ARMS AND ARMOR IN HISTORY

Traditionally, the story of human development has been divided into the Stone, Bronze, and Iron Ages, according to the dominant material used in making hard implements. Modern anthropologists and historians prefer to divide according to modes of subsistence and social organization: Band Societies (hunter-gatherers), Tribal Societies (food producers), and State Societies (urbanized societies).

The prehistoric period—the time before written records—can be divided into the Paleolithic (hunter-gatherer) and Neolithic (food-producing) Ages.

The Paleolithic Age begins with the appearance of the first ‘hominids’ (ancestors of humans as distinct from the great apes) around 2.5 million years ago. Anthropologists often distinguish between early humans and other primates on the basis of regular tool use. Humans lack the obvious natural tools of other species, such as powerful teeth, sharp claws, thick hides, and strong legs. However, they have eyes and minds well suited to focusing on objects, and hands well suited to manipulating them. For humans, tools were the chief evolutionary advantage, and weapons, used in hunting and in rivalries among human groups, were among the earliest implements in the human toolkit. The earliest identifiable weapon is a fragmentary wooden spear with fire-hardened point dating to 200,000 BCE, but doubtless many of the prehistoric stone axes discovered by archaeologists at sites across the globe also served as weapons.

Archaeological evidence as well as comparison with modern cultures using Stone Age technologies suggests that Paleolithic humans lived in small kinship-based bands, with relatively little social differentiation except by age and sex. These hunter-gatherers lived nomadic lives, following the supply of food.
The Neolithic Age begins with the emergence of food production around 8000 BCE in the Near East. This innovation revolutionized the life of those societies that adopted it. Communities ceased to be nomadic, instead settling in permanent villages. This made possible a greater degree of private ownership and accumulation of wealth. The settled lifestyle also facilitated the emergence of new technologies, as did the production of surplus foods which could support specialized crafts. Both pottery and weaving first appear in this period, as do the first walled settlements. Archaeological and anthropological evidence suggests that these early agricultural societies were structured on a tribal basis, consisting of larger communities still maintaining at least the idea of a shared kinship, and subdivided into individual kin-groups within the tribe. The accumulation of wealth allowed some of these kin-groups to attain dominant positions in the community, which would eventually form the basis of class divisions, while the agricultural mode of subsistence brought about the beginnings of land ownership, which was to play a major role in shaping these divisions.

The technological and social changes brought about by food production made possible the first ‘state societies’, or civilizations, again first in the Near East (Mesopotamia and Egypt), somewhere around 3500 BCE. These societies were characterized by high population density and economic specialization, again promoting the emergence of major new technologies, particularly writing and metalworking.

Early state societies were characterized by pronounced class divisions between the rulers and the workers. Leading families passed on their wealth and power from one generation to the next, perpetuating their aristocratic status, while the less fortunate became dependent on the powerful for their livelihoods. Often one particular kin-group was designated the royal family.
Royal authority was in many cases grounded on a claim of a special relationship to the gods. Science in the modern sense was just beginning to make its appearance in Mesopotamia and Egypt, particularly in the form of astronomy and mathematics. However, the causes of most phenomena remained mysterious, and supernatural explanations were invoked. This was especially true of warfare, the outcome of which has always been notoriously unpredictable. From the time of the earliest written records, divine powers have been invoked to explain or influence the outcome of military campaigns, and the military authority of ancient rulers was closely bound up with their perceived access to divine favor. This connection between war and religion remains highly active all the way through the period covered by our collections.

Then as now, military achievement. A classic example is the working of copper and bronze appeared in this region shortly after the emergence of state societies military and prestige purposes. They conferred an obvious military smelting, and working them was a high-capital enterprise only poss
time, because metalworking technologies were expensive, metal goods were prestigious items that underscored the social status of those who had them. This combination of military and social significance was deeply imbedded in metal arms and armor, both of which made their first appearance at this time. They not only conferred material power on the rulers who controlled them, but stood as a symbol of the rulers’ wealth and authority, their exclusive right to use violence, and their divinely-appointed role as leaders in warfare.

The fine Luristani bracelets in the Ancient Gallery reflect the high status of the metalworker’s craft in the ancient world; they come from a culture in western Iran that evolved under the influence of nearby Mesopotamia. The Egyptian bronze axe in the Timeline comes from a period when Egyptian civilization was at its height. It also demonstrates the limits of Egyptian technology of the time—the blade is attached to the haft with a leather thong, rather than being cast with a socket, as in later axes. The Cypriot dagger in the Timeline illustrates cultural diffusion from advanced areas like Egypt and Mesopotamia: its form clearly shows the influence of Egyptian metalworking styles.

The influence of Egyptian and Mesopotamian civilization contributed to the emergence of city-states in Mycaenean Greece around 1400 BCE. These early Greek-speaking civilizations disintegrated around 1200 BCE, but their memory was preserved in the Homeric tales of Troy. The style of warfare represented in Homer is characteristic of the Mycaenean period and other early civilizations, focused on the doings of kings and aristocratic heroes who fight as individuals, often from chariots, amidst ‘mob’-type armies. The northern European bronze sword in the Timeline is based on Greek swords of the sort that would have been carried by the heroes of the Trojan War.
Greece emerged from its post-Mycenaean Dark Age around 800 BCE. The rise of the new city-states, with coincided with new styles of warfare that emphasized the highly disciplined block of footsoldiers, the ‘phalanx’, armed with long spears and employing shock tactics. In hand-to-hand combat, a highly cohesive block of soldiers can defend quite effectively against a less cohesive enemy even when outnumbered, and on the attack the shock delivered by a well disciplined block can break the order of the opponent; breaking the opponent’s order, which can turn an army from an obedient fighting force to a chaotic mob, is one of the most effective means of achieving victory in battle. The long spears of the phalanx made excellent use of the unit’s discipline: longer weapons are extremely effective in the hands of a well-ordered unit, since they can kill the opponents before they are within range to attack; but discipline is crucial, since long weapons are a disadvantage if the unit has lost its order or allowed the enemy to enter past its spearpoints.

The characteristic Greek soldier was the hoplite, or ‘armed man’. The hoplite was a footsoldier, typically equipped with a helmet, round shield, greaves, a cuirass of bronze or linen, and a long spear. The highly regularized order and organization of these Greek armies mirrored the increasingly systematized political structures in the Greek city-states. It may also be that the relatively ordinary social status of the hoplite citizen-soldiers contributed to the impetus toward democratic institutions in ancient Greece.

This period also marks the beginning of the ‘Iron Age’. Iron is more difficult to smelt than copper: the first iron artifacts appear two millennia after the appearance of bronze, and they do not become common until after 1000 BCE. Steel (an alloy of iron and carbon) appears more or less concurrently with iron. As with copper and its alloys, the chief early applications of iron were military—even more so, since the relatively plain appearance of iron limited
its usefulness as a prestige material. Armor continued to be made from bronze, but iron became the preferred metal for weapons.

The long iron spearheads in the Timeline and Ancient Gallery are of the sort used by the hoplite. The spearheads in the Ancient Gallery illustrate the transition from shorter bronze-headed spears, designed for single combat and throwing as in the battles described by Homer, to the longer iron-tipped spears intended for the mass operations of the phalanx. The muscle cuirass in the Ancient gallery is typical of the equipment of a wealthy hoplite. It illustrates the use of metal armor as status symbol: the craftsman who formed this elegant piece was highly skilled, and the warrior who wore it could obviously afford armor that was fashionable as well as protective. The object’s uncertain origin in Greece or Italy reflects the lively cultural interaction in the ancient Mediterranean, facilitated by Greek colonization that extended from Spain to the Black Sea.

The ongoing connection between religion and warfare is vividly illustrated by our “Corinthian” helmets, several of which have had their nose- or cheek-pieces bent as offerings to the gods. A warrior who was successful in battle would often take arms from a defeated enemy and dedicate them to the gods at a temple; in other cases, the arms were dedicated on behalf of a fallen friend; by ruining them for human use, he ensured that they would be consecrated only for divine enjoyment. These helmets also illustrate the increasing refinement and sophistication of Greek civilization in this period, from the simple unadorned shapes of the earliest examples to the delicate artistry of the latest.

The Greek city-states reached their height around 500-450 BCE, the period of the wars against the Persian Empire. In the following century, the Greek city-states exhausted themselves in the Peloponnesian Wars, leaving the country open for conquest by Phillip of Macedonia (father of Alexander the Great) around 340 BCE. Although the Greek city-states never regained their independence, their culture remained highly influential throughout the Mediterranean
The diffusion of Greek culture was accelerated by the conquests of Alexander, whose vast empire gave rise to the Greek-speaking ‘Hellenistic’ culture that dominated the eastern Mediterranean from southern Italy to the Near East.

The Italian peninsula was one of the areas most influenced by Greek civilization. The Etruscans of northern Italy, represented by a number of pieces in our collection, were among the most powerful early civilizations in the area, and passed on many Greek influences to the Romans. The Etruscan “Montefortino” helmet in the Timeline and the Etruscan or Italic helmet in the Ancient Gallery derive their shapes from local tastes, but the technology that produced them was imported from the Greeks. The Etruscans also imported the Greek alphabet, which they adapted and later passed on to the Romans. The differences between our alphabet and that of the Greeks are largely due to Etruscan modifications.

By the time of Alexander’s conquests, Rome was becoming a major power in Italy, and over the following centuries its dominion spread, reaching its apex around 100-200 CE. The Romans introduced surprisingly few major technological innovations of their own, but they excelled at making use of the technologies of conquered and neighboring cultures. The Dura-Europos display illustrates this feature of Roman culture: the technology of siege warfare, represented by the ballista bolts and catapult stones, was largely a product of Hellenistic Greek culture; mail armor and the long sword or spatha appear to have been Celtic
innovations; and heavy cavalry covered with *scale armor* was characteristic of Rome’s neighbors to the east. These diverse technologies were integrated into a standardized military system that the Romans could deploy throughout their domains—Dura lay at the very edge of Rome’s conquests. These artifacts also reflect the increasing use of iron in the Roman world—scale armor as well as weapons might now be made of iron, although decorative items like the *battle standard* were still made of the more decorative, golden-colored bronze.

The Roman military system continued the Greek development of standardized structures to replace the old ‘heroic’ patterns of warfare, although traces of earlier customs remained. The Roman army was carefully organized and highly trained, triumphing by virtue of its organizational and technological advantages rather than by individual prowess. The right to wage war was firmly vested in the Roman state, in contrast with the tribalism and feuding that prevailed outside Rome’s borders. Nonetheless, the upper echelons of military leadership were still drawn from the aristocracy, and the Roman lower nobility, the *equites* (‘horsemen’), retained their old designation even though the Romans never really specialized in mounted combat, and the Roman army often drew its mounted component from non-Romans.
The ongoing cultural significance of violence is dramatically illustrated by the museum’s gladiator helmet. The original gladiatorial games were sacrificial combats between slaves held as part of funeral ceremonies among the Etruscans. The Romans adopted the custom, but it eventually lost its religious significance to become a largely secular form of entertainment. The combatants were typically equipped with stereotyped or even caricatured arms associated with regional cultures in and around the Roman world.
The Barbarian Invasions, c300 CE-500 CE.

The fragmentation of the Roman Empire from about 300 CE onward again changed the face of warfare. Most of the western parts of the Roman Empire were taken over by Germanic tribes: Visigoths in Spain and southern France, Franks in northern France, Burgundians in eastern France, Lombards and Ostrogoths in Italy, Angles, Saxons and Jutes in Britain. The culture of the Germanic tribes, along with Greco-Roman civilization and Christianity, was one of the three main elements that shaped the medieval world.

The Germanic peoples spoke languages related to modern German and English, and all shared a similar cultural background, although they were politically divided into tribes of various sizes. Like other tribal societies, they lacked real urban centers. Their society consisted of four groups: slaves, free people, nobles, and royalty. The free men made up the warriors of the tribe and were allowed to participate in the political process. Slaves were usually prisoners of war or the descendants of prisoners. The nobles were expected to take leading roles in warfare and decision making. One family would usually be the royal family, from whom the tribal king would be chosen—the position was not necessarily passed on to the eldest son. The king served as the leader in war and as a focal
participant in religious ceremonies, but his political powers were limited by custom, by the influence of the nobles, and by the will of the freemen. This political structure was exported with the conquest of the Roman territories, and underlay the social hierarchy of the Middle Ages.

Although their technological repertoire was less complex than that of the Romans, the Germanic tribes excelled at metalwork, and some of the best iron mines lay in the Germanic areas. The **Germanic axe** and the **Frankish spearhead** in the Timeline reflect this aspect of their technology. Their style of warfare can be likened to that of the Mycenaean Age, focused on individual prowess rather than the group discipline at which Classical Greece and Rome excelled.

The collapse of the western Roman Empire was complete by 500 CE. Over the following centuries, new military technologies reshaped medieval society. Developments such as the stirrup (spreading slowly through Europe after 700 CE) and the high-backed saddle (in place by the late 1100s) allowed for much more effective use of the mounted soldier, who increasingly became the dominant force on the battlefield. This precipitated a division in the class of freemen: those who could afford to support themselves as mounted soldiers enjoyed enhanced military and social status; as the emerging class of knights, they eventually came to be partially assimilated to the aristocracy. Those who could only serve as footsoldiers lost much of their military significance and social influence, and were likely to find themselves slipping down into the class of unfree serfs.

By the time of the First Crusade (1095 CE), the classic knight armed with a steel or iron helmet, wooden shield, mail hauberk (shirt), lance, and sword, had become the master of the battlefield. The knights would open the battle with a charge with lances ‘couched’ (tucked under the arm). The impact of a mass of charging knights was considered certain to
break the order of any unit of infantry. If the lance broke, or if the knight needed to fight in a mêlée, he could draw his sword instead. Although knights used shock tactics for their initial attack, their style of combat remained heroic rather than disciplined, emphasizing the prowess of the individual warrior.

The crusader in the Great Hall represents this kind of mounted warrior. His barrel-shaped helm and flatiron-shaped shield were new styles in the 1200s, but otherwise the knight’s equipment was fairly constant from the 1000s to the 1300s. The spurs in the Timeline were highly significant symbols as well as tools in their day, standing as emblems of the knight’s elite status as part of the warrior aristocracy.

The medieval castle emerged at about the same time as the mounted knight, around the 10th century, and was closely associated with the new emphasis on mounted combat. Castles served as bases for the operations of mounted troops, allowing the owner of the castle to control a large surrounding territory: if any enemy army tried to pass through the area, the knights could attack it on the march at the time and place of their choosing, and withdraw to the safety of the castle if they were at risk of defeat.

The First Crusade marked an important symbolic moment in the development of the medieval idea of warfare and the warrior. In the early Middle Ages, the aristocracy, although officially Christian, adhered to a code of conduct that was not very different from that of Homer’s pagan heroes. By 1100, various forces had reshaped the ideals and even the practices of warriors and warfare. The church had endorsed the function of the aristocracy as the warrior class, but it insisted that the Christian warrior needed to be guided by purposes and practices that were in keeping with Christian teaching. Knights were to use their military power not merely in the pursuit of personal gain, but to
uphold justice, to defend the weak, and to support the church. In the mean time, other influences were at work on the secular aspects of the warrior’s life. The idea of romantic love was cultivated in the courts of southern Europe, which were in close contact with the sophisticated cultures of the Moslem world. Romance was also imported from the Celtic fringe. European aristocrats around 1100 were discovering Arthurian tales brought from Britain to Brittany by refugees from the Anglo-Saxon conquest centuries before; these stories incorporated a combination of heroic warfare with romantic love that was characteristic of the Celtic traditions of the British Isles. By the 1100s, a knight was expected not only to be terrible to his enemies, but also pious toward God, loyal toward the church, protective toward the weak, and gracious toward women. The reality was never as glamorous as the ideal, but knights were certainly heavily influenced by the code of chivalry, even if few of them truly lived up to its demanding ideals.

The military supremacy of the knight remained largely unchallenged until about 1300. During the 1300s, several new developments brought a shift in military dynamics. One was the development of staff-weapon tactics using the
same principles of group cohesion and long weapons that had worked so well for the ancient Greeks. At the battle of Courtrai in 1302, Flemish commoners defeated the flower of French chivalry by deploying long spears against the charging cavalry. Similarly at Bannockburn in 1332, Scottish spearmen inflicted a humiliating defeat on English knights. Such outcomes came as a shock at the time, but over the following centuries staff-weapon tactics continued to be developed, especially by the Swiss, to the point where it was by no means rare for footsoldiers to defeat knights in battle. The 15th- and 16th-century halberds, pikes, and other staff weapons in the Great Hall are relics of the rise of infantry tactics in the late Middle Ages and Renaissance.

The cultivation of longbow archery by the English also changed the distribution of power on the battlefield: at Crécy (1346), Poitiers (1356), and Agincourt (1415), English longbowmen played a critical role in defeating larger French armies heavily weighted toward knights. The increased military significance of common soldiers probably had a part in stimulating England’s Peasants’ Revolt in 1381. However, effective longbow archery required long years of training, and the longbow was never a major component in Continental European armies. Other armies were more likely to rely on the crossbow. The crossbow, derived from larger siege weapons, was used by the Romans, but largely forgotten in the early Middle Ages; it was reintroduced to military use in the 10th century, and had become a standard feature of Continental field armies by 1300 (cf. the 14th-century crossbow bolt in the Timeline). The crossbow was more expensive and slower than the longbow, but it required very little training to use, and could be extremely powerful.

The 1300s also witnessed the first battlefield use of gunpowder in Europe. Most early gunpowder weapons were light artillery pieces, and of limited effect. However, by the 1400s artillery was becoming quite effective, rendering the high thin walls of traditional castles obsolete. Meanwhile, ‘hand-cannons’, the earliest form of firearm, were becoming increasingly common. In 1525, the matchlock harquebus, an early type of musket, played a major role in the defeat of the king of France at Pavia in Italy, heralding the beginning of the age of firearms.

As various forces challenged the role of the mounted knight on the battlefield, the aristocracy found new ways to assert their importance. The century that witnessed the rise of staff-weapon tactics, the longbow, and the first gunpowder weapons also saw the emergence of plate armor. In 1300 plate armor was generally restricted to the
helmet, reinforcing pieces at a few critical points like the elbow and knees, and fabric coats with iron reinforcements built into them. By 1400, the fully articulated suit of plate armor from head to toe was a familiar sight on the battlefield. The 14th-century basnet in the Timeline is typical of a transitional style incorporating both mail and plate armor elements.

Various theories have been offered to account for this revolutionary development in defensive gear. Outnumbered armies fighting defensively found it advantageous to dismount their knights and distribute them through battle line to shore up the resolve of the footsoldiers. Since fighting on foot the knight more vulnerable to attack, he had some incentive to look for more effective protection. Another theory holds that the crossbow, which was significantly improved in the 12th and 13th centuries, stimulated the search for a defense that would deflect crossbow bolts. Technological factors may also have played a role: ironworking technology was becoming increasingly sophisticated, which may have facilitated the precise fitting of plates to a not previously possible; iron production techniques were also improving, allowing for increased iron supply.

Whatever the cause, the development of plate armor never restored the primacy of the knight on the battlefield, but for a time it did make battle less dangerous for individual knights, as well as offering an opportunity for display of status. A knight in a full suit of plate was virtually impregnable to ordinary blows with a sword or thrusts with a spear: to defeat him, his opponent would need either to exploit chinks in the armor, or to dismantle the armor itself—hence the development in this period of lighter, tapered swords, designed for better control to thrust at weak points (compare the highly

Transitional armor, 1320s. ffoulkes 106.
tapered **medieval broadsword** in the Timeline), and heavy two-handed swords, pollaxes (cf. the **pollaxe** at the end of the Tournament Wing), and other weapons designed to overcome plate armor.

Plate armor itself offered an excellent opportunity for the wearer to display social status. Decorative possibilities with mail were limited, but plate could be designed and decorated in endless variety according to the latest fashions. Even the steel suit itself was an assertion of status, given the relatively high value of steel in pre-industrial society. Finally, plate armor had a major psychological component, proclaiming the wearer’s importance and invulnerability, and serving as a kind of dehumanizing mask that must have both increased his own sense of power while intimidating his opponents—and many of the armor styles in our collection clearly show an effort at dehumanization and intimidation.

The **16th-century helmet** in the Timeline reflects the trend toward increasing sophistication in armor design and decoration—it is highly decorated, intricately crafted, elegantly designed, and sufficient to protect the head and neck without the use of mail, in contrast with the earlier basnet. The **field, ceremonial, and tournament armors** in the Introductory gallery illustrate the intricacy and versatility of plate armor, and the technological and artistic sophistication it had reached by the 1500s. The introduction of plate armor made possible this kind of specialization. Field armor, for the traditional battlefield role, was designed to be light but sturdy. Ceremonial armor was highly decorated and relatively light and weak, purely for display. Tournament armor provided extra protection at the cost of lower mobility and visibility, which were less important in the controlled circumstances of the tournament.

Military theorists of the period continued to believe in the importance of the mounted soldier, but in practical terms his role on the battlefield was becoming marginal. The cavalry were most useful at pursuing broken enemies and scouting; one of the main battlefield tactics of late Renaissance cavalry was the ‘caracole’, in which one rank after another rode near the enemy line and discharged their pistols, a maneuver of limited effect.
By the late 1500s, the musket had become the backbone of military operations. The **matchlock musket** at the end of the Warfare Wing is typical of this weapon. It is plain and serviceable in design, and musketeer who carried it was a low-paid commoner; shilling for shilling, the musketeer was the best buy on the battlefield.

The musketeer’s chief disadvantage was his vulnerability to a cavalry charge, but this risk was overcome by teaming blocks of musketeers with blocks of armored pikemen, one of whose chief functions was to defend the musketeers at close quarters. The equipment, organization, and tactics of these pikemen was in many ways similar to that of the ancient phalanx, and Renaissance military theorists keenly studied their beloved Classical authors for ideas on how best to train and deploy these modern-day hoplites.

Pike and heavy cavalry, c1616. In practice, the charge with the lance was very rare by this time, and the heavy cavalryman would be more likely to rely on the pair of pistols attached to the front of his saddle. Wallhausen.
Improved metallurgical technology, especially the development of the blast furnace, significantly increased the supply and reduced the cost of iron in the 1500s, and it became increasingly common for ordinary soldiers to wear armor, particularly the pikemen, for whom the protection against hand-to-hand weapons was especially useful. The 17th-century helmet in the Timeline, the pikeman’s armor at the end of the Warfare Wing, and the 16th-century German half-armor next to the column to its right come from an age when armor was being worn by ordinary soldiers, as witnessed by their mass-produced look and shortcut styles of decoration.

At the same time, the increasing use and effectiveness of muskets undermined the usefulness of armor in general. To resist a musket ball, armor had to be made quite thick and heavy, with predictable effects on mobility. Already by the late 1500s footsoldiers on campaign were discarding parts of their armor that they considered not worth the extra burden, and by the mid-1600s it was increasingly common not to issue any armor at all. By 1700 armor had almost entirely disappeared from the battlefield, while the invention of the bayonet in the late 1600s allowed each musketeer to become his own pikeman, marking the final triumph of the firearm on the battlefield. The late 17th-century matchlock musket in the Timeline strongly resembles the flintlock and percussion-lock muskets of the 18th and 19th centuries.

The triumph of the musket had major social ramifications. In the Middle Ages, military power had lain largely in the hands of a small aristocracy who had the money to afford expensive arms, armor, and horses, and the leisure to train in their use. The musket was relatively inexpensive and required much less time to master, and the musketeer was drawn from the lower classes of society. The increased importance of the musket allowed for a much wider distribution of power than had been possible in the Middle Ages, and the revolutions in England (1642), America (1775), and France (1789) were made possible by this unromantic but much more democratic weapon.

Nonetheless, the weapons and armor of an earlier era continued to have an evocative power, and were still seen as practical equipment by military leaders reluctant to face the realities of a changing world. The 18th-century English officer’s gorget (derived from the armor piece worn around the neck to support the cuirass; see also the evolution of the gorgets in the Armorer’s Workshop) and 19th-century French sword in the Timeline, and the 19th-century
French carabinier’s cuirass and helmet in the Warfare Wing illustrate the ongoing role of medieval technologies in the Gunpowder Age.
HIGGINS ARMORY TRAINING: FREQUENTLY ASKED QUESTIONS

GENERAL

What are the different types of plate armor?

Field or Combat: strong, flexible; smooth, glancing surfaces to deflect weapons; relatively light

Jousting: very protective and heavy; maximum protection on the left side; little visibility or freedom of movement

Ceremonial: often heavily decorated; metal usually too thin or weak to deflect weapons and not suitable for battle

What are the materials used in armor? Plate armor of the Greeks and early Romans was made of bronze. In the later Roman period, iron armor became common, and by the late medieval period steel and iron were both in use. Sometimes armor was made of hardened leather plates, which was cheap, but sturdy enough to give protection against some weapons.

What is mail? Mail is interlocking iron (sometimes brass) rings. This could be worn as a coat covering the body (weighing up to 40 lbs), or in pieces covering the head or limbs, or parts of the body less protected by a suit of plate armor, such as the neck, armpits, or groin. Mail was the primary form of body protection used by knights during the Crusades (11th-13th centuries).

If mail has all those holes, how does it protect? The holes are very small in relation to the points of most weapons in use in the time when mail was a primary type of armor. The links are surprisingly strong, usually riveted, and each link interlocks with several neighbors in each direction: it takes a very powerful thrust to force them apart. However, mail provides little or no protection from crushing weapons, such as maces, clubs, or hammers. Part of plate armor’s advantage was its superior resistance to crushing blows.

When did armor go out of use and why? Armor such as that seen here was largely gone from battlefield use by the late 1600s. Muskets fired projectiles that could penetrate all but the heaviest armor, to the point that, to be effective, armor had to be too heavy to be useful.

What did ordinary footsoldiers wear? Usually little or no armor except for a helmet, if possible, and whatever pieces they could get their hands on, and wanted to carry around with them. Many wore quilted coats like the arming jackets worn underneath armor. Armor was generally too expensive for ordinary soldiers to afford.
Are the shields on the walls of the Great Hall for war? Most are not. Battlefield shields went out of general use by the late 14th century when complete plate armor began to supercede mail. These shields are later styles made of iron, many heavily decorated, and were designed for ceremonial use. The exceptions are the ‘bullet-proof’ shields made for footsoldiers called ‘targeteers’.

Why are the Greek helmets damaged? Arms and armor offered as votive sacrifices in the Greek world were often ritually disfigured as part of the votive process; the bent cheeks and nosepieces on our helmets are characteristic of such objects offered at temples. [Snodgrass, *Arms and Armor of the Greeks*, 37, 93]

**ARMOR ELEMENTS**

How could soldiers tell friends from enemies? In the Middle Ages, the ‘coat of arms’ (coat armor) was worn over the knight’s mail, showing his family or national emblem. With the appearance of plate armor and increasing reliance on professional rather than feudal armies, other devices such as different colored sashes, plumes, armbands, or special devices (such as a sprig of a particular plant worn in the hat) might be used. National uniforms did not appear until well into the 17th century, although already by 1300 it was common for individual military units to have some kind of uniform overgarment.

What is the lance rest? This is a device that acted as a fulcrum to help support the weight of the lance [Blair 61] and also acted as a shock absorber to counteract the force of impact from the lance when striking an opponent [Edge and Paddock]. It is found on both field and jousting armors.

What is the codpiece? The codpiece is used in armor from about 1510 to 1570. It was based on a civilian costume element that was in use since at least the mid-1400s, and was intended to provide essential protection for the armored soldier fighting on foot. There is no evidence that the armored codpiece was ever used as a pocket, although like many other armor elements, the interior would be padded [Blair 123].

Some of the armor has pointed toes, or flat, broad ones. Were these weapons? Not at all—the armorers were merely imitating the look of shoes fashionable in the period. The pointed shoes probably also said something about the wearer’s social status: they are relatively impractical for walking, and suggested that the wearer was accustomed to ride.
What are the discs at the armpits? These are called besagues (beh-sah-gews), and are connected to the armor with leather thongs or straps. They provided some protection to the armpits.

Why does some armor have a large, curved shield on the chest? This is the ‘tilting target’. It is found only on jousting armor: it served as a target for the opposing jouster, and the trelliswork on the surface made it easier for the lance to catch so that it might break on impact or unhorse the rider; it also provided extra protection to the wearer.

What’s with the skirts on the armor? The armored skirt or ‘tonlet’ found on some suits, was in use from about 1500 to 1560, especially in Germany. It offered a relatively easy way to protect the lower torso and thighs of a combatant on foot, but it was probably mostly an imitation of contemporary civilian fashions, a fact emphasized by the fake draping often built into the tonlet.

The fabric skirt, called a ‘base’, on the figure in the foot combat scene reflects a fashion popular for tournaments in the 1500s, particularly early in the century. As with other fabric garments worn with armor, these skirts could serve a heraldic purpose, helping to identify the wearer, as well as adding to the pageantry and color of his appearance. As with the tonlet, such a skirt also imitated the skirted coats fashionable for men in the early sixteenth century.

Wearing Armor

Did knights clank as they walked? No—properly fitted and lined armor makes only a soft metallic sound.

Did women wear armor? A few did—Joan of Arc is the most famous example.

How can a knight see out of his helmet? Why isn’t the opening larger? Knights had slits for vision and ventilation. To the sides and below, vision was very limited, so a combat helmet was designed to move freely. Jousting helmets were designed to provide maximum protection, and jousters did not require as much visibility, so their eyeslits were smaller, and usually recessed. The charging knight would lean at the hips forward to see his opponent, then sit back just prior to impact, protecting his eyes from splinters from a broken lance. The door on the right-hand side of many jousting helmets is for ventilation between jousts.
How did they go to the bathroom? Going into battle was like going on a long car ride—it was best to think of these things beforehand. Armor would generally be put on only when it was needed; in a pinch, most armor would not stop the wearer from unlacing his undergarments and pulling them down.

We don't really have direct evidence of what an armored man did when nature called, but we can make a pretty good educated guess based on how a suit of armor was constructed, and on what people did in civilian clothing. Wearing a suit of armor is structurally like wearing a short dress over sweatpants—except of course that it's all made of steel plates and weighs something like 65 lbs. Urinating is actually no more than a minor inconvenience. Your innermost layer—essentially the underpants—are kind of like a pair of bermuda shorts on a drawstring—all you have to do is loosen the drawstring. Over that you may have a pair of "hose"—kind of like tightish sweatpants that probably lace to your upper-body garment. But you don't even have to unlace—the hose generally have a "codpiece", a separate flap of material over the genitals that can be untied. Over that you just have a skirt of mail, which isn't really an obstacle—the plate armor doesn't necessarily cover this part. But it's advisable not to get urine on the armor—acidic, and not good for iron.

Defecation would have been slightly more aggravating, but essentially a variant on the same procedure. This time you would need to loosen your underwear drawstring the whole way, and you would need to untie your hose in the back. At this point defecating would be awkward, but feasible. But in an age before public restrooms, I expect people were pretty used to defecating in awkward situations. The closest thing to "documentary evidence" in this case is an illustration on fol. 33r of the 13c Maciejowski Bible, showing Saul defecating at Engedi—the other figures in the image are wearing armor, but Saul isn't. Nonetheless, the setup is pretty much what I have just described, and would have applied for an armored man, mutatis mutandis.

Was anything worn under the armor? Until the late 1500s, a padded and quilted jacket known as an arming doublet was worn under both plate and mail armor. Late 16th-century armor often appears in paintings worn over civilian costume. After 1600 it became common to wear a 'buff-coat' under the armor; this was a stiff coat of heavy leather, which might reach well down the thighs. Helmets also had a padded lining, often stuffed with horsehair or grasses, and major pieces of armor had cloth linings to keep the plates from wearing on one another and the garments underneath.

How much does plate armor weigh? Depending on the type and amount of armor worn, the suit might weigh from as little as 40-45 lbs for a battlefield armor to over 100 lbs for some types used in jousting. While the jousting armor was definitely not designed for mobility, the weight of battlefield armor was not very different from the equipment a modern footsoldier is expected to be able to carry.

Could knights walk/ride/fight etc in armor? Well-made armor did not greatly restrict the wearer’s freedom of movement: it was designed to move the way the human body moves. Endurance was more of an issue than mobility: the added burden of the armor would make the wearer tired sooner. The combination of armor and the necessary padding underneath could also be very hot, a serious problem given the exertion of battle, and the situation was made more difficult by closed styles of helmets that restricted breathing. Death by heat exhaustion was a very real
risk. Certain types of helmets could significantly reduce visibility, but a knight who wanted to see better could always choose a more open helmet, at the cost of leaving his face more vulnerable to attack.

**How did they clean the armor?** This is what servants are for. Plate armor would be cleaned by hand with light abrasives like pumice or sand mixed with oil. Mail was put into a sack or rotating barrel (think of a cement mixer) with a mixture of vinegar and sand and agitated by hand.

**How long did it take to put on or take off armor? Did knights dress themselves?** A classic suit of plate armor of the 1400s or 1500s was difficult to put on by yourself—as with cleaning, servants were an essential part of a knight’s equipment. Efforts with modern reproductions suggest that the process took about 15 minutes.
HORSES AND RIDING

How big were their horses? To judge by the size of Frisians, a breed used as a warhorse in the 16 and 17th centuries, the medieval warhorse may have stood about 15 hands high (5’ at the shoulder). In general configuration it might be compared to a heavyweight hunter.

How did knights mount their horses? The same way as people mount today, using the stirrups. A knight in prime condition was expected to be able to leap directly into the saddle fully armed; this athletic skill was the origin of modern Olympic vaulting, which still involves a mock horse with two grips representing the front and back of the saddle. For very heavy jousting armors, the knights could put on the leg defences first, then have the remaining pieces put on once in the saddle. Sometimes a small step-up platform was used. Never was a knight hoisted into the saddle.

If a knight was knocked off his horse, could he get up? Absolutely. Unless stunned or seriously injured, the knight could get to his feet quickly. The armor was not light, but it was designed to fit and move like a second skin.

How much did a horse cost? A cheap warhorse in medieval England might range from £5 to £10; the top-of-the line warhorse, or destrier, might cost £50 to £100 [Davis 67]. As a rough rule of thumb, £1 in the Middle Ages might be equated to $1000 today; essentially, a horse can be compared to a modern car: the cheapest can be had for a few thousand, while expensive models run into the tens of thousands.

How could horses support so much weight? The carrying capacity of a medieval warhorse was probably something around 375 lbs. [Ohler 15], so it could certainly carry a large man even in a 75 to 100 lb. suit of armor.

WARFARE

How big were armies of the time? A substantial medieval or Renaissance army might include 1000-5000 mounted troops, and 5000-25,000 footsoldiers.
A GUIDE TO MEDIEVAL AND RENAISSANCE WEAPONS

For convenience of understanding, the soldier’s weapons of the Middle Ages and Renaissance can be divided into haft weapons, edged weapons, missile weapons, and firearms.

HAFT WEAPONS

Haft weapons, which consist mostly of a shaft for gripping and have relatively little offensive surface, were already well established before the dawn of recorded history. The spear is one of the simplest and cheapest of weapons, and was a staple of the ordinary foot soldier until the latter part of the Middle Ages. Spears were also carried by horsemen in the early Middle Ages, although by the high Middle Ages the cavalry spear was evolving into the more specialized lance. In the later Middle Ages, the infantry spear was lengthened to become the pike (about 14-22’ long), in which form it remained in use until the adoption of the bayonet in the late 1600s. The length of the pike made it an especially useful weapon in holding off enemy cavalry. A ceremonial version of the spear, the partisan, was carried in the late 16th and 17th centuries by bodyguards and by officers as a badge of rank.

The mace is another simple haft weapon, essentially a variant of the club. Early maces seem to have been made of wood, but by the 12th century they were bound with metal, or made with iron heads, and in some cases iron hafts. Like other weapons, the mace gave rise to specialized variants, like the “morning star” (morgenstern) or “holy water sprinkler”, a two-handed spiked mace.
Many other haft weapons derived from civilian tools or agricultural implements. The war axe has a history going back to ancient times, as witnessed by the Egyptian example in our Timeline. It was well established by the beginning of the Middle Ages, and continued to be used in both one- and two-handed forms throughout the Middle Ages. It also gave rise to specialized versions such as the halberd, essentially a combination axe-spear that appeared in the 13th century. War hammers also appear in the 13th century.

The flail and bill also appear to have been 13th-century innovations, both derived from agricultural implements. The agricultural flail was used to pound grain in order to crack open the husks and release the seed within. As a weapon, its jointed head increased the mechanical power behind the blow, although it also made the weapon less agile. The bill was a one-handed tool used for tending the hedges that medieval farmers used to enclose their fields and gardens; the military bill had a longer haft and was used two-handed. The military fork, which is first attested in the 15th century, appears to derive from the agricultural pitchfork.

Aside from the spear, haft weapons tend to have their weight concentrated in the head, which meant that
they deliver a more powerful blow than an edged weapon of the same weight but are less handy to maneuver. One-handed haft weapons tended to be fairly straightforward in design, but two-handed ones (also called staff weapons) often incorporated various projections for thrusting, cutting, striking, piercing, and hooking. Many staff weapons had spikes that concentrated the force of the blow on one or more small points, which could be particularly useful for piercing armor. The multiple projections gave these weapons an aesthetic complexity that lent itself well to elaboration and decoration. Many two-handed haft weapons from the 16th century onward are highly ornate and clearly intended for ceremonial purposes; some later examples are intended purely for show or as badges of office, in some cases with heads so light that they can serve no real military purpose.

Staff weapons were only for use on foot; one-handed haft weapons could be used on horseback as well. Staff weapons were especially useful against mounted and armored opponents: their great length allowed them to deliver powerful blows against an armored opponent, and was also useful in reaching a mounted target or in fending off a cavalry attack. There was a substantial increase in the use of staff weapons after 1300, part and parcel of the discovery of new techniques to counteract the predominance of cavalry on the battlefield.

Haft weapons in general tended to be cheaper than edged weapons because they had less metal in them and required less skill to make. Tools and agricultural implements were especially economical for arming peasant levies, since they could be furnished or adapted from existing tools. Since haft weapons were relatively cheap, they were often the weapon of choice for equipping ordinary soldiers, but they were also used by aristocratic fighters, whether because they were especially suited to a particular type of combat, or just out of personal preference.
One last haft weapon worth special mention is the *catchpoll*. This was used in Europe from the 16th century into the 18th, and in some places into the 19th. This weapon was used to apprehend criminals: it is designed to catch a culprit by the neck.

What is the difference between a pike and a lance? A lance is a long spear, averaging 12-14’ and weighing up to 35 lbs. for a jousting lance, with a metal tip, pointed for battle, or blunted for the joust. It was carried only by riders. The pike was also a kind of spear, averaging 12-20’ in length. It was designed to be carried on foot, and especially to be planted in the ground by a body of footsoldiers in a porcupine effect that could resist a charge of mounted knights. Some pikes were shortened by their users, or provided in shorter lengths and called “half-pikes”. A 16’ pike had about a 3’ advantage over a 13’ lance, as in the scenario below (the declination of both weapons and the distance from the back of the weapon to the front of the target area of the person wielding it was about the same). Similarly, the lance had about a 5’ advantage over an 8’ halberd if the halberd was similarly positioned, suggesting that the halberd could not really hold off a cavalry charge in the same way.

EDGED WEAPONS

Edged weapons (swords and daggers) have a relatively short grip and a longer blade; most have at least one sharp edge, although a few styles were designed purely for...
thrusting. Because these weapons had a higher proportion of metal, they tended to be more expensive than haft weapons, particularly in the case of the *sword*, which required a great deal of skill to forge properly. A sword was commonly carried by knights as an auxiliary weapon for use after the initial charge with couched lance. Swords appeared in the 2nd millennium BCE, and by the beginning of the Middle Ages the long one-handed sword, or *spatha*, was already well established in Europe. The sword lacked the power of a haft weapon, but its weight was more evenly distributed than that of an axe or mace, which made it more maneuverable and better suited for defense as well as attack. During the central Middle Ages swords became more tapered, which made them even handier and improved point control. By 1300 longer versions were being made that could be wielded with one hand or two (see the 16th-century sword in the Timeline), and by 1350 there were even longer swords that required two hands. Like a staff weapon, the two-handed sword was designed for use on foot, and reflected the increasing tendency of knights to fight dismounted.

Swords were not generally worn with civilian clothes during the Middle Ages, except by travelers, but during the 1400s this was beginning to change. Since a sword worn with civilian dress was unlikely to be used against an armored opponent, it did not have to be as sturdy as a war-sword, and during the 1500s the civilian sword became increasingly narrow-bladed, allowing for greater speed and point control. It was this *rapier* (from the Spanish *espada ropera*, ‘dress sword’, from *ropa*, ‘robe, clothing’) that eventually gave rise to the very light small-sword of the eighteenth century, the forerunners of the modern fencer’s foil and epee.

**MISSILE WEAPONS**
The chief missile weapons of the Middle Ages were the bow and crossbow. The bow first appears as early as the late Paleolithic period, and was well established by the Middle Ages. The use of the bow reached its height in 14th- and 15th-century English armies, which deployed powerful bows to devastating effect in the Hundred Years’ War against France. However, effective use of such powerful bows requires years of training to develop the necessary strength and skill, and the bow was never as major an element in Continental armies, which relied more on the crossbow. The crossbow made its reappearance in the 10th century after having largely fallen out of use in the early Middle Ages. It was much easier to use because the Bowman did not have to draw the string and aim at the same time. Its disadvantage was greater expense and a slower rate of fire: drawing the string and setting the bolt were separate operations, and on a powerful crossbow the string had to be drawn with a mechanical aid such as the cranequin in the Hunting Gallery. A light crossbow might get about 2-3 shots a minute, roughly the same as a musket, as compared to the 10 or more possible with a longbow.

FIREARMS

Gunpowder weapons first appeared on European battlefields in the 1300s, and by 1400 the first ‘hand cannon’ were in use. These were essentially small cannons mounted on a long staff which the soldier held with one hand while applying a heated wire or lit matchcord (slow-burning rope impregnated with saltpeter) to a tiny hole at the base of the barrel to ignite the gunpowder. Such weapons became a common feature of 15th-century armies, and during this century they were made easier to use by the addition of a wooden stock to hold the barrel, and a match-lock which held the matchcord in a levered arm and lowered the match into the firing hole when the lever was pressed. The wheel-lock, in which a rotating wheel struck sparks against a piece of pyrite to ignite the powder, was in use by about 1500, and early versions of the flintlock, where the spark was struck by a piece of flint against a steel plate, appeared in the 1500s. Pistols were probably in use by the 1530s.
‘THE WORKS OF FIRE’:

METALLURGY AND THE ARMORER’S CRAFT

Throughout history, military technology has been at the forefront of most societies’ technological development, a fact especially well illustrated in the case of metallurgy and metalcraft, which have always been closely tied to military uses. The metal artifacts in the Higgins collection represent some of the most sophisticated achievements of pre-industrial technology.

Copper is occasionally found as ‘native’ (pure) copper, and native iron sometimes falls to the earth in the form of meteorites. In these forms, copper and iron have been worked even in societies that lacked actual metallurgy, among them the North American Indians, the Inuit, and the pre-Bronze Age cultures of the Old World.

Both copper and iron usually occur in nature as chemical combinations, especially oxides, in which the metal is combined with oxygen. The most common copper oxide is cuprite (Cu2O); naturally occurring iron oxides include hematite (Fe2O3), and magnetite (Fe3O4). Other common natural combinations include copper carbonate (CuCO3) and siderite or ferrous carbonate (FeCO3). These combinations are found in copper and iron ores, mixed in with trace quantities of other metals and various contaminants such as sulfur, clay, stone, lime, water, and sand. The dominant contaminant is silicon in the form of silica (SiO2), which is the chief component in most rocks: an ore is worth mining if it has a high ratio of metal to silica. In order to make the metal useful, the contaminants have to be physically removed and the metal separated from its chemical bonds. The following description details the procedure for processing iron oxide ores. Other types of iron

18c. Stripmining. Diderot 1.82.
ores involve similar processes, and similar techniques are also used with copper ores, except that copper can be smelted at a lower temperature: 800º C as opposed to 1150º C for iron ores.

The process begins with **mining** the ore from the ground. The earliest sources of iron were near the surface, and strip-mining and collection of bog-iron continued to provide some iron ore even into the modern period. However, by the Middle Ages most iron had to be extracted from further underground, and by the 1500s some of the technologies for exploiting deep mines were quite sophisticated.

The initial stages of ore processing aimed at physical removal of impurities: the more impurities removed before deoxidization, the better the final product. An obvious first stage was to **sort** the mined pieces to remove those which clearly had no iron content (the presence of iron was typically indicated by the reddish or brownish color of iron oxides—rust!). This process would be repeated at several stages, often in conjunction with **breaking** the ore into smaller pieces to allow more precise sorting.

Another means of removing impurities was **washing**: again, some processing establishments had fairly sophisticated facilities to make this more efficient. The water would remove the soluble or lighter components of the ore, leaving behind a higher concentration of the iron oxide.
One of the final stages before smelting was roasting, in which the ore was heated to burn off the sulfur. The roasting also made the ore more breakable, which allowed yet another round of breaking and sorting.

Roasting. Agricola 275.

Once the ore was sufficiently purified, it was subjected to smelting, a chemical process which detached the oxygen from the iron. The oldest means of achieving this was the bloomery technique, in which the iron oxide was strongly heated in the presence of carbon; the burning carbon formed carbon monoxide gas, a part of which would pick up oxygen from the iron oxide to form carbon dioxide gas.

The bloomery technique was the only available method of smelting until the late Middle Ages, and it continued in use locally even after the appearance of the more efficient blast furnace.

The smelter would build a mound on his hearth consisting of iron oxide fragments mixed with pieces of charcoal and a flux such as lime to facilitate the process. The charcoal was wood that had been subjected to partial combustion to remove impurities, leaving behind fairly pure carbon for the smelting process. The mound was covered with a clay hood, with a hole at the bottom to admit the nozzle of a bellows which blew air into the fire to bring the temperature up. Another hole at the top allowed the gases to escape. The pile was then ignited: once it got up to heat, flaming carbon monoxide gas would issue from the top, some of the impurities would flow out at the bottom as slag, and the remaining spongy lump or bloom would consist of small globules of iron with trace quantities of other metals in a mass of
slag and cinders. The exact results would depend on the temperature of the fire, the duration of smelting, the content of the ore, and the fluxes used.

The slag was based chiefly on silica (SiO₂), and the flux helped separate the slag from the metal. Lime was obtained by roasting limestone (CaCO₃ → CaO + CO₂); the lime combined with the silica to make calcium silicate (CaO + SiO₂ → CaSiO₃). Calcium silicate melts at a lower temperature than silica, allowing these impurities to flow out of the ore.

Since the discovery of the system of elements still lay in the future, nobody actually understood the chemical processes behind smelting: the procedure was based on centuries of trial and error. Individual ironworkers had their own recipes for producing the best results, and their craft might be likened to that of a skilled chef: like the chef, the results they produced were ultimately chemical, but the means were an art rather than a science. Ores from different regions often had characteristic starting components that affected the final outcome: again, medieval metallurgists didn’t understand the science behind it, but they knew that certain parts of Europe produced better iron than others, and that different ores called for different methods of smelting.

After smelting, the bloom was repeatedly reheated and beaten; this process drove out most of the remaining slag and cinders, as well as serving to form the iron into ingots of standard shape. This was the product known as wrought iron.

The bloomery process is also known as direct reduction, as it transforms the ore directly into wrought iron. It was a small-scale and labor-intensive operation, which contributed to the cost of the final product. This began to change in the late Middle Ages with the invention of indirect reduction, in which the ore passed through an intermediate stage as cast iron, a far more efficient process that significantly reduced the cost of iron. A bloomery in the mid-1600s might extract only 55% of the iron in the ore, whereas indirect reduction might yield as much as 92% [Tylecote 302]. There were also economies of scale, since a bloomery might produce up to 60-70 kg at a time, but cast iron could be produced in batches of 300-900 kg [Singer 2.71].
Melting the iron out of iron ore is a much more efficient means of purifying it, but the melting temperature is well above what could be achieved on the bloomery hearth. In the late Middle Ages two innovations were introduced that made it possible to melt iron. One was the introduction of powerful \textit{waterwheel-driven bellows} that increased the temperature of the fire. The other was the discovery that iron mixed with a larger quantity of charcoal could be melted by a fire that was not hot enough to melt pure iron—the carbon reduced the melting point of the iron (pure iron melts at 1535º C, but iron alloyed with 4% carbon will melt at 1149º C. By contrast, copper melts at only 1083º C, and cast copper and copper alloys have been around since ancient times.

These changes led to the appearance in the 15\textsuperscript{th} and 16\textsuperscript{th} century of the \textbf{blast furnace}, a major industrial installation that vastly increased iron output. Iron ore, charcoal, and lime were poured into a tall narrow furnace and ignited; attached to the furnace were water-powered bellows to raise the interior temperature. The iron-carbon mixture melted, and impurities rose to the top, where they were poured off as slag. The molten iron (containing some 2.5-
4% carbon) flowed out through a hole at the bottom of the furnace, branching out into a row of troughs dug into the sand floor. There it hardened as cast iron, and because the row of cast iron ingots looked like a litter of piglets suckling at a sow, the material came to be known as **pig iron**.

The blast furnace was in many ways the first modern industry. It involved multiple technologies: not only the ironworkers themselves, but masons and bricklayers to build and maintain the structures (which were subject to enormous strains from the extreme temperatures within the furnace), and millwrights to build and maintain the waterwheel mechanisms. The furnace had to be worked continuously, as it took several days to get up to its working temperature if it was allowed to stop. Laborers typically worked in two teams, each doing a 12-hour shift. Naturally, this was a very high-capital undertaking.

Cast iron has its own applications (it still makes the best stovetop cookware), but it is extremely hard and brittle, and impossible to shape once it has cooled. In order for the iron to be usable for tools, weapons, or armor, the surplus carbon had to be removed. This was done at the **finery**. In the finery the cast iron bar was introduced to a fire that was hot enough to melt the surface. Molten cast iron would drip off the end of the bar; a bellows blasted air at the falling drops, so that the carbon would combine with oxygen, leaving fairly pure iron that solidified as it fell to form a bloom at the bottom of the hearth. The bloom was then reheated and beaten to drive out most of the remaining slag and produce wrought iron.
The process was further industrialized in the 16th century with the first **rolling and slitting mills**. The thick wrought-iron bar was heated and passed between a series of progressively smaller water-driven rollers to make it thinner; the resulting iron plate could then be passed through the slitter which cut it into rods for making smaller iron items. The apparatus worked much like a modern pasta machine. Between the blast furnace and the rolling mill, iron processing truly represented the apogee of industrial techniques in the Renaissance.

Iron is tough, but if subjected to sufficient strain or impact it will lose its shape. To some degree, it can be hardened by repeated beating, a process known as **hammer-hardening** or **work-hardening**. However, for the sharp edge of a weapon or the hard surface of plate armor, **steel** is far more suitable. Steel is iron mixed with 0.01-1.7% carbon (steel armor is usually 0.2-0.8% [Williams 7]), which makes it harder (and more fragile) than ordinary iron, but less so than cast iron. No means for mass-producing steel was found until the late 19th century. In medieval and Renaissance Europe, steel might be produced by leaving the bloom longer on the hearth to absorb some of the carbon. Another technique was to heat iron in the presence of charcoal or some other organic (and therefore carbon-containing) material, a technique known as **case-hardening** or **case-carburizing**; the carbon would diffuse into the iron, converting at least the outer layer into steel. With the advent of the blast furnace, it became possible to create steel by immersing wrought iron in a bath of cast iron, but this procedure does not seem to have displaced the older technique of case-carburizing.

The techniques available for steel production tended to result in steel of very uneven carbon content. For this reason, steel would often be repeatedly folded and beaten together to even out the carbon content. In fact, because of the
fragility of steel, it was often advantageous for the final product to combine the toughness of iron with the hardness of steel. Swords, for example, might have mixed rods of iron and steel twisted together and hammered out to form the blade (a technique known as **pattern-welding**).

Steel could be further hardened by **quenching**, which involved heating the piece, then plunging it into a cooling bath to reduce the temperature quickly. Quenching produced a brittle steel, so it was advisable to reduce the brittleness by **tempering**. The steel would be reheated, then allowed to cool off gradually. The higher the reheating temperature, the less hard and less brittle the resulting steel.

The craft of the metalworker in shaping the metals overlapped in many places with the metallurgical processes of preparing and conditioning them. The metalworker generally received his iron in the form of bar stock, rods, or plates. The making of iron plates from bar stock was a tedious process when done by hand; by the later Middle Ages it was often done with the aid of a water-driven triphammer (as illustrated in the painting **Venus at the Forge of Vulcan**). The best armors were usually made of steel, but this added to the expense, and munitions-grade armors were often of plain iron.

The armorer cut out his steel plates into the desired shape with shears according to his pattern, much after the fashion of a tailor. The shaping of these flat plates into three-dimensional armor was a difficult task, and the emergence of full suits of plate is testament to the increasing skill of late medieval armorers. In fact, the 14th century saw a change from hot-working to cold, and the
introduction of new metalworking tools such as the file, saw, vise, and drill. Heating a piece of iron to work on it makes the metal easier to shape, but it reduces the degree of precise control, as well as being a pain (one has to wait for the metal to heat, and it has to be held in a pair of tongs, rather than in the hand). From the 14th century onward, hot-working was restricted to rough shaping of the piece. To achieve a complex and precise shape, the piece would be hammered while cold. A series of hammers were used, of decreasing weight, each allowing more precise control than the one before. The outstanding skill of the armorer was demonstrated by their mastery of the thickness of their work. The process of beating armor to shape it tends to thin the metal: skilled armorer used this to advantage to keep the armor light, but were able to keep the plate thick in the places most vulnerable to attack [ffoulkes 51].

Once the desired shape was achieved, the armor was temporarily assembled to ensure that the articulations functioned properly. After this was achieved a sequence of light ‘planishing’ hammers removed the marks left behind by the heavier shaping hammers (cf. the helmet in the Armorer’s Workshop in which the planishing has been omitted for aesthetic effect).

After the mid-14th century, it became increasingly common to demonstrate the strength of armor by proofing, which involved shooting a crossbow bolt at certain elements, particularly the breastplate. With the advent of firearms, pistols and muskets were used to conduct the tests. [Pfaffenbichler 64] Proofing took place before the armor was polished, assembled, and decorated—no point putting all that work into the piece only to have it pierced by the proofing shot.

Next, a series of increasingly fine files would take out irregularities left by the hammers and a hand-applied light abrasive stone or powder would be used to polish the piece. Alternatively, the piece could be smoothed and polished using a series of horse- or water-powered grindstones, then buffed with a leather-covered buffing wheel. The armor could then be riveted and hinged together, fasteners applied as needed, and leather or fabric lining pieces attached to the interior. This work often involved specialist craftsmen, for example locksmiths to make the buckles, hinges, and other fasteners.
Decoration was also often the province of specialist craftsmen. The earliest suits of plate armor were usually decorated with cloth, either in the form of a surcoat or by covering the metal surface with an attached layer of decorative fabric. The armor could also be adorned with decorations of a contrasting metal, such as brass, riveted onto the armor.

In the fifteenth century, other techniques were applied to decorate the metal itself. One was *engraving*, in which the surface of the metal was incised with a design using a hard and sharp tool. Needless to say, cutting designs into the surface of an entire suit of iron or steel was a laborious and extremely expensive process, and relatively few armors were decorated in this way. An easier way of getting a similar effect was *etching*, which was one of the most common forms of armor decoration. An acid-resistant coating (such as wax or varnish) was applied to the surface of the piece, then parts of the covering were scraped away in the desired pattern. When a weak acid (such as vinegar) was applied to the metal, it cut the pattern into the surface; the pattern was then accentuated by applying a colorant such as lamp-black to the cut-away portions of the surface. Another variant of the procedure involved applying the acid resist as a design, and etching away the background instead.

Another means of decoration was *damascening*, in which a line-decoration was engraved into the surface, and gold or silver wire hammered into the grooves. In ‘false’ or struck damascening, the surface of the metal was roughened and a gold or silver foil or wire hammered onto the roughened surface.

*Embossing (repoussé)* involved shaping the metal itself, first heating the metal and hammering out the decoration in rough from the inside, then forming the details from the outside. This was an expensive form of decoration, and tended to weaken the metal if it was very elaborate; it was a favorite technique for the best ceremonial armors. Embossing provided a deeper relief than engraving or etching.

The techniques of *bluing* and *browning* or *russetting* were related to the tempering process. The piece was heated and quenched, leaving behind an iridescent surface oxidation of brown, blue or purple, depending on the degree of heat used. As it is a form of controlled surface oxidation, this form of decoration could also help to protect the metal...
from rust. Bluing was often made into a decorative pattern by painting the decoration over the blued surface with an acid-resistant varnish, then applying a weak acid to remove the bluing in the unvarnished areas.

One of the most expensive forms of decoration was **gilding**. The most common technique was to copper-plate the surface to be gilded with a copper sulphate solution (gold will not bond directly to iron), then apply an amalgam of gold and mercury. When the piece was heated, the mercury evaporated (making this a highly toxic process for the gilder) and the gold was left behind. **Painting**, especially in black, was a cheaper way of coloring the surface of the armor, and also reduced the metal’s vulnerability to rust.

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**FREQUENTLY ASKED QUESTIONS**

**How long did it take to make armor?** It might have taken one armorer well over a year to make an armor by himself, but he would usually have a number of assistants, so the time could be shortened considerably. A rough estimate for a master with 2 journeymen and 2 apprentices might be 1 season for an ordinary armor, perhaps twice as long for a decorated one. [Cf. Pfaffenbichler 53] The time could be significantly shortened for munitions-grade armor by recycling existing pieces or using prefabricated components.

**How much did a suit cost?** It is hard to make accurate comparisons of money, because the purchasing power of money has been redistributed over time (for example, labor is now much more expensive, and manufactured goods much cheaper). In rough terms of today’s buying power, a complete suit might cost $30-40,000. **Could all knights afford to purchase armor?** Many couldn’t. Some would wear only those pieces that they could afford, or perhaps second-hand, hand-me-down, or older, superseded styles.

**How did they make mail?** The iron was first made into wire, itself a complex procedure involving cutting and hammering and/or drawing through a series of successively smaller holes. The wire was then coiled around a rod of appropriate thickness, and the coils cut through to make the links. The ends links were flattened and pierced to receive a rivet. The links were then joined according to the chosen pattern, and riveted together. For extra strength, joined links were often alternated with solid links punched out of a sheet of iron.

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The technique of mail making, *ffoulkes 45*
Who were the armorers? The makers of arms and armor were for the most part specialized craftsmen, usually with fairly precise specialization within the craft. Armorers would specialize in either mail or plate, and within a large workshop there might be considerable division of labor. Weapon makers included cutlers (bladesmiths), furbishers (who assembled and polished swords), bowyers, fletchers (makers of arrows), and crossbowmakers, to name a few. A few makers of high-end ceremonial armors were actually goldsmiths by trade.

Most arms and armor makers lived in towns, and their activities were regulated by the guild for their particular trade in that town. As with other crafts, one started as an apprentice, after which one could become a journeyman (a fully qualified craftsman paid a daily wage); only those with connections would be likely to establish themselves as masters, running their own workshop. An aspiring armorer served for 4 years as an apprentice and another 4 as a journeyman in 16th-century Augsburg, but in London the apprenticeship lasted 7 years, and sometimes as much as 14 years [Pfaffenbichler 28, 29]. The sons of armorers were usually exempt from such restrictions, and given their special access to resources and guidance, it is no surprise that armor making and decoration tended to run in families.

The character of the armorer’s workshop was varied. Italy was noted for its massive armor making enterprises employing large numbers of specialists to turn out bulk orders of armor. In Germany, guild regulations generally prevented this kind of size: the armorer was typically supposed to limit himself to 2 journeymen and 2 apprentices, although enterprising armorers might subcontract work for large orders.

Some armorers were directly employed by noble or royal patrons. The English royal armories established by Henry VIII in 1515 were usually staffed by a master armorer at 40s a month; a clerk; a yeoman; 9 hammermen who shaped the plates into armor, at 32s. a month; 3 millmen who operated the polishing machinery, at 30s. a month; 3 locksmiths responsible for the fastenings, paid 24s. a month; two laborers, and an occasional apprentice at £10 a year (about 17s. a month; a pretty good living for a laborer at the time); and a gilder at 3s. 4d. a month. The
workmen also received allowances for clothing, food, and lodging. In 1544 the armory was supposed to produce 32 harnesses yearly at £12 each [Foulkes 32].

The Parts of a Suit of Armor

**FURTHER READING**


**FREQUENTLY ASKED QUESTIONS**

**Where did Higgins get all his armor?** Much the same places that high-end antiques collectors look today—dealers and auctions. A large part was purchased in Europe, but some came from existing collections in America.

**How early did he start collecting?** He collected a few items prior to the end of World War I in 1918, but his serious collecting career began in the 1920s.

**Why can’t we touch the armor?** The oils and salts on your hand are corrosive to metals, and will cause them to rust.

**Is all of this armor real?** Most of it comes from the Renaissance, during the time when armor was still in use. There are also a few 19th or 20th century reproductions that reflect the modern revival of interest in armor. Since many armors were modified during their working life or subsequently by dealers or collectors, hardly any armor can truly be said to survive in its original state.

**Is the stained glass original?** The large ‘rose’ window was made for the museum. The stained glass at the ends of the 4th floor gallery was made in the early 20th century. The various glass panels throughout the museum are modern reproductions. However, the tall window in the Warfare Wing depicting St Adrian is original, dating to about 1510-25.

**Why can’t we photograph Roman and Native American items?** These are loaned items, and we are not allowed to permit photography under the terms of the loans. Occasionally other items are not to be photographed because they are light-sensitive.

**SOME POPULAR MYTHS**

**People spiced their food to mask the flavor of tainted meat.** It is true that medieval recipes call for a much wider variety of herbs and spices than one finds in ordinary North American cooking today, but the quantities were not necessarily overpowering. A good comparison is modern Indian or Near Eastern cooking, which also relies on a very diverse selection of flavors. As to tainted meat, people who eat it tend to die young, and medieval people knew this as well as we do. Although there was no refrigeration, there was no need to eat rotten meat: whatever couldn’t be consumed fresh could be salted for future use.
People were shorter back then. Improvements in diet have resulted in increased average heights, but the difference is not all that great: one study of skeletons found an average height of 5’7” for men, 5’3” for women. Some individuals are known to have been quite tall: Henry VIII stood 6’, and the Royal Armouries have an armor for a man of over 6’ 6”. A look at the armor in the Great Hall will confirm that its wearers were not particularly stunted. There has certainly been no evolutionary change in human size in a mere 500 years. Remember also that different nationalities and ethnic groups often have different average heights: modern Scandinavians tend to be taller than modern Italians, and modern Americans tend to be taller than modern Europeans.

A forty-year-old was ancient in the Middle Ages. Average lifespan was shorter then, but not because people grew old quickly: the problem was the prevalence of disease, and the lack of means for dealing with it. Children were especially vulnerable: as we know, they are particularly susceptible to illness, and in the absence of medical means of treatment, probably about half the children born did not make to adulthood. If you lived to 30, the odds were good that you would see 60. Sixty was usually reckoned as the beginning of old age: for example, this was the age at which men ceased to be subject to military service, although non-physical forms of service (jury duty, for example) might continue to age 70.

The military salute derives from the action of lifting the visor of a helmet. The salute does not seem to appear before the eighteenth century, some time after helmets had gone out of use. It almost certainly derives from the gesture of doffing one’s hat to a superior.