Glass, Metals, and Amber, but not Woad

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Summary

The mistaken idea that ancient Britons understood a word like modern Welsh *glas* to mean 'blue' has contributed to multiple historical misunderstandings. To begin sorting them out, we delve into the linguistic development of colour words, the history of dyeing with indigo, the use of vitriol (metal sulfates) in tattoo inks, and the occurrence of glass in place-names. It emerges that Caesar's *vitrum* and Pliny's *glastum* were not woad, while Anglo-Saxon *wad* and Greek-Latin *isatis* were probably dye plants more generally. The Indo-European root of *glas*, glass, and many other words developed an early yellowish colour sense exemplified by Latin *glaesum* 'amber'.

Introduction

Glass is a short word with a transparently simple meaning and yet it lies at the heart of some classic historical and linguistic puzzles that have been repeatedly discussed. This article suggests how a little scientific curiosity may help solve some of those puzzles.

The word glass in place-names is usually an anglicised form of Celtic *glas* or *glaise*, meaning a small river or a patch of greenery. More than 500 glassy names, from Glas Bheinn Bheag to Brynglas, and from Glasgow to Porthglaze, are in the Ordnance Survey Open Data 50K gazetteer and no one could possibly doubt the Gaelic, Welsh, or Cornish roots of most of them. However, we wondered if a few glassy place-names might be exceptions from that Celtic norm.

That simple beginning with glass and *glas* was rather like Alice in Wonderland's rabbit hole: it led us into a maze of circular logic and historical misunderstandings that have caused generations of scholars to believe six impossible things before breakfast about the skin decorations of ancient Britons. In particular, a false idea has grown up that the words *vitrum*, *glastum*, and *isatis*, as used by ancient authors, can be translated as woad, a plant that yields the blue dye indigo. This article corrects some long-standing errors, but often we can only highlight a problem for the attention of specialists in subjects a long way from place-names.

North-western Glassy places

Leather (1994) drew attention to four place-names containing the word glass on the coast of north-west England where bases of the *Classis Britannica*, the Roman Navy, were probably located next to Roman forts. Three are called Glasson: (1) by Maryport on the river Ellen; (2) downstream from Lancaster on the river Lune; and (3) downstream from Carlisle on the Solway estuary. None of these three names can be traced back before 1250, but Ravenglass on the river Esk was the base of *Cohors 1 Aelia Classica*, an infantry unit raised from the fleet around AD 120 (Shotter, 1998), and a C-to-G change is common in Celtic names.

Other names containing glass occur at both ends of the Antonine Wall, built by the Romans across Scotland in the AD 140s: the Roman fort at Kinglass is by the seaport of Bo'ness on the Forth estuary, and Dunglass is near Dumbarton, capital of the post-Roman kingdom of Strathclyde on the Clyde estuary. And Dunglass occurs three more times (near the Mull of Kintyre, at the tip of Cromarty Firth, and on the south-east Scottish coast) at logical places for the Roman navy to set up temporary bases.

Coincidences? Quite possibly, but in Roman times this area may not have been as Celtic as is often assumed. A language similar to Welsh was probably widely spoken around Cumbria until AD 795 when Vikings started arriving or AD 937 when Anglo-Saxons won the battle of Brunanburh. However, the naval activity described by Tacitus and implied by archaeology suggests that in Roman times naval personnel would have been a major fraction of the population, and even more so of the local economy, along the coast, especially at places like Ravenglass. They would have spoken Latin, but also their native languages, some of which

were Germanic: the Usipi of AD 83 (mentioned by Tacitus) were much like early Saxons, and the Heruli (active around AD 280) were much like early Vikings.

Genetic traces in the modern population from Chester northwards may result from settlement of Roman soldiers from the Balkans, including some from the *ala Gallorum et Thracum Classiana civium Romanorum* (Bird, 2007). Around Hadrian's Wall, many Roman troops came from the areas of modern Benelux or the Middle East. In particular, Arab bargemen from the Tigris were based at Roman *Arbeia* (modern South Shields), which looks very like *Arbela*, now modern Erbil in Iraq. Other bargemen were at Roman Lancaster. In short, many languages need to be considered as possible contributors to ancient names.

Not really Celtic?

A disturbingly large fraction of etymologies that are commonly cited for proper names in Roman-era Britain and on the Continent do not stand up to critical examination. The problem arose largely because everyone used to believe in the (now discredited) ideas of an Anglo-Saxon "invasion" and of a central European Celtic homeland. So there was a desperate urge to find Celtic roots for all ancient proper names even when, with hindsight, it is obvious that many names contain elements that have survived better in English than in Welsh, or that can be explained purely in Latin.

In the south and east of England we have found that ancient names explained as "Celtic", as reviewed by Rivet and Smith (1979), are often a sign that something interesting remains to be found out about the early history of the place or river concerned. The key to progress is to avoid pre-judging the chronology of language changes, but to make full use of modern computer technology, archaeological results, and geographical information. It came as a surprise that the same approach works in north-west England.

Glassonby lies up the river Eden from Carlisle, which was the linchpin of Roman military strength at the western end of Hadrian's Wall. If Selkirk (2001, p133, p154) is right that there was a Roman-era lock by Wetheral Priory and a weir at Armathwaite, barges of the *Classis Britannica* could easily have reached Glassonby. At the very least, this directs attention to the five rivers in Britain that are called Eden and share a common feature of being good transport routes, navigable a certain way inland and/or with valleys that were good for walking. Eden probably descends from Ptolemy's Ιτουνα, which would make sense as 'travel river', compounded of Latin *itus* 'going' plus the *–na* ending common on goddesses and rivers.

Near Glasson on the Solway estuary is Drumburgh, which was the site of a Roman-era fort called *Concavata*. It lay at one end of what is now called Sandy Wath, where until quite recently people and animals waded across the estuary at low tide. Norse-derived *wath* is cognate with Latin *vadum* 'ford' and English wade, while Latin *conca* 'shell' evolved to mean 'basin, pool'. So *conca-vata* might just mean 'basin fords'.

Roman-era *Derventio* is usually explained as coming from a Celtic word for oak trees and is thought to be the origin of four rivers called Derwent plus one called Darwen. However, Solopov (2005) noted that names based on trees were virtually absent from Latin place names, while Kitson (1996) drew attention to other European rivers that begin with something like *$*d^hreg^h$*- 'run' and end like a verbal present participle. Since the higher reaches of all five rivers descend steeply it would make sense to consider *Derventio* a verbal noun derived from Latin *dervo* 'fall down' and to translate it simply as 'steep'.

Μορικαμβη (Morecambe) and *Camboglanna* (Castlesteads) are usually said to contain Celtic **cambo*- 'curve', but why do they share a hummocky glacial landscape that makes one think of Scots kaim and English comb? Canon Winder (a Roman-base-like place on the coast), *Clanoventa* (at Ambleside, according to Shotter, 1998), Windermere (formerly *Winandermere*), plus *Vindobala*, *Vindogara*, *Vindolanda*, and *Vindomora* are usually said to contain a proto-Celtic **vindo*- 'white'. It is dangerous to project colour words back 2000 years (as discussed below), so a proper discussion is needed of alternative links to *vindex* 'defender', tribes like the Veneti, and Old English *winedas* 'Wends, border foreigners'.

Caesar's *Vitrum*

Glass is the normal translation of the Latin word *vitrum*, but Julius Caesar must have intended some special meaning in this strange sentence (Gallic War 5,14):

Omnes vero se Britanni vitro inficiunt, quod caeruleum efficit colorem,

Almost everywhere at present this is translated incorrectly as something like this:

'All the Britons stain themselves with woad, which produces a blue colour'

As will become clear, the correct translation should be:

'All the Britons tattoo themselves with vitriol, which produces a blueish colour'

The mistaken idea that *vitrum* equals woad, a plant source of the blue dye indigo, has been around for several centuries. It is deeply embedded in dictionaries and in popular consciousness, as epitomised by this schoolboys' ditty, sung to the tune of Men of Harlech:

Ancient Britons never hit on
Anything as good as woad to fit on
Necks or knees or what you sit on ...

Chadwick (1958) critically examined the classical references behind the "painted Britons" idea. She analysed who was copying whom in the ancient texts, and recognised the importance of iron, notably when the late Roman poet Claudian described Britain as having *ferro picta genas* 'cheeks marked with iron' and a dying Pict as having *ferroque notates ... figures* 'designs marked with iron'. But she missed the crucial piece of chemistry that links Caesar's *vitrum* to iron.

Pyatt et al. (1991) analysed the skin of a real ancient Briton, Lindow Man, and discovered that copper was prominent. So they suggested that *vitrum* was some kind of copper-based pigment and had nothing to do with woad. However, they did not take the next step, of recognising that *vitrum* meant vitriol.

The English word vitriol comes from Late Latin *vitreolus*, which is a diminutive of *vitreus* 'glassy'. We do not know when the word *vitreolus* first evolved, but it may have been as late as AD 800, when Arabs were leaders of alchemy and dye technology. So vitriol was unlikely to have been in Caesar's vocabulary, leaving *vitrum* as its nearest equivalent.

Nowadays vitriol is used to mean corrosive words, but that is a metaphor derived from oil of vitriol, concentrated sulfuric acid. Originally vitriol meant various metal sulfate salts: blue vitriol (copper sulfate, $CuSO_4$), green vitriol (ferrous sulfate, $FeSO_4$), and white vitriol (zinc sulfate, $ZnSO_4$, or alum, potassium aluminium sulfate) (Karpenko & Norris, 2002). All these salts form beautiful (hydrated) crystals, which look a bit like gem stones. In particular, ferrous sulfate crystals are a pale green colour and look strikingly like broken glass.

But why would Caesar know anything about metal sulfate crystals? The link is black ink, which can be made in three main ways: as a suspension of soot (*fuligio pictoria*), as an over-strong solution of a dye (such as indigo), or by mixing iron (ideally ferrous sulfate) with tannic acids (usually from tree galls, oak apples). A huge amount of research (best looked up on the Internet) exists about iron-gall ink and its use in old documents. How widely iron-gall ink was used in early times (for example on Dead Sea Scrolls) is still uncertain, but in the AD 70s Pliny was aware that an infusion of galls turned black in response to metals.

So Caesar's remark merely means that ancient Britons followed the barbarian practice of sporting tattoos as decorations or marks of courage, in contrast with what Caesar and his readers were familiar with – punitive tattoos upon criminals, slaves, and prisoners of war.

Early Glass

In Julius Caesar's day most glass was strongly coloured and used for decoration. So it would have been natural for him to apply *vitrum* to something small and colourful like crystals of vitriol. A century later, by Pliny's day, much clearer glass was serving as a functional material in window panes and kitchen vessels (*www.romanglassmakers.co.uk/articles.htm*).

Chemically, glass is usually silica, SiO_2, with its melting point reduced by combination with $CaCO_3$ (readily available as limestone etc) and Na_2CO_3 (Egyptian natron) and/or K_2CO_3

(potash or plant ashes). The key technological developments – glass-blowing and using raw materials low in iron – are neatly embodied in the fable recounted by Pliny that glass was discovered by Phoenicians making a fire on a beach.

The word *vitrum* developed quite late in Latin. Its earliest known occurrence is in Lucretius' poem *de Rerum Natura* (4,602) of about 58 BC, just before Caesar's trip to Britain. Before then glass was generally called *hyalus*, from Greek υαλος, which probably came from the same root as υω 'to rain', cognate with Latin *sucus* 'juice'. Ancient people seem to have mentally linked water and glass at many levels. Gemstones (crystal, κρυσταλλος, something hard, related to crust) were perceived as created from water inside the earth, thus involving two of the four ancient elements. And of course frozen water is ice.

The notion of glass as a supercooled liquid, rather like a metal, played into the ancient religious fascination with flowing water. The Christian Bible (Revelation 4,6) has a passage 'And before the throne [there was] a glassy (υαλινη) sea like unto crystal (κρυσταλλωι)', which picks up on Old Testament passages in Ezekiel and Job. Bible commentaries discuss those two Greek words, plus a one-occurrence Hebrew word and the Latin words used to translate them.

For the etymology of *vitrum*, in about AD 630, Isidore of Seville suggested **vid* 'to see' plus the agent suffix -*trum*, but that idea has not been generally accepted. Instead *vitrum* is usually linked with the PIE root **ued-ro* and hence with English water, or with **kwei-* and hence with white or its cognates like Indic *sweta* 'white' or Slavic свет 'light'.

It is unlikely that the glass objects Caesar saw were predominantly *caeruleum*-coloured. The ancient Egyptians had long made glass in many colours, including cobalt blue, while natural glass of volcanic origin was usually very dark (obsidian) though Libyan desert glass could be translucent yellow-green. The adjective *caeruleus* naturally means 'sky blue' because it probably developed from **caeluleus* (in which Romans found two Ls close together hard to pronounce), which came from *caelum* 'sky'. Most Latin authors used *caeruleus* like Caesar, though Lewis and Short (1879) suggested a darker sense, closer to 'navy blue'.

Tattooing

About AD 230, Herodian (3,14,7) wrote of the (northern) Britons that:

> 'They tattoo their bodies with coloured designs and drawings of all kinds of animals; for this reason they do not wear clothes, which would conceal the decorations.'

In the AD 200s, Solinus' Wonders of the World (22,12), as translated by Chadwick (1958), fairly explicitly described tattooing in northern Britannia:

> 'The area is partly occupied by barbarians on whose bodies, from their childhood upwards, various forms of living creatures are represented by means of cunningly wrought marks; and when the flesh of the person has been deeply branded, then marks of the pigment get larger as the man grows, and the barbaric nations regard it as the highest pitch of endurance to allow their limbs to drink in as much of the dye (*fucus*) as possible through the scars which record this.'

Archaeology has revealed decorative tattoos in a wide range of ancient cultures. Examples include Ötzi the ice man of about 3300 BC, Amunet the Egyptian priestess of about 2100 BC, and a Scythian chieftain of about 450 BC. Greek vases and Gaulish coins show what look like tattoos. Multiple Greek authors discussed high-status tattooed women in Thrace (modern Bulgaria) and in about 440 BC Herodotus told several stories about tattooing.

The ancient word for a tattoo was στιγμα or *stigma* (Jones, 1987), though until recently stigmata were often misinterpreted to mean brands, burned rather than inked into flesh. Jewish law forbade tattooing, an attitude that ultimately prevailed in Christian Rome and persisted until European sailors reached the south Pacific. However, some early Christians bore stigmata proudly as emblems of their faith.

Caesar would have seen many foreheads marked with "runaway slave" or similar disfigurements (Gustafson, 1997), a practice apparently imported to Greece and Rome from

Persia. In late Roman and Byzantine times, soldiers and armourers were tattooed on their arms, as described in about AD 400 by Vegetius and by the Codex Theodosianus (X,22,4), but this may not have been true in Caesar's day.

Some Egyptian mummies' marks have been described as blueish-black, and in about 300 BC Phanocles mentioned Thracians with blueish (κυανεα) marks. Jones (1987) told how tattooing at Jerusalem in the 1600s left permanent marks in blue and remarked on the "predominantly blue colour of the mark" of tattoos more generally. Classical words for ink (μελαν, *atramentum*) unequivocally indicate a black colour and ancient tattoos that have been analysed seem to have contained charcoal as pigment. So why blue?

Nowadays in the street one can still observe tattoos that started black and faded to blue. This is usually alleged to be caused by inferior ink, but one tattooist told us that pale, Nordic skin was the main factor. Human skin can naturally turn blue because of temporary pathology (bruising or cyanosis), or some birthmarks. The colour usually comes from venous blood low in oxygen but it can also come from particles under the skin. However, on the whole one must ask if any pigment(s) used in tattoo ink were inherently blueish.

In about AD 500 Aetius of Amida wrote Sixteen Books on Medicine, in which he gave a recipe for tattoo ink, which is widely translated incorrectly. Page 417 in book 8 of the Greek text available on the Internet includes this passage:

> μελανι δε χρωνται τοιουτω ακανθης Αιγυπτιας ξυλου και μαλιστα του φλοιου λι α χαλκου κεκαυμενου β κηκιδων β χαλκανθου α κοψας σησας λειου πρωτον μετοξους τον χαλκον επειτα και τα λοιπα λεια επιβαλων επιξεε υδατος μερη β και πρασου χυλου μερος α και ενωσας χρω, κεντων τους τοπους ταις βελοναις

The key components seem to be:

1 lb Egyptian acanthus (ακανθης Αιγυπτιας) wood and especially its bark
2 oz burned copper (χαλκου κεκαυμενου)
2 oz galls (κηκιδων)
1 oz chalcanthon (χαλκανθου)
all dissolved in leek juice

Egyptian acanthus sounds like an acacia, from whose sap comes gum arabic, a traditional binder for paints and inks, and whose bark would also be rich in tannins. Galls (tumours on trees, especially oak) are a rich source of tannins and sometimes of red dyes from insects inside. Leeks were a common vegetable with a juice considered beneficial.

In principle, χαλκανθου was blue vitriol ($CuSO_4$), but in practice it would have contained a lot of green vitriol ($FeSO_4$), which would have been the active ingredient that made the ink black. However, iron-gall complexes are not covalently bonded and are inherently doomed to fade inside a human body, which naturally maintains an extremely low concentration of free iron in body fluids as a defence against microbial infection. It is hard to predict how fast that fading would happen, but the long-term colour of the tattoo would surely result from any truly insoluble, non-dissociating materials in the ink.

Over 400 years before Aetius, Dioscorides (5,76) described χαλκου κεκαυμενου thus: 'Burned copper is good if it is red ... The black burned copper is burned more than necessary'. This sounds like a description of Cu_2O, which is red, and CuO, which is black. So our best guess to explain the blueish colour of tattoos reported by Caesar is that it results from a mixture of insoluble copper corrosion products (CuO, $CuCO_3$, etc) much like one can see on an old bronze coin or copper roof.

Picts

Hollywood's idea that ancient Britons were painted blue comes partly from the *Picti*, a name apparently first used in AD 297 to describe people from Scotland who raided late Roman Britannia. In fact the word Pict might not come from Latin 'painted' but rather from a local word for a piece of land, found in place names like Pitlochry, while other mentions of Picts

by Roman authors, notably Claudian, are mostly just poetic froth on top of ideas taken from earlier writers.

During Caesar's conquest of Gaul, the *Veneti* tribe were skilled seagoers living in Brittany. A coastal tribe living south of them was called *Pictones* or *Pictavi* , while north of them there was a leader called *Viridorix* 'green king'.

In about AD 400 Vegetius mentioned *pictae* as the name used by the Britons for some light naval warships (though he did not make clear whether they fought for or against the Romans), which had sails, rigging, and sailor's clothing coloured 'Venetian blue', presumably for camouflage. In fact the vital word is hard to read in the original manuscript and may really be *picatos* 'pitch-covered', describing the tree resin used to water-proof thin-skinned boats (Bennozzo, 2010).

It is often suggested that the name Britannia started out as **Pretania*, a P-Celtic version of Q-Celtic *Cruthin*, the Gaelic name of a tribe who might have been Picts. Here too there is a nautical alternative to consider, in Germanic words for plank (Dutch *brit*, German Brett, Old English *bred*), since sewn-plank boats were used around British coasts from before 1500 BC (Van de Noort, 2006).

Glastum

Possibly most influential in generating the false idea of blue-stained ancient Britons is a short passage in Pliny's Natural History (22, 1-2) of about AD 78:

> *herbis ... simili plantagini, glastum in Gallia vocatur, Britannorum coniuges nurusque toto corpore oblitae quibusdam in sacris nudae incedunt, Aethiopum colorem imitantes*

In English it means something like:

> 'a plant ... similar in appearance to the plantain, and known in Gaul as *glastum*, is used by the matrons and girls of Britain to stain the body all over, so they rival the hue of Ethiopians when taking part naked in sacred rites'

In that passage the word *Gallia* 'Gaul' played into past scholars' belief (traceable partly to French nationalism) that everyone in Gaul spoke a Celtic language in the same family as Welsh and Irish. In reality, Roman-era Gaul contained four language zones, of which only one (*Gallia Lugdunensis*) definitely had a Celtic-speaking majority, while Greek and Roman authors sprinkled around terms like Gaulish, Galatian, and Celtic almost interchangeably to refer to diverse tribes living further north in Europe. By Pliny's time, most people in Provence spoke Latin, while in the Belgic zone most people traced their roots to the German side of the Rhine and probably spoke Germanic dialects at home, even if they spoke Latin or Celtic to the ruling classes.

Woad slightly resembles the common plantain by growing in a rosette-shaped clump (during its first year) but not by the shape of its leaves (*plantago* = 'foot-shaped'). However, woad's unprocessed sap is pretty useless for staining skin, certainly not to Ethiopian darkness. Wiener (1921) wondered if this passage arose as an interpolation to Pliny's text by a scribe mistakenly linking *glastum* with *arnoglosson* 'plantain' (literally 'lamb's tongue').

The whole issue of ancient colour words is discussed below, but the hypothetical **glasto-* 'blue', cited by proto-Celtic and Indo-European dictionaries as a precursor of modern Welsh/Cornish/Breton *glas* 'blue, green, grey', is definitely a mistake. In fact the closest parallel to *glastum* in the Latin of Pliny's day was *glaesum* 'amber', a word loaned from Germanic.

Our best guess to explain Pliny's *glastum* is the dandelion, which grows a bit like a plantain and has sap that is notorious for staining skin. Dandelions give by far the most prominent splash of yellow in northern grassland, but their absence from early herbals (despite being edible and pharmacologically active) suggests that they were not common around the Mediterranean. It is easy to imagine northern maidens picking dandelions for the sake of eyeliner or a fake tan, or the type of temporary skin decoration with dyes such as henna or turmeric that is still popular in hot countries today.

Indigo

Woad enters the blue-Britons story because it was the main source in temperate climates of the blue dye indigo, and because many people (for example Carr, 2005) seek to project mediaeval agricultural practices and modern chemical ideas back into Iron-Age Britain. Normally we are sympathetic to this kind of argument, because the ingenuity of ancient craftsmen tends to be underestimated, and because technologies so often get lost and then reinvented over the centuries. However, on balance, it seems very unlikely that *omnes Britanni* had access to enough pure indigo to colour their skin blue.

Indigo has been a mainstay of the dyer's craft as far back as archaeology can look (before 2000 BC), because it is the only blue dye that is light-fast and readily available in nature. Nowadays, chemically synthesized indigo is most familiar in blue jeans, but natural indigo is being revived by modern craft dyers. See, for example, *www.woad-inc.co.uk*. Indigo was definitively reviewed by Balfour-Paul (1998, 2006), while Cooksey (2012) has provided a thorough bibliography. For natural colorants more generally, see Bechtold and Mussak (2009) or *www.vscht.cz/lam/new/banc.pdf*.

Indigo was hard for ancient craftsmen to understand because it is very insoluble in water, but it dissolves (and becomes colourless) if it is (a) chemically reduced, and (b) made alkaline. Fabric dipped into that solution and lifted out into the air will gradually turn blue, as if by magic, as indigo precipitates onto the fibres. Besides being the only reliable blue dye, indigo was also the key to strong greens, purples, and really dark black, so most early civilisations around the world used it very actively.

Literally hundreds of plant species (plus some marine animals) make significant amounts of indigo, and more than 20 species have been used commercially at various times and places. Historically, the plant that produced the most and the best indigo was *Indigofera tinctoria*, which grew well in India, especially in British colonial Bengal. Woad is an altogether different plant, *Isatis tinctoria*, capable of growing in temperate climates.

The simplest way to use indigo is to stew up leaves of a suitable plant with an alkali, such as lime, wood ash, or stale urine, then let bacteria grow in the mush. A more sophisticated process (used by the woad industry in mediaeval Britain) is to chop up leaves and let them ferment for several months while indigo breaks free from its chemical combination inside the plant. Balls of semi-dried leaves can then be stored for use later and/or elsewhere. The most advanced process is to boil up the leaves in lots of water, which is then oxygenated to precipitate out fairly pure indigo, which can be dried and traded over long distances.

From antiquity until quite recently the standard way to dye fabrics with indigo (no matter how close to its leafy origin) was in a big vat de-oxygenated by bacterial growth. It is hard to imagine anyone volunteering to be tattooed with that horrendous soup, though dye workers had chronically blue, smelly hands. Wool was relatively easy to dye, but even that might require multiple dunkings.

Pure indigo is non-toxic and can be ground up and used as a pigment in ink or paint, so until recently it was used for tattooing in Arab lands (Balfour-Paul, 2006, p225). However, there seems to be no evidence that pure indigo was made in ancient Britain, or that enough arrived in trade to make it cheap and widely available. Maybe the best indigo-source plants grew in hotter countries or maybe the technical skills never arrived from the East. John (2009) wrote that many species can be cultivated to produce fairly similar amounts of indigo (up to 0.5% of dry weight of leaves) but there tend to be differences in the purity of product, while cleaning up the leaves to remove soil and unwanted plant matter can be critical.

Pliny (33,57) wrote that *Non pridem adportari et Indicum coeptum est*: '*indicum* has not long been imported'. Both Dioscorides (5,107) and Pliny (35,27) described *indicum* as coming from the froth of Indian reeds. At face value, this suggests that indigo, made in India from *Indigofera*, started reaching Rome some time before AD 70. Most authors, for example Balfour-Paul (2006), accept that ινδικον and *indicum* were so named because of this Indian origin, but Loret (1889, p177) firmly stated that the name really came from *terneken* or *ti-*

inkon mentioned in several Egyptian inscriptions. Earlier (Loret, 1887, pp 41-42) quoted a spelling of *dinkon*.

Pinning down the ancient indigo trade to definite dates, plant species, and countries of origin is a tricky problem on which we and others have had limited success. Key elements of the ancient dyers' heritage passed through an Arab filter, notably the Sanskrit word *nil* 'indigo' leading to the English word aniline. The rise of Islam after AD 632 was a political earthquake, which cut the trade routes into the Mediterranean from the hot-country sources of indigo (Yemen, India), killed off the ancient Phoenician industry of making Imperial Purple from shellfish, and ultimately led to the capture of Byzantium in 1453.

Imperial Purple was made by fermenting shellfish glands in alkaline anoxic solution (Koren, 2005). It contained mostly dibromoindigotin (purple), plus monobromoindigotin (blueish purple), indigotin (blue), and other compounds, but selecting particular types of shellfish yielded the blueish shade called *tekhelet* in Jewish scriptures and a Babylonian tablet (Ziderman, 2008). Biggam (2006) cited evidence for small-scale production of shellfish purple near Britain before AD 700.

Van der Veen, Hall and May (1993) found 18 seed pods from woad at a British Iron-Age archaeological site and cited other evidence for early north-European woad. Actually, the strongest reason for thinking that woad was grown in pre-Roman Britain is just that vat dyeing (warm, alkaline, and anoxic) is so simple – not greatly different from making beer. Even if the trade secrets of Tyrian shellfish dyers did not leak across the Channel in the Iron Age, there was so much demand for blue-dyed cloth, or at least thread, that the process must surely have been discovered independently by enterprising British craftsmen.

Woad

Woad is a well-defined plant species that still grows vigorously as a weed in parts of Europe and America. However, one cannot be sure how closely modern woad cultivars resemble ancient woad, because crop plants change genetically over the centuries. More seriously, the word 'woad' has been used very uncritically in translations of ancient texts. Sometimes the context clearly refers to a plant yielding a blue dye, but often the original author's precise meaning is highly debatable.

One cannot even fall back on pragmatically accepting 'woad' as meaning 'indigo-yielding plant', because early usage seems to have been far looser than that. The big Anglo-Saxon dictionary of Bosworth and Toller (1898) translates Old English *wad* as 'woad', but then cites six Latin glosses, of which none refers to a plant that provides indigo: 3x *sandyx*, 2x *hyacintho*, 1x *fucus*. Those numbers expand to 12x, 4x, and 2x in the larger corpus of Old English glosses online at *http://oldenglish-plantnames.org*, but still none points to true woad.

Sandyx or *sandix* implies a reddish colour, probably from the madder plant, because it was the Latin name for the mineral cinnabar (HgS). *Hyacinthus* implies a blueish-purple colour because it was Latin for the blue iris and was used by Bible translators for *tekhelet.* *Fucus* or φυκος was a general classical name for cosmetic paints such as rouge, especially coloured with orchil, from the lichen *Roccella tinctoria*, otherwise known as 'poor man's purple'. In about 30 BC Propertius (*Carmina* 2, 18B, 1-4) mentioned a lady's brow coloured *caeruleo fuco*, where it is hard to decide what colour was intended.

One could discuss at length how far those glosses refer to a colour rather than to a plant and how well monkish scribes understood dyeing technology. However, the core conclusion seems to be that *wad* was a general word for dye plants, possibly with a bias towards the red to blue colour range. In this generality, woad resembles other English agricultural words, such as weed, wort, bean, corn, and pea.

Much the same holds for old German *Weit* (and variant spellings), glossed 9x by Latin *sandix*, 1x *sandaraca*, and 1x *isatis* (Björkmann, 1908). The plant Dyer's Rocket yields a yellow dye, yet its other English name is weld and its young plants look very like woad. The words weld and woad may even be etymologically related, a confusion that is shared by other

European languages. French has *guède* and *gaude*, both probably loan words from German, which suggests that the word did not exist in Latin.

Four place names in Britain are cited by Hallam (1988) as based on *wad* – Watton 969, Wadborough 962, Waddon, 1086, Woodhill 1086 – and several smaller places have been suggested elsewhere. In those names *wad* might well refer to a dye plant, but not necessarily woad, for which a better candidate may be blue in place names such as Blofield, Blowhead, Blowen, and Blurridge. One Old English textual citation suggests smearing *wad* on burns, not using it as a dye.

Woad has been investigated for possible medical uses, partly inspired by Hippocrates and Pliny, but also by the use in traditional Chinese medicine of another indigo-source plant, *Polygonum* or dyers' knotweed. *A priori*, one would not expect woad to be much different from other brassicas in pharmacological activity, or more useful than dozens of other plants in making astringent poultices. However, coloured substances are popularly perceived as effective medicines: think for example of such antiseptics as acriflavine, permanganate, or iodine. In fact, some substances that occur in woad extracts as impurities alongside true-blue indigotin, notably indirubin, do show promising biological activity. See Leclerc (2001) for an entry into this research.

Other dyers' plants

If 'woad' cannot be pinned down linguistically, how about botanically? Ancient dyers used a wide range of materials, of animal, vegetable, and mineral origin, to produce colours from red to blue, broadly known as purple. Double-dyeing was particularly common, with a red dye (usually madder) and with indigo (from any of 20-plus plant species). Many dyes change from red to blue when made alkaline, including orchil, litmus, or red cabbage juice, but we know no way to fix the alkaline colour on cloth. Alkanet, *Anchusa tinctoria*, of the borage family, was much used for its reddish, or burgundy, colour.

A recurrent theme in this article is that colours previously attributed to woad may really have been due to metal salts interacting with plant materials. So Pliny's chapter 33,57 is interesting. Separately from his mention of indigo, Pliny described three kinds of *caeruleum*, which were probably three types of blue copper mineral: *tinguitur autem omne et in sua coquitur herba bibitque sucum* 'every kind [of *caeruleum*] is immersed and boiled with its plant and it takes up the sap'. What was Pliny really describing?

Ancient authors did not always distinguish organic products (such as dried indigo) from inorganic products (such as blue vitriol). For example, they saw nothing incongruous in adsorbing plant dyes onto minerals to change their colours. Also they did not know all the trade secrets of dyers, especially in places outside the Roman Empire, and they must have found the action of mordants, metal salts that help dyes (though not indigo) bind tightly to fabric, very puzzling. Then there were all the accessory uses of plants: to provide alkalis (from ashes), tannins (for use with leather and in ink), detergents (from soapworts), and of course the fibres to be dyed.

Ideas do not necessarily get transmitted down the generations and "since prehistory we have lost more technologies than we have gained" (Spinney, 2012). In Britain, many technologies largely died out during the climatic downturn and economic collapse of the "Dark Ages", only to reappear centuries later. If woad-growing is to be put in that category, one must ask what else – notably uses of vitriols – belongs there too. Was the ability of ferrous sulfate to reduce indigo chemically, and avoid the need for microbial fermentation, really not discovered before the 1800s? And did those 'Venetian Blue' sailors of Vegetius discover the fungicidal action of copper long before the use of Bordeaux mixture on vines from 1885 and copper soaps on fishing nets from 1911?

Isatis

The botanical name of woad is *Isatis tinctoria*, but this was bestowed in 1753 by Linnaeus because he linked woad back to a plant called *isatis* or ισατιν by classical writers. In that he

was following earlier writers, notably Fuchs (1542) who was often wrong in finding German equivalents of Mediterranean plants. But was ancient *isatis* really the woad plant?

Perhaps the most solid evidence about *isatis* comes from some land leases written in Greek between AD 100 and 400 on papyri recovered from an ancient rubbish dump at Oxyrhynchus in Egypt, where the texts cannot have been distorted by mediaeval scribes. At least 12 such leases contain a clause permitting any crops to be sown and gathered χωρις ισατεως 'except *isatis*' and one other hard-to-translate word that may mean coriander

This prohibition against *isatis* has been much discussed. Maybe the Jewish objection to blue vegetable dyes persisted in Christian Oxyrhynchus. Renner (1970) argued that woad tended to exhaust soil fertility (because it needs a lot of nitrogen, unlike *Indigofera* species that are leguminous and fix their own nitrogen) but *isatis* is not in the list by Pliny (17,7) of seven crops known to the ancients as soil exhausters. Woad is also invasive, and considered a "noxious weed" in some US states (Zouhar, 2012), perhaps because of its many seeds, deep and wide roots, a tendency to poison other plants, and avoidance by browsing animals.

The earliest known mentions of *isatis* were in about 400 BC by Hippocrates. He recommended treating reddened (presumably infected) wounds with a poultice moistened with *isatis* juice (χυλω ισατιδος) made by pounding its leaves (φυλλα ισατιδος) in *De Ulceribus* 11 and then mentioned ισατιδος φυλλα again in *De Affectionibus* 38.

Hippocrates twice described a sick patient's watery excrement exposed to air (in Epidemics 2,3 and 4,45) as becoming ισατιδει. This sounds very like production of indigo from the dietary amino-acid tryptophan, as may have occurred in King George III's illness (Arnold, 1996).

Galen (about AD 200, 5,11 in the Kühn edition) wrote that "black bile" was called ισατωδης because ισατιδος was γλαυκης 'blue/grey/green'.

The Stockholm Papyrus (Caley, 1927) is a set of 153 recipes written in Greek, which read rather like the laboratory notes of an early experimental chemist. It was found near Thebes in Upper Egypt and was probably written around AD 300, though it seems to embody much earlier knowledge. Just under half of the recipes refer to dyeing, and ισατις is mentioned five times (in sections 101, 104, 117 and 120), plus several more times when it is not named but is the implied subject of sentences, and there are two mentions of ινδιχος (sections 64 and 79).

Some of this papyrus very obviously describes indigo dyeing, as practised centuries later: cutting and crushing the plant, drying it to 'charcoal', then stewing that up in a vat with urine and soapwort. However, indigo blue seems not to have been valued in its own right, but only as a component of various shades of purple dye for cloth or to make gemstones look green.

This papyrus recommends taking *isatis* foam from the dyer, which sounds mysterious until one recalls (a) the mention of soapwort (στρουθιον, a natural foaming agent), (b) that Pliny and Dioscorides wrote about the foam of Indian reeds, and (c) the modern practice of de-inking waste paper with foam. Evidently ancient dyers had worked out empirically that indigo would collect in a hydrophobic layer of scum on top of a vat in which they were stewing fabric in a stinky mess of *isatis* leaves etc. That scum could be dried as a more concentrated form of indigo to sell.

Two other ancient mentions of *isatis* may not refer to a plant. In about 300 BC, Theophrastus (On Sense Perception, 77) expounded Greek theories of colour and wrote that the hue of ισατιν was composed of deep black and greenish-yellow (χλωρου), while light green (πρασινου) was composed of purple (πορφυρου) and greenish-yellow. He went on that dark blue (κυανουν) was from *isatis* (ισατιδος) and fiery red (πυρωδους). In this context *isatis* appears to signify a colour, not a plant. Theophrastus' text went on with a curious mention of 'needle-shaped figures' to make the colour gleam, which sounds very suggestive of crystals from a mineral pigment.

In about 20 BC, Vitruvius (On Architecture 7,14,2) wrote:

> ‘Those who cannot afford the use of *chrysocolla* [probably malachite] mix *caeruleum* with the plant called *luteum* [yellow, presumably dyers’ weld] and thus obtain a brilliant green. These are called *infectiva* [dyers’] colours. Also, because of the scarcity of indigo, *vitro*, which the Greeks call ισατιν, is mixed with *selinucian* or *anularian* earth, to make an imitation of the colour of indigo.’

This Vitruvius text would make good chemical sense if his *vitrum* was mainly copper sulfate and the other two mysterious minerals were alkaline carbonates. The phrase ‘*vitro*, which the Greeks call ισατιν’ might be a mistake by Vitruvius or a later addition to his text. In general, the way that ancient manuscripts got transmitted to modern times is always a huge concern. For this article we have tried hard to track down the best source texts, and have often needed to prepare fresh translations into modern English. Reader beware. There is no such thing as a perfect translation.

This warning applies particularly to the two main sources of information about ancient *isatis*, both written around AD 70, independently but drawing on some common sources. Dioscorides’s *De Materia Medica* (written in Greek) suffered from mediaeval copyists adding phrases to advance their prejudices or (as they might see it) to help readers understand the text. Then later copyists sometimes blended these glosses into the original author’s text. Pliny’s *Naturalis Historia* (in Latin) may also have been affected by mediaeval copyists, but its sheer scale (like the Wikipedia of its day) makes its information not always reliable.

Here are three mentions of *isatis* by Dioscorides, based on the master Greek version and section numbers of Wellmann and the fresh translation by Beck (2005). First (2,184):

> ‘The ισατις, which the dyers use, has foliage like the plantain’s, but shinier and darker, and a stem over a cubit long. When used as a poultice, its leaves are able to dissipate every swelling and growth; they close bloody wounds, stem haemorrhages, and treat cancerous sours, shingles, and erysipelas.’

And then (2,185):

> ‘The ισατις αγρια, which closely resembles the one the dyers use, has leaves that are larger in relation to the leaves of the lettuce, and many delicate and much-cloven reddish stalks. From their tip, as if hanging, there are many tongue-like little sacks containing the seed; the flower is quince-yellow and delicate. It is capable of the same results as the one before it; it also helps people with spleen disease when drunk and when plastered on.

And then (4,132):

> ‘τριπολιον [almost certainly the sea aster, *Aster tripolium*] has leaves closely resembling the leaves of woad but thicker’.

Other manuscripts of Dioscorides contain extra text, presumably glosses added later. One whole paragraph by a Byzantine commentator, started off ‘One must consider faulty the information on *isatis*’ and then went on to accurately describe a plant that Riddle (1984) thought was *Vaccaria pyrimidata*. The manuscript imperfectly translated by Goodyer in 1665 (Osbaldeston, 2000), added that the first ισατις was ‘also called *augion*, or *egne*, the Magi call it *arusium*, and the Romans *ruta*’, while the second ισατις was ‘also called *egne parva*; the Romans call it *ruta minor*.’

Pliny (20,25) mentioned four varieties of wild lettuce. The third kind grew in woods not fields, was called ισατιν and its leaves ground up with polenta were good for treating wounds. A fourth kind was used by dyers of wool, and had leaves like those of sorrel but more numerous and darker. It could staunch blood and heal wounds that were putrid and spreading, as well as rodent ulcers or non-suppurating tumours, and its root was medically useful.

Pliny (26,22) wrote that *tripolion* had *folium isatis crassiore,* ‘thicker leaves than *isatis*’, but also (27,60) that ‘*Glycyside*, which some people call *Paeoniam* or *pentorobon’*, had *folia qualia isatis* ‘leaves like *isatis*’.

Maybe some experienced botanist can make sense of all this. Some features are strongly suggestive of woad (yellow flowers, tongue-like seed pods) but there are difficulties about the leaves. Similarity to plantain and sea aster would fit woad, but the multi-lobed leaves of rue or peony sound more like *Indigofera*. And Pliny must have known that the distinctive feature of the whole lettuce family *lactuca* was to have milky sap and probably also that some wild lettuces are mild narcotics. Woad does not have milky sap and Pliny anyway implies that ισατιν was not the dye plant.

At least four silver ingots have been found stamped with EX OFFI ISATIS, which the excavators translated as 'from the workshop of Isas' and dated to around AD 400.

Many books try (unconvincingly) to link *isatis* etymologically with woad and *vitrum* via Latin *vis* 'strength' and a hypothetical precursor **wisatis* with an initial W sound (Greek digamma). Linking *glastum* to Spanish *guasto* is no better. Other vaguely similar words include Sanskrit *asita* 'black, blue', plus an Egyptian goddess *Seshat* whose rope was made from *jms.t* or *ameset* 'hemp'. If Greek ις 'sinew, plant rib' acquired a suffix, like κλημα 'vine twig' led to κληματις 'clematis', ισατις could have started out meaning 'blue thread'.

Perhaps the most likely etymology was suggested by Verhille (2009) on the basis that dyers' plants may have been mixed up with herbalists' plants from the most ancient times, and that the yellow-dye plant weld was given a Latin name *Reseda* 'settled down'. If *isatis* was first named for a pharmacological action of reducing swelling, in a Greek-speaking area, before it was taken up as source of blue dye, it might be derived from the verb ισαζω 'make equal'.

The idea that ancient *isatis* was a form of woad, a plant in the modern genus *Isatis*, seems to be plausible, but not confirmed. Our hesitation arises from ancient texts' chronic confusion between *isatis* and other plants (Indigofera, Polygonum, plantain, rue, weld) and between plants and colours. Modern translaters would be wise to leave *isatis* always untranslated, with woad consigned to a footnote.

Blue materials in Egypt

Ancient Egypt seems to have greatly appreciated the colour blue, for which the words used in hieroglyphics have been variously reported as *irtyw*, *ssyt*, *terneken*, *ti-inkon*, *uab,* and *thur*. From early in the Bronze Age, before 2000 BC, and certainly by the time of Tutankhamun around 1330 BC, blueish materials used as gemstones or ground up to make paint included:

Egyptian Blue = artificially made, imperfectly fused $CaCuSi_4O_{10}$
faience = blue-green artificial glazes containing copper
blue glass = glass coloured with cobalt mined in Egypt
lapis lazuli = blue semi-precious stone (ultramarine), imported from Afghanistan
turquoise = blue-green semi-precious stone, mined in Sinai
azurite = copper carbonate, related to malachite, imported from Cyprus.

Indigo might have been used similarly, as a solid pigment, but it was certainly used to dye the textiles (usually linen) decorated in various blueish shades that have been reported from numerous ancient Egyptian tombs. Petrie (1908) found blue-stained dye vats at Athribis in Roman-era Egypt, and most likely the dyers mentioned in inscriptions and papyri from many centuries earlier operated much the same.

Did ancient Egyptian indigo come from woad or *Indigofera*? And was it grown locally or imported? Many writers suggest that woad was a logical crop to grow in the ancient Nile delta, because that region was integrated with the Greek world, and because climate favours woad north of the Mediterranean, including Anatolia, which may have been the original heartland of the whole woad genus. However, we have not seen any hard evidence to support that argument, nor even any well-founded opinion which plant would give the best yield of indigo under modern Egyptian conditions.

Our best guess would be that in pharaonic times, when the royal capital was at Thebes in Upper Egypt, indigo was obtained from *Indigofera* plants, not woad, and was called something other than *isatis*. Some *Indigofera* species grow wild in Egypt and the heartland

of the whole genus seems to be around Yemen and Ethiopia. This is probably the location of Punt, where Queen Hatshepsut sent an expedition in about 1470 BC, and was certainly the source of high-value plant products like frankincense that were actively traded via the Red Sea and the Nile towards the Mediterranean (Bernstein, 2008).

Whether indigo know-how moved from India to Egypt, or vice versa, or they both developed the technology independently, is at present unknowable. The Mohenjo-Daro civilisation in the Indus valley was dyeing fabric around 2500 BC, but it is important to remember that a timescale of millennia tends to include multiple climatic cycles plus rises and falls of entire civilisations.

Colour words

Woad and glass are far from the only words that did not always mean what they mean now. Most English speakers unthinkingly assume that the names of colours, such as 'blue', follow naturally from human physiology and the laws of physics. In fact colour language is remarkably non-universal and non-obvious, much discussed by academic linguists, especially since the seminal book of Berlin and Kay (1969) about Basic Colour Terms.

Germanic *glaesum* 'amber' and Welsh *glas* 'blue' are fundamentally the same word, yet they describe two colours that are complementary (optical opposites). This is just one example, among many, of colour terminology in ancient texts that looks very odd to modern eyes. Ancient people initially named colours as salient properties of particular objects, and the semantic development of particular words into abstract concepts, signifying particular ranges of colours, often proceeded differently in different regions.

The English word blue is particularly noteworthy (Biggam 1997, 2006b). Anglo-Saxons would not normally have used a word ancestral to blue, but would mostly have used *hæwen*, related to modern hoary. Most likely, *hæwen* started out meaning 'mouldy, downy' and developed from there to mean 'cool, pale' and then to shades of blue more generally.

The earliest uses in Britain of words like *blue* applied to fair or golden hair, not to the modern hue. Latin *flavus* 'yellow' is cognate with **blewaz*, the proto-Germanic ancestor of Old English *blæwen* and modern German *blau*. A separate line of development from that Germanic ancestor led to late Latin *blavus*, then to French *bleuet*, which crossed the Channel with the Normans, but with primary meaning 'dark blue', particularly as applied to dyed fabric. Even in Shakespeare's day the word blue had not fully settled down to its modern sense.

Modern Welsh is not particularly unusual among languages in that its *glas* covers a range of hues from blue to green to grey. Greek γλαυκος 'light blue, greenish, grey' is similar, but in Homer's day it meant 'gleaming', related to γλαυσσω 'to shine'. The idea that *glas* developed from a proto-Celtic word **glasto-* 'blue' is obviously wrong, but maybe *glas* came from something closer in sense to *glais* 'stream, rivulet'. Irish dictionaries cite *glaise* as 'rivulet, stream, greenness' ahead of 'blue'.

The University of Wales dictionary of Welsh traces *glas* back as far as the 12th century, with just two earlier citations. One is *glastum*, which is circular logic. The other is a Welsh chieftain addressed by Gildas in about AD 540 as *cuneglase, romana lingua lanio fulve*, which appears to mean that *Cuneglasus* was Latin for 'tawny butcher'. This clear equation of *glasus* with *fulvus* 'deep yellow' is often ignored because later forms of that name, such as *Cynglas*, look like modern Welsh for 'blue dog' or 'greyhound'.

Cune most likely meant something like 'king', related to kin and to Latin *genus*. *Cuneglasus* probably had fair hair, a feature often attributed to semi-legendary heroes, such as Achilles, Alexander the Great, Boudicca, and Baedan of the Yellow Hair. Gildas even gave a nod to that interpretation (as part of his general fixation on animal metaphors) by addressing *Aurelius Caninus* as *catule leonine* 'lion's cub'. The Roman family name *Aurelius* meant something like 'golden' and probably also referred to fair hair.

Another equation between *glas* and *fulvus* was made by a Breton monk Wrmonoc in AD 884. In about AD 800 an Old Irish gloss (on Philargyrius' *explanatio in Bucolica Vergilii*) equated *glas* with Latin *croceo* 'saffron yellow'. On the next line *glaus* glossed *sandix*, red from madder. Latin *glaucus* was used for the colour of a horse by Isidore of Seville and for a cat's eyes by Servius, both suggestive of 'yellow' but perhaps better interpreted as 'shining'.

Pliny (17,4) mentioned *glisomarga* as a type of marl dug from deep underground in Gaul and Britain to fertilise soil. Nowadays this process is understood as restoring calcium carbonate and other minerals to rain-leached soil, for which the best material to dig is chalk with a small content of clay. So the element *gliso-* most likely meant something like 'off-white' or 'grey'. Delamarre (2003) reckoned that *gliso-* continues in French *glaise* 'clay'.

The old propensity for everything Gaulish to be claimed as Celtic seems to have stopped scholars looking closely at another sentence by Pliny: *columbinam Galliae suo nomine eglecopalam appellant* 'the Gauls' name for the dove-coloured [marl] is *eglecopala*'. This looks very like Old English *aglæca* 'miserable wretch' plus *pal* 'spade', and it is hard to imagine a better description of marling than 'misery with a spade'.

Modern English glass, glisten, glow, gloom, glitter, etc can all be traced back to a PIE root **ghel-*, but so too can words in other European languages that mean gold, yellow, green, blue, iron, river, smooth, etc. Interesting examples include Polish *złoty* 'golden', Lithuanian *zleja* 'twilight', and Greek names like Γλαυκιας 'sparkling, the moon'. Pokorny (1959) allocated separate PIE roots to Latin *glacies* 'ice' and to Greek γαλα 'milk, sap' (plus Latin *lactis*, *lactuca*, etc), but we suspect that they really belong to the **ghel-* family.

Modern Russian has developed the **ghel-* root into some quite distinct colour words (голубой 'blue', жёлтый 'yellow', and зелёный 'green'), while Lithuanian has five distinct but related words for 'gray', 'blue', 'green', 'gold', and 'yellow'. Wiener (1921) drew parallels with Arabic and argued that the deep root of glass, *glas* and *glaesum* was an ancient word for the half-light of dawn.

Copper or Iron?

It is strange that people ever equated Pliny's word *glastum* with Caesar's word *vitrum*, because Pliny (34,32) himself likened *vitrum* to *chalcanthon*, which was probably an impure mixture of copper and iron sulfates:

> 'The Greeks, by the name which they have given to it, have indicated the relation between shoemakers' black and copper; for they call it *chalcanthon*. Indeed there is no substance so singular in its nature. It is prepared in Spain, from the water of wells or pits which contain it in dissolution. This water is boiled with an equal quantity of pure water, and is then poured into large wooden reservoirs. Across these reservoirs there are a number of immovable beams, to which cords are fastened, and then sunk into the water beneath by means of stones; upon which, a slimy sediment attaches itself to the cords, in drops of a vitreous appearance, somewhat resembling a bunch of grapes. Upon being removed, it is dried for thirty days. It is of a *caeruleus* colour, and of a brilliant lustre, and is often taken for *vitrum*. When dissolved, it forms the black dye that is used for colouring leather.'

This is instantly recognisable as the leaching process still used to extract copper sulfate today. Until 1828 it was also used to produce ferrous sulfate, on Copperas Street in Deptford, as described in one of the world's earliest scientific papers by Colwall (1677). Nodules of iron sulfide, harvested from the shores of the Thames estuary, were piled into large tanks to air-oxidise, thereby generating a dilute solution of sulfuric acid and ferrous sulfate. Scrap iron was added to increase the yield and keep the iron reduced to the ferrous state (until the acid became a valuable chemical in its own right), which was then used to make ink and paints.

Pliny would have recognised Brownsea Island in Poole Harbour in the 1690s (Fiennes, 1949):

> '... place them on ground raised like y^{e} beds in gardens ... so y^{t} y^{e} raine disolves y^{e} Stones and it draines down into trenches and pipes ... and so as y^{e} Liquor boyles to a

candy it hangs on those branches ... it look'd like a vast bunch of grapes. Y^{e} Coullour of y^{e} Copperace not being much differing it lookes cleare like Suger-Candy.'

The confusion between copper and iron that persisted for millennia is not surprising because:
(1) Copper and iron ores often occur together, especially in chalcopyrite and in Cyprus.
(2) Water passing through mines or spoil heaps often has a coppery colour, from ferric iron.
(3) Scrap iron placed in copper-salt solutions becomes coated with metallic copper.
(4) Ferrous sulfate has a similar pale green colour to copper corrosion products.

Purifying salts by recrystallization is a simple technology, known since the dawn of agriculture, when common salt started being used to preserve food. So at least some of those dirty "bunches of grapes" must have been cleaned up into beautiful crystals and named, ironically, after the ultimate non-crystalline material – glass. However, it is unlikely that many ancient people understood that blue, green, and white vitriols were sulfate salts of different metals, with water of crystallization that could come and go. Ancient texts' association between iron and tattooing were perhaps metaphorical references to needles and to the mines where many tattooed criminals were sent.

Green vitriol on its own is not strongly coloured. Ferrous salts are pale yellowish-green in solution or as hydrated crystals but they readily oxidise and darken to the reddish brown (like rust) of ferric salts. The only intense blue pigment built around iron is Prussian Blue, which is unlikely to have been known in Roman times, and there is no evidence that any ancient dyer performed the conceptually simple experiment of evaporating down a solution of indigo and vitriol to make Saxon Blue.

One experiment that is easy to do now is to add a trace of iron or copper sulfate to a tannin solution made by liquidizing some oak tree galls. The iron makes an intense black whereas the copper makes a much lighter brown. The conclusion seems inescapable that it was the iron in ancient *chalcanthon* which made tattoo ink black, when it formed a complex with gallic acid and other tanning elements from tree bark and galls.

So why was there copper in the ink? Was it just "along for the ride" because ancient vitriol was an inherently mixed commodity from the leach water of mines dug primarily for copper? Or was copper deliberately included to add a touch of blue-green to tattoos? Or to make the ink just that little bit blacker? At the very least, whether deliberate or not, copper would have served to keep the ink sterile and not a gross infection hazard or covered in mould.

Hydrated copper sulfate is a rather pretty blue, but too water-soluble to be useful as a pigment. In about 300 BC Theophrastus (On Stones: 31,39,51,55) named as κυανος three blue pigments known to the ancient Greeks: lapis lazuli, azurite, and Egyptian Blue. An important practical issue with some pigments was that grinding their crystals finely made them fade towards white, which limited their use in paint. Vitruvius (7,11) used the term *caeruli temperationes* 'blue mixtures' for Egyptian Blue manufactured near Naples.

For a clear explanation of ancient knowledge of copper minerals see Caley and Richard (1956). *Chrysocolla* (literally 'gold glue') was malachite, copper carbonate, but the name was applied to any bright green mineral associated with copper deposits and is used in modern times for a slightly different mineral.

Amber

In about AD 98, Tacitus (*Germania* 45) wrote that a people called the *Aestii* living beside the Baltic Sea resembled their Germanic *Suebi* neighbours but had a language that was 'more like the British'. He went that they were 'the only people who gather amber, which they call *glesum'*. The name *Aestii* hints at Latin *aestuarium* 'saltmarsh', which fits the Vistula lagoon beside what is now Russian Kaliningrad where most amber originated.

Because the *Aestii* language was 'like the British', people have tried to argue that it was Celtic. Very unlikely. Baltic (akin to modern Lithuanian) or Slavic are possible, but Germanic is by far the most likely because of proximity to the Baltic island of Gotland. That

whole maritime zone seems to have enjoyed a population boom in the Roman warm period that set off the migrations of the Goths, Burgundians, etc.

Pliny (37,11) wrote that 'amber is called *glaesum* by the Germans' and mentioned the island of *Glaesaria* (probably near Heligoland), which seems to have been a trading point for amber. Pliny knew that most amber came from the 'northern ocean' and was traded towards Rome by Germans. He understood its origin from the *sucus* 'sap' of trees, so that the normal Latin name for amber was *sucinum*, and that it was also called *electrum* from the Greek.

Latin dictionaries are happy to cite *glaesum* 'amber' as a loan word from Germanic related to modern English glass. Trade in amber is very ancient (Rice, 2006) and may have started before trade in glass. *Glaesum* was not a primaeval word for amber (judging by the remarkable diversity of words for amber in European languages) but probably meant something like 'transparent', from the PIE root **ghel-* discussed above. Any sense development towards the range of colours of amber (from pale yellow to quite deep red) presumably happened later.

In the Old English of Alfred's day *glaer* meant 'amber'; presumably this evolved from *glaes* by rhotacism, the common S-to-R change seen for example in was/were. Old Norse *gler* 'glass', led to Icelandic *glaer* which underwent a Celtic-style sense development from 'transparent' into 'sea'.

Glastonbury

Probably the best-known glassy place name is Glastonbury. The earliest recorded form of its name seems to have been *Glastingei* (in Anglo-Saxon charter S257 of AD 745), followed by a monk's letter mentioning *Glestingaburg*, and the Anglo-Saxon Chronicle's statement that King Ine built *Glaestingabyrig* in 688. Translations into Celtic *Ynswytrin* etc are an irrelevant confusion, introduced by later authors with agendas to pursue, notably William of Malmesbury, who was employed by Glastonbury Abbey. See Gray (1935), Finsburg (1964), Ekwall (1980) and Grimmer (2003) for relevant references and previous attempts to explain the name.

Previous analyses of *Glastingei* have sought to divide it *Glast-inga* ('Glast's people'), but Germanic glass-tinge-island or Latin *glaesum-tingeo* 'amber coloured' actually make better topographical sense as a description of the Chalice Well, a chalybeate 'iron-containing' spring near the foot of Glastonbury Tor. This natural spring would probably have been a focus of pre-Christian religion (as at Bath), but it was built over in mediaeval times to provide a water supply for Glastonbury Abbey, then buried under four metres of sediment, so it escaped the common fate of becoming a spa after 1670 (Mather and Prudden, 2005). Chalybeate springs typically attract names like Red Well or Red Rise, because of reddish ferric deposits or water that runs noticeably rust-coloured when its iron interacts with vegetable tannins.

Glassenbury (*Glestingeberi* 1301 etc) in Kent is a nearly identical twin (or possibly a copy) of Glastonbury (Wallenberg, 1934). It lies in the main iron-producing area of ancient Britain, the Weald, near the source of a small stream from a chalybeate spring at position TQ746368. To its west, just beyond the fashionable spa town of Tunbridge Wells, lies Rusthall (*Rusteuuellæ* c770).

Glazenwood House in Essex has a name that Breeze (1998) traced before 995. Nearby springs feed the river Blackwater, though they are not obviously mentioned among the many chalybeate springs of Essex. Gleaston (Domesday *Glassertun*) in the Furness region of Cumbria is traversed by Gleaston Beck, which runs from the iron ore mining district around Lindal and often still runs quite red even though mining has long ceased.

Another chalybeate spring is at Gilsland Spa, near Red Beck Bridge and Hadrian's Wall. This area was strategically important in Roman times because it lies at the watershed from where one can descend by river to the east coast of Britain or the west. The nearby Wall fort of *Banna* 'peak' had a substantial garrison and adjacent *vicus*, so either that whole area was

farmed intensively or supplies were brought up regularly from Carlisle. Selkirk (2001, p128) even wondered if the Roman commitment to water-borne logistics caused them to dig a summit-level canal to link the Tyne and Solway catchments near Gilsland, roughly along modern Pow Charney Burn.

Gilsland has a curious link to Glastonbury, where the monks so conveniently claimed to discover the body of "King Arthur", because the Hadrian's Wall fort of *Camboglanna* (modern Castlesteads) is a strong candidate for *Camlann* "where Arthur and Mordred perished". Analogous watersheds were the sites of two other early British battles: Dyrham in AD 577 and Watling Street in AD 61 (most likely at Church Stowe). And the fort at *Aballava* (modern Burgh-by-Sands) is a strong candidate for Avalon, because it would make sense for the slain body of a Dark-Age warlord to be transported there down the old Roman logistic route of the rivers Irthing and Eden, past *Luguvalium* (potentially Latin for 'mournful farewells', modern Carlisle).

How appropriate – after a long ramble through chemistry and botany, this investigation ends up back where it started, on water near the west end of Hadrian's Wall, and wondering if any significance can be read into old place-names. Our core conclusion is that colour words can be very informative for a historian, but often did not mean what modern people naively assume.

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