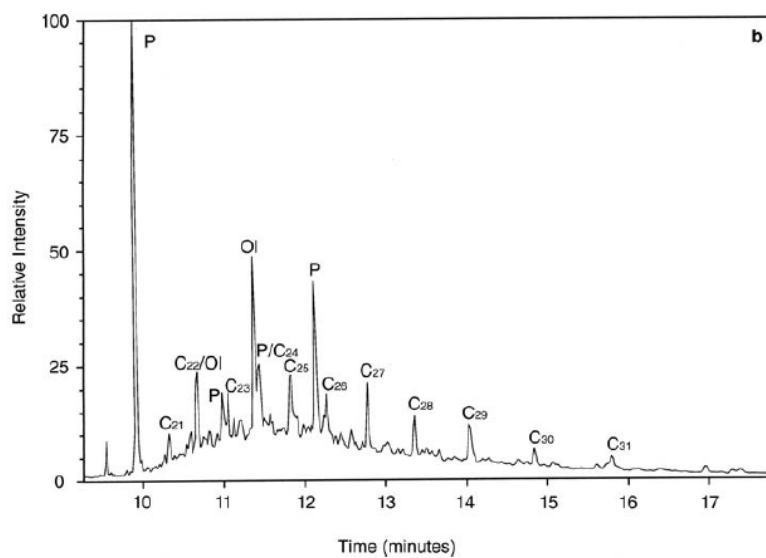
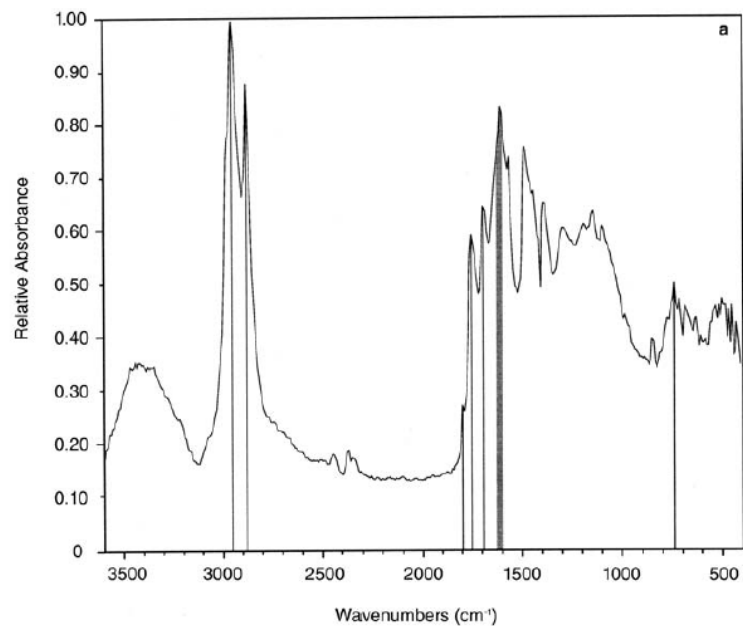


Fig. 5. Representative chemical results for Liangchengzhen mixed fermented beverage. *a* = DRIFTS spectrum of sample no. 1 (methanol extract), a *tongxing bei* tubular cup, showing the principal absorptions of the mixed fermented beverage of rice, honey, and fruit. Spectra deresolved at 8 cm⁻¹ wavenumber. See text for discussion. *b* = GC/MS analysis of sample no. 2 (chloroform extract), total ion chromatogram, a *gaobing bei* tall-stemmed cup, showing the homologous paraffin series from C₂₁ to C₃₁ (P = phthalate contaminant; Ol = oleamide contaminant). Chinese beeswax has elevated levels of the odd-numbered members of the series.

A MIXED FERMENTED BEVERAGE

The combined chemical results for the large group of twenty-three Liangchengzhen samples are best explained as a mixed fermented beverage composed of rice, honey, and a fruit, possibly with barley and a plant resin (or herb) as additives (listed in the last column of Table 1). A beverage in which rice was a principal ingredient accords with archaeobotanical findings thus far. Millet, which is also well represented at Liangchengzhen, does not appear to have been used in making the beverage, although barley—yet to be identified archaeobotanically—is suggested by the chemical evidence. At present, although it is not clear when barley was introduced into China or domesticated there, an early date is implied by the finding of archaeobotanical samples as early as ca. 1000 B.C. in Japan and Korea, across the Yellow Sea from Shandong province (Crawford 1992:21–22).

You could call this extreme beverage a "Neolithic grog." It was comprised of honey mead and a combined "beer" or "wine" made from rice, grapes, and hawthorn fruit. Rice is a grain, like wheat and barley, so by that definition it makes a beer (of about 4-5% alcohol), but when it's fermented to 9-10% and has pronounced aromatic qualities, then it's more like a wine. Maybe, the best modern comparison is with an aged Belgian ale or a barley wine. Although some ingredients have been interchanged, it's also not all that different from Midas Touch in combining a wine, beer and mead, even if Jiahu precedes Midas by some 6000 years.



Protochemistries are the Bridge

stress the essential importance of experiment, and... of the underlying economics that governs much human activity

render homage to the past, to the ingenuity of human beings

connect our world, in time and in substance

these stories normalize science

and put it in the context of world culture – chemistry in culture, culture in chemistry

Good Stories in Teaching Chemistry

Storytelling is human, it is old

The facts are... mute. Narrative is tremendously important in science, but it is not recognized as such because it is not “mathematicizable.” In this it shares the fate of other human tools for shaping understanding, such as metaphor

After simplicity, I believe storytelling is the main pleasure-giving principle in science

Dignifications of storytelling that scientists do allow themselves: pattern recognition, hypothesis formation