**3. Technology. Making Things in Medieval Europe**

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In the mid-eighth century, a potter settled down to work for the day in the settlement of Ribe. They turned their clay on a wheel, and fired their pots in a kiln, producing a range of vessels in an apparently south-German style. These products were completely different to Jutland’s prevailing ceramic tradition. Some have thought this potter a Frank or Frisian. In any case, in Jutland they were an innovator. Their products displayed previously unavailable ideas of form and fabric, style and durability, and potentially brought Ribe into the ceramic world of continental Europe. But the innovation never took off. Despite extensive excavations in Ribe, little comparable material has been recovered. The ceramics produced were not it seems imitated by others, and the tradition seems to have dwindled to archaeological invisibility by the second half of the eighth century (see [Feveile et al. 1998)](https://paperpile.com/c/3bSJDL/W3Yx). Clearly, despite its superior qualities, this new form of pottery struggled to arrest the consumer’s imagination, and failed to be adopted. Instead, the tradition of low-fired, hand-made ceramics continued in Ribe for the succeeding centuries, and wheel-turned pottery would not return to the town as a manufacturing tradition until c. ad 1200.

This little vignette teaches us an important lesson. So often the history of material culture is presented as a series of steps along an unwavering path; a sort of technological teleology. This allows us to take forms and motifs as ‘type fossils’, to characterize times and places in material terms. But of course, technology does not work like this. Much like Stephen J. Gould’s vision of natural selection in his *Wonderful Life* [(Gould 1990)](https://paperpile.com/c/3bSJDL/aVjy), artifactual traditions progress by virtue of the exploration of multiple avenues, some of which take off, while others prove to be dead ends. This contingency is central to understanding the way in which change happens in the material world.

Though relatively little attention has been paid to it in medieval archaeology, anthropology and the social sciences have seen a wealth of research into precisely this phenomenon (e.g. [Pfaffenberger 1992; Klein and Kleinman 2002; Latour 2005; Law 2010)](https://paperpile.com/c/3bSJDL/zhFd%2B9gNC%2Bf6tE%2BzYle). Through the study of technological development in the modern and contemporary worlds, it has become clear that it is insufficient to isolate the technological as a subject of study in its own right, and that it rather needs to be situated within its social, economic, and political context. The *chaîne opératoire* (or operational sequence) provides an important framework for interpretation, but only when socially situated; the description of technological process for its own sake serves little purpose. Moreover, the history of technology is not just one of innovation, but also one of adoption and rejection, while the drivers that determine the success of a technological advance often lie very far from the technological sphere.

 This chapter does not seek to present a descriptive overview of the organization and output of the various medieval industries; this has been well done elsewhere (e.g.Bayley 1991; [Blair and Ramsay 1991](https://paperpile.com/c/3bSJDL/XHIX); [Leahy 2003;](https://paperpile.com/c/3bSJDL/ogJj)Schofield and Vince 1994: 98-127; [Thomas 2011](https://paperpile.com/c/3bSJDL/lqFB)). Instead, I will review some of the key theoretical approaches to the study of innovation, adoption, and rejection relevant to the development of technologies in medieval Europe, and then apply some of these ideas to examples drawn from across the period c. ad 450-1450. Recent developments in archaeological method and theory have been significant, and though their influence has been felt in the study of technology, to date this material has not been well synthesized. This chapter moves on to present a theoretically engaged overview of north-European craft production across the entirety of the medieval period.

 Within this timeframe, it should be noted that larger quantities and higher concentrations of evidence relating to manufacturing are apparent in assemblages post-dating c. ad 800-900. Indeed, the urban focus of many Viking-Age and later medieval industries gives voice to the increasing specialism and growing market of the early-medieval artisan. The focus here is artifacts, which allows this synthesis to be framed with reference to a coherent body of classic literature: that concerned with craft and industry (including what has frequently been referred to as ‘handicraft’). In selecting case studies, no distinction is made between ‘everyday’ items (see Hansen et al. 2015b) and those whose production or consumption is traditionally associated with elite sites (e.g. Hinton 2000), but where there is evidence for significant technological disparity of convergence between these two contexts of production, this will be highlighted.

## **Medieval craft**

If archaeology is seen as the material study of the human past, then the recognition of change – social change, economic change, political change, religious change – is central to that project. Technology (the practical application of knowledge) is fundamental to human society, while innovation (which we might simply define as forward steps in the punctuated development of that technology) plays an important role in relation to those social, economic, political and religious changes. The nature of that role, however, is ambiguous. Is necessity really the ‘mother of invention’, with technology following the needs of society, according to the directives of those with the power to make change possible? Or is technology rather in the driving seat, opening up certain opportunities and closing off others, ultimately determining the trajectory of social and cultural development? This paper is not the place to rehearse the debate between political and technological determinism, but it is useful to distil how this discussion has played out in the study of medieval Europe (for a review of the wider philosophical debate, see [Pfaffenberger 1992)](https://paperpile.com/c/3bSJDL/f6tE).

 Artifacts were of course a fundamental component of the antiquarian’s knowledge base in archaeology’s formative years. Technology was the cement that held together the building blocks of archaeology’s first chronologies (see [Rowley-Conwy 2007)](https://paperpile.com/c/3bSJDL/EO8g), but in general more attention was paid to form and ornament than to methods of manufacture. From this starting point, one might have expected the study of artifacts to maintain a central position in discussion of the medieval period, but the rise to prominence of the New Archaeology in the 1960s, 1970s and 1980s saw many aspects of the study of portable material culture relegated to the back of the archaeological auditorium. Artifacts retained a functional place, being well positioned as indicators of production and exchange, and typological sequences still provided a useful anchor for studies of social evolution (see [Dunnell 1978)](https://paperpile.com/c/3bSJDL/xAbm). In such models, technologies developed in response to the changing needs of society (see [Binford 1965)](https://paperpile.com/c/3bSJDL/dbNM). The influence of this thinking on medieval studies is perceptible in many ‘straightforward’ explanations for change in the material record, such as the suggestion that England’s seventh-century proliferation of fine-toothed hair combs may have been a response to increasingly dense settlement patterns and a concomitant escalation in the problem of hair lice (see [Riddler and Trzaska-Nartowski 2011](https://paperpile.com/c/3bSJDL/GKOl): 137).

 An alternative perspective sees technology as the *driver* of change. Such a concept has obvious appeal to archaeologists, as it takes social and economic development out of the hands of a small number of elite specialists and assigns it firmly to the more impersonal engine of long-term accretion of knowledge and skills. For medievalists the influence of such technological determinism is visible particularly in the archaeology of conflict, such as the suggestion that the Viking Age was brought about by the invention of the sail (see [Barrett 2008 f](https://paperpile.com/c/3bSJDL/pe87)or a response to this popular myth), the origins of feudalism in horse equipment (see [White 1962)](https://paperpile.com/c/3bSJDL/ToLO), or the discussions of the political impact of the longbow in late-medieval England and France (see [Rogers 2011)](https://paperpile.com/c/3bSJDL/1KHo).

However, the last 20 years or so have seen major sea-changes in the study of medieval technology, innovation and communication: these developments themselves emerging from a number of theoretical and methodological innovations. Chief among these have been the resurfacing of Ph.D. research around artifactual study (e.g. Forster 2004; Gustin 2004; Hansen 2005; Ashby 2006; ten Harkel 2010; Glørstad 2010; Pedersen 2010; Kershaw 2013; Jervis 2014; Weetch 2014; Baug 2015; Martin 2015; Leonard 2016), and the publication of major synthetic overviews (e.g. Gilchrist 2012; Sindbaek 2007, 2008). One might also note a significant shift in thinking towards understanding of both the social setting of production and of the importance of consumer choice (Callmer 2003; Hansen 2005; Christophersen 2015a, 2015b). Key theoretical developments that have just begun to bear fruit relate to the idea of artisans as agents in the production process (e.g. Hansen et al. 2015c), and to the concepts of chaîne opératoire and object biography (e.g. Ashby 2014). The most useful applications of the latter approaches have tended to incorporate the use of non-traditional analytical techniques (frequently drawn from the natural sciences), ensuring that biography or *chaîne opératoire* provide more than simply a framing device (e.g.Perry 2016; Forster and Jones 2017; Neiß et al. 2018). Equally important have been the medieval co-opting of both complex-systems analysis and actor-network theory, which have led to significant new insight by allowing us to see artifactual material as big data, drawing together patterns on both the regional (Schou 2017) and macro scale (Sindbaek 2007, 2008).

 In what follows, I consider recent scholarship dealing both with production through a focus on technology and innovation, and with the ways in which such phenomena impact upon medieval society and populations. This is achieved via biographical exploration of a number of medieval crafts, in order to set them in context: a vital prerequisite for investigation of differences in technology, organization and communication. A particular source for this discussion is the work of the Crafting Networks in Viking Towns project (CNVT) in which this author has been involved (see [Sindbæk 2013](https://paperpile.com/c/3bSJDL/B3SS); [Ashby and Sindbaek in press)](https://paperpile.com/c/3bSJDL/gL7V).

 An attempt to discuss the full range of north-European medieval crafts in their entirety is beyond the scope of this chapter, instead, the chapter draws on cases from England and Scandinavia as proxies for general changes in the period. It shuttles between a number of social themes: the transformative power of technology; its agency as a revolutionary force; its relationship with identity; the extent and character of interaction between artisans working in diverse media; and the identification and implications of the rejection of innovation. Within this framework, a number of questions will be touched upon. Beginning in lowland Britain: how were the various industries affected by the disarticulation of Roman infrastructure in the late fourth and fifth centuries ad? How did they respond and develop in the middle of the first millennium, and how does this compare with what we see in northern and continental Europe? Can any regional differences in trajectory be explained through consideration of social circumstance? With improved communication across the North and Baltic Seas, and the appearance of coastal emporia (see [Hodges 1982](https://paperpile.com/c/3bSJDL/wIT4); cf. [McCormick 2001; Wickham 2005)](https://paperpile.com/c/3bSJDL/EKN7%2Brm5X), did the clustering of craft activity or access to foreign markets substantially affect industrial organization? Did such new arrangements themselves impact upon the scale or character of long-range movement and connection? What was the relationship between craft and the urban revolution of the tenth century? And as craft activity became very largely urbanized in the second millennium AD, how did this impact upon the social context, and the economic output of our craft-workers? These questions are difficult, but much more interesting than those which start and finish with the detail of operational sequence.

**Technology as transformation**

The study of metalworking in the post-Roman and early Saxon period has, as noted in the introduction to this volume, been dominated by a focus on objects found in graves: most notably swords and jewelry (e.g. [Leeds and Pocock 1971](https://paperpile.com/c/3bSJDL/6mRE); [Dickinson 1979; Stoodley 1999)](https://paperpile.com/c/3bSJDL/T6RF). While traditional work was often fundamentally typological or technical [(Hines 1997)](https://paperpile.com/c/3bSJDL/RJqX), and more recent studies have focused on the social and political interpretation of this material (e.g. [Martin 2015)](https://paperpile.com/c/3bSJDL/Ruy5), or on improving chronological precision [(Bayliss 2013)](https://paperpile.com/c/3bSJDL/jkz8), a small number of technological analyses have sought to situate manufacture in its social context. For instance, a study of the fifth-century ‘quoit-brooch’ style of metalwork found its unifying characteristics to be technological rather than morphological, and tied its production to methods best known from Late Roman contexts). Technological analysis of this previously enigmatic material has thus situated it in the world of post-Roman continuity and transformation, rather than linking it with Anglo-Saxon settlement [(Inker 2000)](https://paperpile.com/c/3bSJDL/Pvea). It is clear that theoretically-informed analysis of technology has the power to answer questions that would remain elusive were our focus to remain firmly fixed on form and ornament. Decorative metalwork, however, is clearly not representative of the material culture being used by the wider community, many of whom would have led less charmed lives, devoting much of their time to subsistence farming and survival (see Fleming 2012: 4). Robin Fleming has argued that much of the population of post-Roman England was relatively impoverished, and that the end of Roman rule would have been keenly felt by way of the collapse of complex industries such as metalworking. The disarticulation of supply networks, and concomitant de-skilling of the artisanal community must have made life very difficult for the population at large.

 So what can we say about craft during this period? Of course, there was still a need to manufacture in the fifth and sixth centuries, and in metalworking (as, no doubt, in other crafts) the demand for raw material appears to have been met by scavenging and recycling of Roman objects and building materials [(Fleming 2012](https://paperpile.com/c/3bSJDL/Xqqb); cf. [Birch 2011)](https://paperpile.com/c/3bSJDL/DjF6). This rather mixed, uncontrolled source was less than ideal for the production of weaponry, to the extent that some have claimed spearheads from this time period were never intended for active use (see [Fleming 2012](https://paperpile.com/c/3bSJDL/Xqqb): 25). In contrast, the high-quality, pattern-welded swords found in many of the graves of south-east England cannot have been manufactured using such materials, and it seems clear that one of the difference-makers in the world of the Anglo-Saxon aristocracy was access to high-quality, continental iron. It thus seems very clear that technology, and its associated networks of production, made up a central element of aristocratic identity in the early medieval period. Technology is always socially embedded; here is a case in which it was also deeply political.

 We should also consider the possibility that technologies were invested with particular social, even ritual resonance (see Gell 1992). In this post-Roman period of material scarcity, the working of metals in particular may have accreted new meaning, perhaps even as something of a supernatural process. Suggestions of this are visible in both the context of smelting (see Haaland 2004; Giles 2007*)*, the ostensibly itinerant, marginal status of the smith (Gibson 1996), and in the control of technology at high-status sites (estates, so-called ‘palaces’, and ultimately monasteries (e.g. Carver 2004; Carver et al. 2016). As the centuries passed, the availability of iron appears to have improved, such that by the seventh century we start to see evidence for smelting and specialist ironworking across lowland England [(Fleming 2012](https://paperpile.com/c/3bSJDL/Xqqb): 30-32), and the control of such practices on aristocratic estates by the eighth and ninth centuries. Smithing continued to be an important rural practice, of course, right through the Viking period and Later Middle Ages (see Goodall 2011). There is evidence that the manufacture of certain items – locks and keys, for example – started to become more specialized from this date, with the necessary expertise increasingly to be found in towns (see [Sindbæk 2013 and papers therein)](https://paperpile.com/c/3bSJDL/B3SS). This set the scene for the world of urban crafts in the Middle Ages, when craft as a whole became more specialized, intensified, organized, and sedentary, though operative differences between the various trades were no less apparent.

The situation and development of contemporary non-ferrous metalworking was rather different. Following an extended period in which metal-casting seems to have been conducted on rural estates, presumably under aristocratic patronage, by the later eighth and ninth centuries the bulk of non-ferrous metalworking appears to have been aggregated at a small number of proto-urban centers and market sites. The reasons for this are discussed below, but it was to have a profound effect on technological development. Technological change emerged out of communication mediated through the transmission of ideas and techniques. For effective adoption of new technologies, people and places were particularly important, as copying of technology is dependent on observation and experience of practice to a much greater degree than is the case for the straightforward mimicry of design or ornament (see, for example Scott 1990: 148-149). In medieval northern Europe it is clear that a number of particular places – first monastic and aristocratic sites, followed by market sites, trading entrepôts, and towns – served as catalysts in this process.

 The siting of artisans in towns was probably rather more about production than sales; working copper alloys in particular was a job for an experienced hand, with an appropriately specialized toolkit, workshop, and raw materials. The last, an often overlooked requirement, may have been the deciding factor in siting the craft in markets and urban settlements. By this point recycled metals were no longer appropriate for skilled production, with metal-casters relying more and more on the higher-quality brass that could be imported from continental Europe by the ingot (see [Sindbæk 2013](https://paperpile.com/c/3bSJDL/B3SS) and references therein). Of course, for ease of access to these imports, one needed to be at the harborside (see Sindbæk 2003), so the natural solution for artisans working in these materials would be to set up shop in urban centers.

This is precisely what we find in archaeological excavations at sites in Ribe, Kaupang, Birka, and Hedeby: extensive deposits of casting waste, fragmentary crucibles, molds, and ingots (see Ambrosiani 1998, 2005; Feveile 2002; [Pedersen 2010, 2016](https://paperpile.com/c/3bSJDL/UBQZ%2BQUP6); Sindbæk 2012). From relatively unsophisticated workshops, it appears that Viking-Age craft-workers were almost mass-producing brooches, pendants and amulets, using serialised lost-wax casting [(Madsen 1984](https://paperpile.com/c/3bSJDL/6emx)) (Figures 3.1 and 3.2). Similar modes of operation are perceptible in Ribe’s bead workshops, where imported glass cullet and Mediterranean tesserae were a vital raw material, and comb manufactories, where we have shown that access to imported reindeer antler was a concern, even before the start of the Viking Age; Ashby et al. 2015).

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Though practised elsewhere in the world for millennia, this technique was innovative in Viking-Age Scandinavia, and it offered significant potential. Not only could large numbers of items be produced by a small number of specialists with access to the right materials and equipment, but the use of lead models to impress brooch form into molds meant that it was also possible to make small adjustments to detail and design between castings. This space for creativity has proven very helpful for archaeologists. Study of the jewellery produced at Ribe and Birka is suggestive of similar technical developments, indicating a level of contact and communication between craft-workers in the Baltic and North Sea region. At the same time, the two sites display very different forms of ornament (Feveile 2002: 20; Sindbæk 2012). It seems that, although they maintained close and regular communication, the artisans of Ribe and Birka were fundamentally grounded in their own urban communities, and made pieces to appeal to local fashions. Indeed, it may be that such anchoring was essential to their work, not only in providing access to raw materials, but also in facilitating close integration with specialists in other materials and outputs. Pedersen [(2015a)](https://paperpile.com/c/3bSJDL/VP7r) has shown that copper-alloy workers at Kaupang were also working in lead, to produce amulets and mounts. Might they have collaborated across other materials and skillsets? The ‘comb factories’ of later medieval Norwegian towns such as Trondheim, Bergen, and Oslo were dependent on access to large numbers of copper-alloy rivets, as well as decorative copper-alloy plate and chains (see Wiberg 1987; [Flodin 1989; Hansen 2005)](https://paperpile.com/c/3bSJDL/x1Mp%2BszUJ%2BYwCU). It seems unlikely that they manufactured these components themselves, but some form of integrated relationship must have been essential. The more one considers the detail of technological process, the more clearly one can see the importance of community and communication (see below). Once again, this demonstrates the value of considering technology as a discrete element of the artifact, rather than as a subsidiary component of morphology or ornament.

 These large, fluid urban communities played a central role as locales for communication. The advent of productive entrepôts such as Ribe, Kaupang and Dorestad brought together producers, traders and consumers, catalyzing opportunities for technological transfer, innovation, and transformation. The motif pieces of later Viking towns – most notably from Dublin, where in excess of two hundred are known – give us a further insight into the workings of urban craft-working communities (Figure 3.3). These pieces of bone, slate, and wood feature arrangements of decorative carvings, carried through with various degrees of symmetry, artistry, and proficiency. Their function is unclear, but they likely played some role in the practicing or planning of design ahead of ornamenting finer objects manufactured in materials that probably included but were not necessarily limited to non-ferrous metals. Jessica McGraw [(2015),7](https://paperpile.com/c/3bSJDL/ETEw) has noted the co-occurrence of elements taken from both Scandinavian and insular art, and interprets this as evidence that artisans were working across, rather than strictly within these worlds. As such, they represent something akin to written statements of cross-cultural communication.

>>>>Figure 3.3 here

 Yet despite such contexts for technological exchange and development, some processes of production remained highly conservative. Even in the later Middle Ages, there is little sign of significant change in the basic technology of copper-alloy working, with lost-wax still being the primary method used in casting (though sand-casting may have occasionally been employed before the end of the medieval period, see [Blair and Blair 1991](https://paperpile.com/c/3bSJDL/XHIX): 85-89). Nonetheless, the range of products seems to have expanded to incorporate a range of high-status and more rudimentary homewares. Similar trends are apparent in the working of other base metals. The manufacture of lead-alloy jewelry is now well known as a significant craft in early-medieval England (e.g. [Weetch 2017)](https://paperpile.com/c/3bSJDL/PfPb), while the significance of lead jewelry is becoming increasingly clear in Scandinavia (see [Pedersen 2015a)](https://paperpile.com/c/3bSJDL/VP7r).

 By the later medieval period, in England the primary uses of unalloyed lead were in building construction and the production of non-portable items. However, upland Britain’s supply of tin meant that the production of toys and trinkets in pewter became an important industry in its own right (see [(Forsyth and Egan 2005)](https://paperpile.com/c/3bSJDL/Hjob). Given that many of the items produced (chalices, patens and the like) were intended for use in ecclesiastical contexts, it may be that much manufacture was focused in monastic contexts (see [Homer 1991](https://paperpile.com/c/3bSJDL/XHIX): 66), but by the fourteenth century it seems that changes in demand allowed it to take hold as an urban craft, serving diverse markets, and producing everything from church plate and domestic table wares through to pilgrim badges. Moreover, by the end of the Middle Ages pewter products were being exported on some scale. While the basic requirements of the craft are pretty meagre – the low melting point of lead alloys mean that casting can be done in antler or even wooden molds, as well as those of copper-alloy, stone or ceramic materials – time has to be taken to remove casting flashes. Finishing of objects such as jugs and flagons must have involved a lathe, and other objects seem to have been manufactured by the soldering together of smaller components ([see [Homer 1991](https://paperpile.com/c/3bSJDL/XHIX)](https://paperpile.com/c/3bSJDL/XHIX): 66-7). Here it seems that privileged access to tin, coupled with a close connection with the church go some way to explaining the particular trajectory of lead and lead-alloy working in England. Through their alloying, materials of little intrinsic value were used to produce a range of objects for use in diverse contexts, many of which, through their use in particular social settings became highly desirable overseas. Once again, technology is inseparable from either its material network or it social context, and it seems that urban growth and the mobility of a large part of the demographic together drove a charge toward greater degrees of connectivity and communication. This was achieved via a number of mechanisms. First, urbanism drove technological change, before increasing demand by making consumers more aware of the kinds of goods that might be available to them. Simultaneously, technical innovations and more stable resource networks catalyzed mass production, driving down costs, and ultimately making the products of urban industry accessible to a wider range of potential consumers.

## **Technology as revolution**

Robin Fleming has recently synthesized and characterized a series of observed changes in the ceramic industry in the years following the collapse of the Romano-British economy. It has been argued that certain ceramic traditions persisted – albeit rather idiosyncratically – for some time after the Roman withdrawal (see Gerrard 2016 and references therein), but Fitzpatrick-Matthews and Fleming [(2016)](https://paperpile.com/c/3bSJDL/2QBl) have identified a number of peculiar traits of lowland Britain’s ceramic corpus of the fifth and sixth centuries, including: the contemporaneous use of ‘early-medieval’ and ‘Late Roman’ pottery in the fifth century; the manufacture of both hand-built skeuomorphs of Romano-British forms and of Anglo-Saxon style vessels in ‘Roman’ fabrics; and the existence of the rather wonderfully named ‘slightly odd’ pots, which seem to reference Roman ceramics but do not altogether fit the recognized repertoire. Fitzpatrick-Matthews and Fleming’s explanation of these phenomena sits comfortably with the theoretical models outlined herein: the artifact collections of the fifth and sixth centuries are not simply reflective of the end of Roman rule or the impact of migration, but rather tell a story of the efforts of individuals to maintain and develop technology – even to innovate – in a rapidly shifting climate characterized by failed infrastructure, disarticulated supply networks, and a de-skilled workforce.

 In certain parts of Britain (particularly, but not exclusively, the south of England), the centuries that followed the Anglo-Saxon settlement saw the use of low-fired, largely hand-thrown and locally-distributed wares in a range of relatively soft and friable fabrics. Usually produced in clamp-kilns or bonfires, these wares are often expressed as simple jars in coarse, sandy fabrics, tempered with grass, chaff, or other organic material. Such temper (burnt out in the firing process, though visible in the form of the voids it leaves behind) has been the subject of some discussion. No doubt it improved the workability of the clay, but may also have buffered vessels against thermal shock, as well as being lightweight and relatively portable [(Jervis 2012)](https://paperpile.com/c/3bSJDL/uuft). On the other hand, it has been suggested that such organic-tempered wares could not have withstood even the temperatures needed to boil water [(Skibo et al. 1989)](https://paperpile.com/c/3bSJDL/8Yie). In any case, as Jervis (2012) points out, there is little to be gained from simply maligning this material as poor quality or impractical; clearly it served its purpose well enough, and is best considered within its particular technological context, as emergent from re-aligned and articulated post-Roman industrial infrastructures. Jervis also notes that the floruit of this material lies some years after the initial Anglo-Saxon settlements, so it cannot be explained in simple ethnic terms. Rather, its distinctive character is better seen as a product of particular technological circumstance. Jervis argues that its south-west-focused distribution suggests that this ceramic product emerged from the manufacture of vessels produced for the long-lived tradition of salt production. The reason for the adoption of this technology, however, requires some thought, and Jervis explains this using Actor Network Theory: their use was rooted in relatively transient, self-sufficient societies settled on marginal lands, and for whose lifestyle the portability and ease of manufacture of organic-tempered wares was well adapted. This case study demonstrates that we can best frame technical change by thinking about it in social terms. The details of form and function need to be situated within their social context; it is not sufficient to explain widespread transformation in ceramic technology as the result of a drive for better pots; rather we must consider the implications of such innovation in terms of relationships with changing human lifeways, needs, and tastes.

Alongside the widely distributed, relatively high-quality Ipswich ware, these organic-tempered wares were accompanied and superseded by hand-thrown, sandy and shell-tempered wares such as Maxey-type ware [(Addyman 1964)](https://paperpile.com/c/3bSJDL/UdAx). These irregular, clamp-fired wares were produced in a limited number of vessel forms (chiefly bag-and barrel-shaped jars, typically equipped with suspension lugs). Better adapted to heating, these appear to have been multi-purpose cooking vessels, intended to be suspended over the hearth. Similar forms are known in a range of regional wares, suggesting that some similarity of use-context had emerged in tandem with increased stability of rural settlement and the emergence of new proto-urban centers.

 This was the situation in the late ninth century, when ceramic production, at least in the north and east of England, underwent something of a revolution. The area in which Scandinavian settlement seems to have been focused (later to become known as the Danelaw) appears to have been served by a number of new ceramic industries, producing vessels that would have been truly alien in Anglo-Saxon England. With the exception of Ipswich ware [(Blinkhorn 2012)](https://paperpile.com/c/3bSJDL/d9yI), whose baggy, straight-rimmed jars seem to have been thrown on a slow wheel, no pottery from medieval lowland Britain offers anything like a precedent for these standardized, high-fired, wheel-thrown vessels. They displayed a new level of ‘professionalism’, being produced in a distinctive range of forms that was both wider and more systematic than that seen in previous wares: large and small jars, dishes, bowls, and pitchers. Moreover, though each industry had a fairly extensive reach, they tended to emanate from known centers of Scandinavian settlement: Stamford [(Kilmurry 1980)](https://paperpile.com/c/3bSJDL/g3Rw), Lincoln [(Miles et al. 1989)](https://paperpile.com/c/3bSJDL/qgua), and Torksey [(Perry 2016)](https://paperpile.com/c/3bSJDL/B7xz), to name a few.

 This production pattern has the look of an imported industry, brought in by Scandinavian settlers in order to serve their particular needs. The problem with this explanation is one of geographical asymmetry. While the aceramic nature of Scandinavian society has been overstated, it is clear that wheel-thrown industries were not known in southern Scandinavia (with the exception of the short-lived Ribe output introduced at the start of this essay). Anglo-Scandinavian products look much more like the kinds of vessels being used in continental Europe, and in the Normandy area in particular. Nonetheless, attempts to attribute the new industries of late-ninth century England to long-held Frankish connections (rather than new Scandinavian ones) are unconvincing on chronological grounds. The most likely scenario seems to be that Frankish potters arrived in lowland Britain in association with the Viking Great Army, who appear to have been campaigning on the continent prior to their arrival in East Anglia in ad 865. Whether they were active members of the army itself, opportunistic free artisans, or bonded slaves is unclear, but the transformation of the technology in Anglo-Scandinavian England is striking, and speaks of the dynamics of the industry. Ceramic production is often thought of as rather static and functional, but the Anglo-Scandinavian revolution demonstrates that pottery manufacture was a dynamic enterprise, and could involve the movement of specialists over significant distances, from where they were able to force change even from rather unstable and (in some senses) liminal contexts (see Perry 2016).

 It is not clear what the emergence of these new ceramic repertoires signifies: was the distinctive range of Anglo-Scandinavian vessels intended to provide for existing culinary technologies familiar to Scandinavian settlers, or new ways of cooking and eating emerging in these cosmopolitan centers? Did it play an important visual and experiential role in the social spectacle of eating and drinking? Or was it a simple reflection of different aesthetic tastes? How did such tastes relate to broader patterns in the distribution of tablewares and regional cuisines across northern Europe? Ongoing research is exploring these questions by focusing on the articulation of design, intended function, and eventual use, and there is a clear need to situate explanation of technological change in its social, rather than simply economic, context (see Ashby 2018).

 The post-conquest development of the ceramic industry is complex and regionalized, and there is insufficient space to explore it in detail herein. However, it is clear that in England there was a clear relationship between the developing world of towns, the changing activities taking place within them, their connections with both the English countryside and overseas ports, and the nature of ceramics being produced in these contexts. While wheel-thrown pottery dominated in the towns from at least the time of the Norman Conquest, handmade pottery continued to be manufactured on rural sites, with occasional returns to popularity, and was still being produced at some sites even into the thirteenth century [(Cherry 1991](https://paperpile.com/c/3bSJDL/XHIX):201). Indeed, the post-conquest history of the ceramic industry can certainly not be characterized as one of smooth and unarrested development. On the basis of tax and other documentary records, for instance, it seems that the economic standing of potters declines substantially between the eleventh century and the end of the medieval period, and it is notable that this was one profession that never became formally taken into the organization of guilds. It seems that late-medieval urban potters were far from prosperous, while rural ceramic manufacture was part-time, and undertaken as simply one element of the complex of responsibilities of rural labor (Cherry 1991: 202-4). There is no evidence that potting was sustained through any sort of systems of apprenticeship, and it may be that assistance came through family hands, with the by-product of investing the craft with a level of regional, multi-generational stability.

 Like many aspects of social life in northern Europe, it seems clear that the English ceramics industry went through something of a transformation between the late fourteenth and mid-fifteenth century. The scale of production seems to have increased, but not simply as a result of increased productivity in urban workshops. Rather, we see an increase in the number of production sites, in the level of regional variation, and in the diversity of forms [(Cherry 1991](https://paperpile.com/c/3bSJDL/XHIX):205). At the same time, there is a move in emphasis from coarseware cooking pots towards finer tablewares. This has been explained in several ways, all of which necessarily put ceramics within the wider contexts of both urban industry and cooking and dining. The change has been seen as an imitation of metal tablewares, as the result of the newly widespread availability of metal cooking pots, or as emerging from competition with woodturners. It has also been explained as a response to rising demand for conspicuous, fine tablewares from an increasingly wealthy urban middle class consumer (see [Gaimster 1994; Gaimster 1997)](https://paperpile.com/c/3bSJDL/EB4w%2B2pnd). Conversely, some scholars have focused on the idea of an increased output coming from rural workshops, or from larger agglomerations of ceramicists working close to towns, which attracted merchants who could ensure wider distribution of wares in return for assurances of relative homogeneity of product. Cumberpatch [(2003)](https://paperpile.com/c/3bSJDL/BG4U) has suggested that something more fundamental changed around the end of the medieval period: the coming of a new social order, mediated using a new repertoire of material culture.

Ceramics also offer us particular opportunities to explore the communication of technology over very long distances, and the ways in which this relates to patterns of trade and consumer choice. The long-range relationship between politics, mobility, and technology is clearly expressed in the production of late medieval glazed wares which, as accessible exotics, came to act as important foci for aspirational consumers in northern Europe, notwithstanding the variable and sometimes relatively expensive prices of some imported wares (see Gutierrez 2000: 175–8). Early examples of this phenomenon include Middle-Eastern fritware, an alkaline-glazed, decorative ceramic, occasionally found in northern Europe, which seems to have been put to varied uses (Gutierrez 2011: 306–7). Fritware was originally developed in eleventh-century Egypt, owing its origins to a period of military instability and mobility between China and the Middle East (Pitt et al. 2013: 64). It soon became distributed across a wide area, even reaching northern Europe as a result of long-distance travel (including that associated with Crusades in the Holy Land). For example, eight examples were found in late-medieval levels at Plantation Place, Fenchurch St, London, together with other Syrian, Turkish and continental European ceramics, and Islamic and Venetian-style glass vessels (Pitt et al. 2013: 64). This unusual concentration may relate the presence of returning travelers (see Hurst 1968), or (as proposed by the excavators) foreign merchants or doctors, but in the following centuries there are numerous occurrences of the north-European adoption of imported ceramics produced by distinctive technologies (e.g. Gutierrez 1997). In particular, one might note the fifteenth- and sixteenth-century popularity of majolica (see papers in Gaimster 1999a). This tin-glazed earthenware provided a sympathetic surface for the application of painted decoration; the technology appears to have developed first in Islamic Spain, before being transferred to Italy. In northern Europe, where pottery tended to be undecorated and less brightly colored, such wares became highly desirable. Eventually then, production was taken up in the Low Countries, France, and England in order to serve this demand from the middle classes (Gaimster 1999b).

Indeed, there were many contexts in which English consumers provided a market for imported glazed ceramics. This phenomenon speaks to an interest in products with the aesthetics of exotic technology, but suggests relatively little concern with either the meaningful associations of the objects, the detail of the technology by which they were produced, or the social context in which they emerged. Thus, consumer demand for an aesthetic of the exotic could be met by an approximating or mimicked technology. This is an important reminder that while the details of provenance that archaeologists can access via analytical procedures can be transformative in our understanding of the movement and reach of particular technologies, they are not necessarily directly informative as to the ways in which object biographies were understood in antiquity (Thomas 1991; Miller 2002).

 We have thus seen how ceramic technology offer something of a barometer of social, economic, and political change. It is clear that the complex transformations of the craft cannot be explained simply through the idea of potters responding to changing fashions, but rather we need to consider a more integrated and reflexive scenario, in which various material, social, and economic ‘actants’ played a part. If read in this way, the typological development of pottery over a thousand-year period should not just be seen as the result of technological improvement, or as a response to economic stimuli, but rather as one of a number of players in a series of complex social interactions that played out in time and space, resulting in occasional moments of revolutionary change to products and accessibility.

## **Technology and identity**

It is clear then, that technology has to be understood in context, and that particular technologies have to be seen within their own social, economic, and political settings. As a further case in point, let us take the issue of early-medieval textile manufacture: a phenomenon bound up in complex ways with urbanism and landscape, with social hierarchy, and with gender.

 From the earliest Middle Ages, textiles were worked extensively on rural sites. Across Scandinavia and the coastal North Sea area, rural estates feature dense concentrations of pit-houses (or sunken-featured buildings). Their purpose has been much discussed, but on the strength of the consistent presence of loom weights and related paraphernalia, it now seems indisputable that one of their key functions was in textile manufacture.

In recent years, some effort has been taken to go beyond this label, to try to characterize the nature of the activities taking place in these structures, and to think about the ways in which they might facilitate the social ordering of time and space. For instance, textile-working is tied to the calendar of farming and rural life to a remarkable degree [(Cartwright 2015)](https://paperpile.com/c/3bSJDL/4sHD), opening up the opportunity to think about the craft in terms of taskscape [(Ingold 1993b)](https://paperpile.com/c/3bSJDL/FGrj). Karen Milek [(2012)](https://paperpile.com/c/3bSJDL/qide) has gone a step further, and begun to think about the space of the pit-house as an explicitly political space.

 In a careful, multi-dimensional approach to the study of pit-houses in Iceland, Milek has shown how their primary use in textile manufacture echoes their perceived function in northern Europe. She argued that this did not make them mundane, functional spaces, but rather that they were ideologically charged and highly-gendered. Consideration of the internal arrangements of pit-houses, likely dimensions of the loom, and documentary accounts that confirm that early-medieval weaving was undertaken very largely by women, but of all statuses, and was something of a group activity. This allowed Milek to re-imagine the experience of working at the loom. Thus, while it has long been understood that textile manufacture was a female occupation, Milek has begun to explore what this might have looked like, and what it may have meant in social terms. Once again, the social situation of technology is key to its operation and development.

 As for the products of this technology, by the time we reach the Viking Age, textiles show a high level of specialization, emerging from an equally tailored toolkit. Weaving was undertaken using the warp-weighted loom, attested chiefly by the frequent finds of loomweights. By this point the craft seems to have been organized with the idea of surplus production front and center, even if in England much production would still be characterized as ‘domestic’ in its setting. Lise Bender Jørgensen [(1992)](https://paperpile.com/c/3bSJDL/9Ph3) has noted the systematic combination of particular materials, spinning techniques, and styles of weaving to produce a limited range of distinctive textiles.

One of the most striking findings of the comparative analysis of textiles and textile tools in northern Europe, however, is the similarity of fabric, which may suggest some degree of copying or following shared templates or patterns. However, when one compares the respective toolkits of the Anglo-Saxon and Scandinavian weaver, there are clear differences in technological choices. Scandinavian-form spindle whorls, for instance, never seem to have found a home in Anglo-Saxon England (see work by Walton Rogers and Bender Jørgensen in Sindbaek 2013; see also [Walton Rogers 2007)](https://paperpile.com/c/3bSJDL/oS1G). This may tell us something important about the demographics of settlement: did only very few Scandinavian women settle in England in the ninth to eleventh centuries? It seems at least that the textile industries of England and Scandinavia remained relatively distant when judged by the degree of personal contact between their practitioners; any similarities in the products produced must have emerged from copying textiles or templates of some sort. These crafting communities were in contact, but perhaps in a very different way to those involved in other, arguably more mobile trades like comb makers or classically itinerant smiths, and peddlers.

 Interestingly, however, these findings are at odds with recent analyses of another form of portable material culture, and whose results once again stem from close analysis of technology. Jane Kershaw’s [(2013)](https://paperpile.com/c/3bSJDL/V3nF) analysis of metal-detected female brooches in Viking-Age England drew upon elements of technology (principally the pin mechanism) to distinguish between genuinely Scandinavian brooches and ‘Anglo-Scandinavian’ imitations and hybrid forms. Her findings were striking: that large numbers of these brooches were actually made in Scandinavia, and that they most likely arrived in lowland Britain attached to the clothes of female settlers. Here then, technology is indicating a significant female migration. One is left asking why these results differ so much from what we saw in the textile tools. The nature of textile manufacture arguably does not lend itself readily to itinerancy, but there must be more to it than that. Perhaps the differing contexts of production presented too great a divide to cross? Or perhaps Scandinavian immigration (and more particularly Scandinavian female immigration) was greater in the countryside than in the towns. More research is needed, but it is interesting to note the ways in which subtle differences in technology can tell stories of migration and culture contact, particularly given that our usual focus of attention in such studies is on form and ornament.

These stories relate to the domestic production of textiles for everyday wear and use, but a different picture emerges when one considers the importation and exchange of exotic fabrics. There is sufficient archaeological and documentary evidence to demonstrate that by the Viking Age, the popularity of silk had stretched far beyond its Asian place or origin. Indeed, across much of Europe, silks were popular not only in the tailoring and trimming of garments for the secular and ecclesiastical elite, but also in dressing the dead and wrapping relics. By the tenth and eleventh centuries, certain lower-grade silks became more widely available in northern and western Europe, with bolts of fabric even being shipped into the towns of England and Ireland before being tailored into domestically-produced items. As a result, silks became a focus of aspiration, with different qualities of material being utilized in different ways, according to status and wealth (Fleming 2007). Silk’s widely-felt appeal surely came not only from its physical and aesthetic qualities, but also from its associations: an item that was associated with the great and the powerful, and which was produced far away, using unfamiliar technologies (cf. Gell 992).

 More broadly, one phenomenon of note in textile manufacture is its combination of long-term conservatism on the one-hand, and apparent agility and flexibility on the other. Household-level production appears to have continued across major periods of social transition: the arrival of Scandinavian settlers, urbanization, and the Norman Conquest to name a few. On the other hand, urbanization brought about an intensification of production within particular centers, though even here spinning seems to have remained a strictly gendered and household-based practice. Textile production thus serves as an example of the multi-faceted nature of medieval craft, drawing upon the labor and knowledge of diverse individuals working in particular settings.

 In the later medieval period, these people and settings became subject to revision, as the gender associations of textile craft appear to have undergone something of an inversion. By the end of the Middle Ages, organized weaving had become a major, guild-controlled industry, undertaken largely by men, using horizontal treadle looms that were able to produce larger, tighter textiles more quickly and efficiently than the warp-weighted loom. This has always been seen as something of a package, thrown into action in order to maximize efficiency and output. However, by meticulously taking apart in various strands of evidence, Ingvild [Øye (2016; see also Standley 2016b: 289)](https://paperpile.com/c/3bSJDL/rGEe) has shown that in actual fact these changes happened slowly, at variable rates in time and space, and that we should try to separate the effects of gender involvement and new technology. Moreover, Standley (2016b: 270-2) has argued for greater gender fluidity, as well as the continuing importance of household-based spinning as a recognized profession, even outside of the context of urban guilds. The increasing availability of lead-alloy spindle whorls in post-conquest England probably speaks not only to demand from spinners, but also to opportunism on the part of non-ferrous and white-metalworkers (see above). Through their ability to use casting technology to produce whorls decorated with motifs and inscriptions, they identified a niche to be exploited within another craft (Standley 2016b: 276, 278-85). Such symbiotic or parasitic relationships must have been common across medieval Europe, but at present we know little about them.

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## **Technology and communication**

Indeed, the interaction between crafts – so long artificially separated both in reports and in the mindset – merits scholarly focus. In particular, there is a need to undertake more comparative analysis of craft technology; for too long syntheses have looked at the idea of ‘craft’ as a generic idea, while individual specialists have worked away in virtual silos. It is time for a detailed investigation of the ways in which individual crafts converge, contrast, mimic and parallel one another. We need to consider the ways in which their practitioners interact, how this varies across time and space, and to situate all of this within a reflexive understanding of social and economic context.

 By way of exploration rather than demonstration, it is worth investigating what such a study might look like. With its well-preserved manufacturing debris, and well understood chaîne opératoire*,* comb making is a good candidate for the study of a craft’s inter-relationships with other trades. Nonetheless, it is striking that so much doubt remains about the scale, character, and organization of the comb maker’s work. On interrogation, accepted models tend to simplify or generalize, and there is a need for a more nuanced, particularistic approach (see Ulbricht 1978; Ambrosiani 1981; Ashby 2015b).

 Notwithstanding the above, it is important to note the strength of early work undertaken on comb making and bone/antler working, particularly in England (e.g. MacGregor 1991). MacGregor has convincingly demonstrated that in Anglo-Saxon and Viking-Age England, hair combs were the primary product of the antler worker, but, importantly, that they were not the sole output. The manufacture of combs, as complex, composite objects, demanded a level of expertise far beyond that required in the carving of rudimentary pins, gaming pieces, skates, and textile tools, many of which must have been made by their eventual end-users on an ‘as-needed’ basis. Nonetheless, it seems inherently likely that the skilled artisans who made combs also produced a range of simpler items for sale, and that they worked in postcranial bone as well as antler. But to what extent did they work in other materials, or collaborate with other artisans?

 There are hints in the construction of combs that their manufacturers were at least competent in working with other materials. First, it is notable that the toolkit of the comb maker compares most closely with that of the woodworker; both crafts involved not only the rough processing and breaking up of materials with an axe, but their shaping with chisels, planes, and – most tellingly – saws, before finishing. The conditions for their work would also be similar: there was a requirement for some sort of workbench to which objects could be fixed while under manufacture. There is no direct evidence to support this assertion, but it would be unsurprising if comb makers were also occasionally to be found working at carpentry.

 In contrast, there appears to be little overlap in the skillsets of the antler worker and the non-ferrous metalworker, with one being a reductive technique involving cutting and shaping, and the other being more additive, and dependent on facilities for heating, mold-making, and so on. It is also striking how little overlap exists in the decorative schemes and grammars applied to combs, and decorative metalwork. Though tools such as punches could be used in both, the almost total absence of complex zoomorphic interlace in combs is striking. This is not simply a matter of material affordance; stone, wood, and bone could certainly be carved ornately, as sculpture, furniture, and motif pieces in the classic Scandinavian art styles attest. Nonetheless, combs are invariably decorated with simple geometric ornament: the points of reference for these two groups of artisans were clearly very different. However, there were elements of the comb making practice that certainly involved working with metal, even if only on a rudimentary level. Anglo-Saxon and early Viking-Age combs were usually held together using iron rivets. These pins may have been purchased from a smith, but it seems unlikely that anyone but the comb maker had responsibility for their use in assembling and securing the various components of the comb. Thus, the comb maker must have had some form of working relationship with the ironworker; this was as fundamental a requirement of the craft as was the availability of antler. It is of course possible that the antler worker and ironworker worked together as members of a production line, but there is no direct evidence for this, and to invoke such a scenario arguably presupposes an unnecessary level of logistical sophistication.

 The situation does become rather more complex in later Viking-Age and medieval Scandinavia, however. Many northern European towns – Oslo, Bergen, Trondheim, Schleswig, Lund and Sigtuna to name a few – became host to something akin to factories producing combs on an unprecedented scale. Often exploiting the availability of reindeer antler sourced from the north, the products of these workshops spread across the Norse world, reaching as far as Russia in the East, and Greenland in the west. These combs, however, depart from their first millennial antecedents in one important respect: they invariably make use of copper alloy, rather than iron rivets. Moreover, the use of material is precocious. Though initially, the rivets were used exactly as iron ones (that is to say in a minimalist, functional manner, though not without care for symmetry and aesthetics), soon they began to be incorporated as a fundamentally decorative element of the object. Rivets could be closely spaced, even in double or triple rows: where once a comb might have had 7-10 rivets, now 20 to 30 might be possible. They could even be arrayed into decorative arrangements such as crosses, and in many ways seem to be the successors of the equally versatile ring-and-dot motifs seen so frequently on earlier combs.

The characteristics of the rivets themselves are variable. Some seem to be made of solid copper alloy: perhaps each was a clipping of wire given an expanded head, and hammered into place, and it is notable that possible drawplates and rivet- shaping tools have been found in association with likely comb makers workshops in Bergen and Sigtuna (Hansen 2005: 159-161, fig 41; Anon. in press). X-ray fluorescence analysis has suggested that other rivets may have had a ferrous core plated with copper alloy, while some clearly consist of copper-alloy sheeting, clipped and tightly rolled, before being peened into place. More research needs to be undertaken to determine if there is any chronological or spatial patterning to these phenomena, but it does seem likely that the manufacture and incorporation of the metal elements of these later Scandinavian combs took place within the workshops themselves. This becomes even more clearly apparent when one considers the more extravagant uses to which copper alloy was put in the manufacture of certain combs. Certain forms of eleventh- and twelfth-century comb featured openwork carving in the antler plates, overlying copper-alloy sheeting. Others feature decorative copper-alloy cuffs or bonding elements, and even suspension chains. Some combs are characterized by a deep and evenly applied green staining, which must be deliberate rather than an artifact of taphonomy, and is likely the result of the application of some form of copper agent. All this is indicative of a close, overlapping world of specialist bone/antler workers and non-ferrous metalworkers, collaborating on the production of specialist items. This was not an entirely novel development; combs with copper-alloy connecting plates have a wide but thin distribution across northern Europe, probably being produced in tenth-century Hedeby, and perhaps distributed via Gotland (Hilberg 2008: 80-82), but little is known about the context or details of their manufacture. Perhaps the seeds of cross-technique collaboration were sown in the early Viking towns, but its potential could only be effectively exploited in the serial production of the urban workshops of the second millennium. In this context, the ability to work across media resulted in the eventual development of what can be seen as an entirely new product. It is notable that these objects, though ubiquitous in the late Norse world, were never adopted in post-Conquest England. This was likely the result, in part, of the different circumstances of production that developed in Scandinavia and across the North Sea, but it is impossible to divorce these phenomena from either the environmental setting of the supply chain, or the social context of comb consumption and use (see below).

## **Technological rejection**

Technological development, as we have seen, was socially contingent and non-linear, reliant on the flux and change in communities in terms of needs and desires, access to materials and on the mobility of specialists and the development of specialist centers. Innovative development in a continuum was not a given. Famously developed pottery industries appear to have failed to find a home in the towns of Viking-Age Scandinavia. As we have seen, this contrasts sharply against the situation encountered in the Anglo-Scandinavian towns of northern and eastern England [(Kilmurry 1977](https://paperpile.com/c/3bSJDL/rQxN); [Mainman 1990](https://paperpile.com/c/3bSJDL/fe5u); Brown 2003; [Perry 2016)](https://paperpile.com/c/3bSJDL/B7xz). It is not the case that centers like Ribe were cut off from innovative technologies in operation in other parts of Europe, but the products of these short-lived workshops (like those of our continental potter in Ribe) industries were not widely dispersed, and may even have been intended for use in the cosmopolitan, urban context in particular. In any case, they were not adopted by the regional population at large.

Such stories of selective technological adoption and rejection are actually rather commonplace. On an international scale, Soren Sindbaek [(2006)](https://paperpile.com/c/3bSJDL/74pV) has convincingly demonstrated that, at the Baltic town of Wolin, there is a lack of evidence for long-distance exchange prior to the tenth century. The absence of evidence for incoming stone goods or glass beads, or for outgoing Slavic ceramics, cannot have been the result of lack of access to the maritime market, given Wolin’s topographic and social context. Rather, Sindbaek argues, the pattern reflects a deliberate choice grounded in an ‘ideology of independence’ coupled with a relatively egalitarian society, and that change eventually came in the context of developing power structures and the beginnings of state formation. The potential for such agency can be seen in the adoption or rejection not only of engagement with markets and imports, but also of technological invention and innovation.

 When considered in turn, the rejection of some forms of technology appears fairly straightforward. It seems likely, for instance, that the absence from England of Scandinavian iron equipment such as ‘rattles’ (perhaps used for driving horse-drawn sledges), and the mattocks known as ‘celts’ owes much to differing environmental conditions and agricultural regimes (see Ottaway in press). While early-medieval Ireland’s relatively late adoption of advanced smithing techniques such as pattern-welding cannot be the result of ignorance of its products, it may relate to a lack of familiarity with the necessary techniques (Scott 1990: 147-149). Other absences are less understandable: why, for example, are the long-toothed (weaving?) combs so common in continental Europe between the twelfth and fourteenth centuries never found in the United Kingdom (see [MacGregor 1985](https://paperpile.com/c/3bSJDL/ud9C):190)? They are well represented in the Low Countries, whose towns we know to have maintained close contact with English ports – not least through the trade of wool – and yet this particular item was apparently deemed inappropriate for adoption in England. Why did the copper-alloy riveted hair combs so popular in eleventh to thirteenth century Scandinavia and its colonies never gain a foothold in England (see above; [Ashby 2015a)](https://paperpile.com/c/3bSJDL/XDU0)? On a slightly grander scale: why were monumental brasses not widely adopted in fourteenth and fifteenth-century northern England, when they were so pervasive in the south? This cannot, as has been argued, be a simple matter of relative prosperity and access to resources; it seems that many wealthy members of the northern secular elite were memorialized in incised stone. This must rather be a question of local or regional identity, manifest through maintenance of a shared technological heritage [(McClain 2010)](https://paperpile.com/c/3bSJDL/L22z). Such traditions are powerful, and often resistant to change or external influence (see Lemonnier 1993).

**Conclusion**

In recent years, the study of medieval technology has gathered significant momentum. We have seen how technology has the power to transform society, through both its importance to politics and hierarchy, and its potential as an economic driver, while its study can act as a way into understanding social change on a range of scales. We have also seen that it can provide insight into the nature of identities – here the focus has been gender and status, but craft is also a great window onto the construction of mercantile, urban and ethnic identities (e.g. Hadley in press). Barely studied to date, a particular area of potential is a synthetic understanding of the overlapping and interdigitated relationships between artisans; previously rendered inaccessible by low levels of stratigraphic resolution, new ‘high-definition’ approaches to excavation and analysis offer considerable potential in this regard (Raja and Sindbaek 2018). Finally, we come back to our potter and their short-lived operation in Ribe, as we have seen how a local or regional lack of engagement with innovation does not always signify ignorance, but may equally be the result of active rejection on grounds of technical irrelevance, social incompatibility, ideology, economics or politics.

Notwithstanding the fact that the study of medieval technology is clearly a vibrant and developing field, readers will note that much of this work has been undertaken by a relatively small number of researchers, and there is scope for much more widespread engagement. Back in 2000, Sillar and Tite made the case for social constructivism as a framework within which material scientists and archaeologists could work together in a theoretically informed manner, so as to address the big social and economic questions facing the discipline (Sillar and Tite 2000). The theoretical groundwork has now been well-tested, and archaeological science now offers more unexploited potential than at any point in recent memory. We can now routinely use archaeological science to ask big questions of artifactual material, and the time is ripe for more projects that explicitly set out to do just this.

 From a material-culture perspective, what is needed now is a systematic, comparative survey of the material produced by our various crafts, including both their artifactual output and their waste products, by-products, semi-manufactures, and debitage. Such a survey may identify the degree to which rural and urban sites around the Baltic and North Seas were interconnected in terms of knowledge as well as economics, and will test the idea that patterning in technological detail may be used as a subtle proxy for travel, culture contact and communication.

 There are positive signs that this is beginning to happen. In particular, one might note that a sustained focus on ‘difficult’ materials is starting to pay off. One of the great lacunae in our discussion relates to the evidence for the working of organic, perishable products such as leather and fur (see [Cameron 1998)](https://paperpile.com/c/3bSJDL/Q1B8). While textile manufacture is represented by a relatively robust and frequently encountered repertoire of manufacturing equipment (e.g. spindle whorls, loom weights, and weaving swords), the sporadic survival of leather and fur products is not similarly supported by associated technological paraphernalia. Recognition of the fur trade, for instance, is largely dependent on taphonomically sensitive zooarchaeological evidence. Thus, while the animal bones from Birka provided significant evidence for the transit or finishing of semi-processed furs [(Wigh 2001)](https://paperpile.com/c/3bSJDL/fk3P), similar indications have been less forthcoming in the archaeology of contemporary towns, even where identifying evidence for fur trade has been actively highlighted as a research priority [(Barrett et al. 2007](https://paperpile.com/c/3bSJDL/KBfr): 307). However, other areas of animal-centered craft have seen initial exploration from new perspectives. The application of stable-isotope analysis to medieval textiles [(von Holstein et al. 2016)](https://paperpile.com/c/3bSJDL/tvzE) shows some promise in tracking the movement of particular crafted products and raw materials, while the proteomic technique known as ZooMS (zooarchaeology by mass spectrometry, see Buckley et al. 2009) has found considerable success in the speciation of worked-bone objects and waste ([von Holstein et al. 2014; Ashby et al. 2015; Brandt et al. 2018)](https://paperpile.com/c/3bSJDL/5ra7%2BXjeG). This has made headway in resolving long-debated questions about raw material supply in Scandinavia and the North Atlantic, and also shows potential for the high-resolution analysis of leather and parchment [(Collins et al. 2015)](https://paperpile.com/c/3bSJDL/cLSk), perhaps offering a solution to the problem of taphonomic invisibility in the fur and skin trades.

 Recent research on the extraction, working, and use of steatite and soapstone utilized both rapidly developing analytical techniques and novel theoretical perspectives, hinting at the potential that remains to be exploited (see papers in [Hansen and Storemyr 2017)](https://paperpile.com/c/3bSJDL/rr6J). Most excitingly, researchers have started to think a little more about the people involved in the craft (cf.[Hansen et al. 2015)](https://paperpile.com/c/3bSJDL/h0Iq), noting, for instance, the possibility that Viking-Age steatite production may have been a multi-ethnic activity, with significant Saami involvement [(Bunse 2017)](https://paperpile.com/c/3bSJDL/doL2). While the implications of this possibility remain to be fully thought through, progress continues to be made in the difficult task of chemically provenancing steatite, and some important steps have been made in morphological analysis [(Forster and Jones 2017; Høegsberg 2017)](https://paperpile.com/c/3bSJDL/nZZL%2BB0Db) and the relationship between form, function, and fashion [(Vangstad 2017)](https://paperpile.com/c/3bSJDL/QvOR).

 Another area in which the study of medieval technology may have space to develop is in the application of experimental archaeology. Through controlled experiment, careful observation, and application of analytical techniques (e.g.microwear; traceology) and theoretical frameworks (*chaîne opératoire*), prehistorians have made great strides in this arena (e.g. David 2009; Elliott and Milner 2010; Bergsvik and David 2014; Little et al. 2016). These developments have not only elucidated the technologies that underlay a range of otherwise well-researched material, but have also transformed our understanding of the social context of material culture. As we have seen, medievalists have tended to lag some way behind the early-prehistoric vanguard. While important work is being undertaken (notably at University College Dublin’s Centre for Experimental Archaeology and Material Culture; see also Söderberg 2004; Fairnell 2008), the implications of this research have not yet filtered into mainstream archaeological debate. This is clearly an area ripe for further work, provided it is undertaken with clearly defined questions in mind: questions that are both theoretically informed and of relevance to current debates in medieval archaeology.

If this review can be distilled to a single finding, it is that studies to date seem to show that the superficial differences we see in crafts like comb making and textile manufacture – visible in raw materials, working practices, and aesthetics – are generated out of differences that persist at a much deeper level. These relate to phenomena such as the social status, gender, and personal mobility of the artisans involved in production. There is a need, therefore, to bring these individuals into focus if we are to understand the workings of trade and craft production at large. We might achieve this by drawing on the remains of those individuals themselves, where they can be identified. Archaeological science is now beginning to offer the potential to tie actual individuals to particular crafts; microscopic and biomolecular analysis of dental calculus found on human teeth demonstrates its ability to capture inhaled particles and trapped fibers, which, with the right reference material, could conceivably help us to identify weavers, boneworkers, and metal-casters (e.g. [Buckley et al. 2014)](https://paperpile.com/c/3bSJDL/Fz2p). Though as yet relatively unexplored, for the historically attested past, the potential of these approaches is immense (e.g. [Radini et al. 2016)](https://paperpile.com/c/3bSJDL/bPhf).

 There is still much to do. However, artifacts and their associated production waste represent a rich and relatively unexplored reservoir of technological (and thus social) information. If we have the courage to take on comparative analyses that are both large- scale and fine-grained, and endeavor to engage creatively with the opportunities afforded by interdisciplinary collaboration, on structural and environmental archaeology, as well as human osteology, we will gain access to a much more detailed understanding not only of social and economic structure, but of the rhythms of everyday life, and of the ways in which people communicated and built communities.

## *Acknowledgements*

The production of a synthetic overview such as this is beyond the abilities of the lone scholar (or at least this one). This essay draws more or less directly on many conversations I have had over the past several years. Those which I can remember involved James Barrett, Irene Baug, Johan Callmer, Axel Christophersen, Robin Fleming, Gitte Hansen, Jane Kershaw, Ailsa Mainman, Quita Mould, Patrick Ottaway, Unn Pedersen, Gareth Perry, Soren Sindbaek, Dagfinn Skre, and Penelope Walton Rogers, but there were many more, not least my own M.A. and Ph.D. students. It also builds on discussions that emerged from the British-Academy funded CNVT project (co-directed with Soren Sindbaek, and involving several of the above named specialists). I am grateful to Patrick Ottaway and Dawn Hadley, for allowing me to see and refer to their unpublished work. All errors remain uniquely the author’s own.