

Forging Techniques in Ancient Cultures

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Abstract

This report attempts to trace the technology of sword making in the Japanese and European cultures. It covers the interactions of society, religion and warfare as they relate to the art of sword making. The Japanese sword smiths developed long-standing processes, guided by their mysticism, that resulted in a remarkable weapon. The European smiths, in contrast, evolved their swords through experiment and innovation, with little regard for mystic underpinnings, yet ultimately produced a blade very similar in quality.

Chapter 1: Introduction

Throughout the long and frequently bloody history of mankind, few symbols have emerged as more universal than the sword. War and conflict have permeated the shared experience of all cultures; and through the works of artists, storytellers and the not-uncommon court revisionist-historian, the stories of the battlefield have assumed a dominant role in the sagas and histories in every civilization. As the principal weapon in many societies, the sword has persisted as a metaphor for battle and (perhaps more importantly) those elements that the culture associates with war. The sword is iconic for divine providence, as in the legendary story of King Arthur's Excalibur. It symbolizes power – and power lost – in the ritualistic “surrender of the sword” that has marked the end of many wars, such as Robert F. Lee's surrender of his weapon to Ulysses S. Grant at the end of the American Civil War. It has represented the continuity of culture in many societies across the world, as a treasured heirloom handed down from generation to generation. The sword is even used as a metonym for war by those who yearn for its eradication, such as when the Jewish prophet Isaiah spoke of “beating swords into ploughshares.”

Of course, “the sword” has hardly been a constant, unchanging creation throughout human history. Its earliest forms, in Europe and elsewhere, were simple extensions of the dagger, brought about by the discovery of alloys – notably bronze – and their superior strength, allowing longer blades that wouldn't

bend from use. From there, some advanced to an understanding of steel and steelworking, permitting great improvements in performance, quality, and (eventually) consistency in production. As a result, near-modern swords would be all but unrecognizable to the wielders of their Bronze Age counterparts.

In terms of swords and swordmaking, the most celebrated and revered cultures would certainly include those of the Japanese katana (popularly referred to as the “samurai sword,” after its wielder), and the medieval European swords, of their various types. The Japanese sword has been enveloped in mystery and legend, owing in part to Japan's insular culture and the weapon's historical mystical elements. The Japanese swordmaking craft remained remarkably stable for generations: swordmakers of the culture made essentially the same weapon for hundreds of years. As a result, the ancient beliefs and customs were able to take deep root in the creation of a weapon.

The European swords, perhaps as a result of familiarity from Western military influence across the globe, have developed a negative reputation as clunky, unwieldy and poorly-constructed, especially when compared with the katana. A European sword is presumed to be a poorly-balanced weapon, requiring great strength to wield. Additionally, European martial arts are very much maligned, and sword combat is envisioned as a lumbering and clumsy flailing of swords by two armor-encumbered titans.

Still, the term “sword,” for many, mostly conjures images of blades from one or both of these two cultures. This affords us an interesting comparison of

the techniques and craft of weapon-smithing, in two contrasting cultures halfway across the globe. An investigation of how the European and Japanese blade developed and evolved, and a survey of the two cultures' histories, will evince both intriguing divergences and fascinating parallels.

Chapter 2: The Sword in History

Introduction

At its core, the sword is a simple tool: a long single- or double-edged blade with a *hilt* for the wielder to hold. Other parts have come (and sometimes gone) from the sword. A *crossguard* sometimes divides the hilt from the blade. The hilt sometimes ends with a *pommel*, a piece larger than the hilt's grip. Also present in some blades is the *ricasso*, an unsharpened length of blade on the blade side of the crossguard. But from Man's first swords to those of the modern era, all swords have followed this same, fairly basic design.

But it would be far from accurate to say that the sword has not changed at all over its several millennia. Swords have featured an impressive array of variation in height, weight, shape, material, and usage, throughout the myriad societies that created and fought with them. In some circumstances, the sword's design has evolved to meet the needs of its society. In others, an advancement in design or technology has induced changes in how the society viewed or used the weapon.

Before any attempt can be made to understand the role that society played in the development of the sword, it is important to examine the history of the societies in question. Medieval European civilization was an amalgam of distinct cultures: clashes on the battlefield, and swings of power on the continent, were often mirrored by clashes of culture. This tumult had two effects unseen in

Japanese culture. First, the religious or mystical elements could not take hold as deeply, because often swords and swordmaking techniques were imported from other, foreign lands with different beliefs and customs. Second, the weapons themselves tended to have a greater diversity, as differing cultures developed differing battle tactics and differing needs from their swords.

In contrast, Japan's homogeneity afforded the culture an era of relative stability that Europe lacked, throughout this period. With a lesser level of conflict, the technology and techniques of sword making took on a decidedly more conservative, traditionalist aspect.

The European History of the Sword

The history of Europe, to even the casual observer, is a history of warfare. Wikipedia's "List of European Conflicts" page lists a major battle, war or campaign in virtually every decade for the last millennium, with scarce few generations exempted from a major multi-year war or campaign. For a number of social, geographical and psychological reasons, Europe never had the opportunity, or perhaps even the capacity, to unify as a cohesive state to the degree of empires in other places and times in history.¹ As a result, there have always been several loci of power across the continent, competing and battling to win land, resources and treasure. This struggle frequently played out on the battlefield.

As such, it stands to reason that European history would be replete with stories of not only war, but also a great variety of weaponry, battle tactics and strategy, as the competing city-states attempted to innovate themselves into advantage against their neighbors. And this was indeed the case: the first two great empires of Europe – the Greeks, and then the Romans – favored the polearm, and adapted their tactics to suit that weapon. Most states recognized the immense value of ranged weapons – first the longbow, then the superior crossbow – to an army's effectiveness.

But none of these weapons seemed capable of capturing the allure of the sword. This is perhaps because, while other weapons were most effective in a tightly-dictated strategy involving an entire army, the master swordsman has the potential to evoke the romance of the solitary hero. One of the world's preeminent scholars on the methods and implements of European warfare until his death in September 2002, Ewart Oakeshott wrote that "underlying all or any tactics of battle is one basic art which for nearly 3,000 years remained unchanged... -- the art of hand-to-hand combat with sword and shield."

The shield, Oakeshott observed, is probably the most obvious tool in weaponry, since "it does not take much imagination to picture some Paleolithic hunter grabbing up the first object that came to his hand to ward off the flint spear of an irritated fellow cave-dweller."² But the sword, perhaps not quite as intuitive, required metalworking advances to arrive, and thus did not do so until

¹ It is beyond the scope of this paper, but for an interesting discussion on Europe's balkanization, see Jared

about 3,500 years ago, at best estimate, as a lengthening of the daggers used at that time. Although it has likely never been considered the principal battle weapon, in Europe or elsewhere, it has found its place in combat throughout most of the history of warfare in Europe as the most visible weapon.

Europe's Earliest Swords

The middle to late Bronze Age in Europe is really the first era of arms technology in Europe relevant to our topic. Prior to the Bronze Age, warriors primarily fought with stone axes and spears, which were sharp, chipped stone, affixed to the straightest and sturdiest tree branches the warrior could find. It was not until the discovery of the utility of copper, marking the dawn of the Bronze Age, when "weaponsmithing" as a concept is germane to this discussion. The earliest discovered uses of bronze were domestic tools, such as copper axes and knives. The utility of copper in combat and hunting, however, certainly did not take long to discover.

The earliest artifacts which could reasonably be classified as swords in Europe have been dated as originating in the middle Bronze Age, from 1500 to 1100 BC. Celtic Britain and Minoan Crete both appear to have adapted bronze knives to an extended, more sword-like design around this time.³ Fine rapier-type artifacts found in Yorkshire in England, as well as Ireland's Lisbane, lead

Diamond's Pulitzer-winning *Guns, Germs and Steel*.

² Oakeshott, *Archaeology of Weapons*, p.24

³ To be precise, the Celtic "knives" would probably be more accurately referred to as "daggers", due to the long, thin shape, and their clear primary usage as a thrusting, rather than a cutting weapon.

some authorities to the conclusion that the Bronze-Age inhabitants of what are now the British Isles were the early masters of swordsmithing in Europe.

The artifacts found in Crete from the same time period demonstrate similar advances, although they lack a design flaw seen in the Celtic artifacts. The Celtic hilt was fastened with bronze rivets, which could easily tear from a lateral stress, such as a swinging strike. As expected from the thin, tapered shape of this early blade, the mid-Bronze Celtic rapier was intended as a thrusting weapon.

These thin Celtic rapiers were a rarity in the era, however. The metalworking of the Bronze Age favored a thrusting weapon. Bronze swords, largely, were cast bronze: bronze workers would pour molten metal into a stone cast to create their weapons. This type of metalworking simply does not allow for relatively long or thin blades, because the cast would need to be very shallow, and thus lack precision. As a result of this technique, bronze swords had thick blades, relative to their lengths. Since a bronze weapon possesses a wider profile, it is less well-suited as a cutting weapon, because a thicker cross-section requires more effort to push through a solid object.

The biological evolution of the human shoulder, arm and hand, however, lends our body more easily to swinging strikes. Thus, something of an unconscious tension between the wielders and the makers of these swords developed, one that would not be resolved until a new technology was discovered.

Iron: The Halstatt Tribes

The sword underwent a significant transformation with the discovery of iron that heralded a new age. The Hallstatt tribes of central Europe began their rise to prominence near the beginning of the first millennium B.C. The new Hallstatt weapons were a departure from Bronze Age weapons: compared to the bronze weapons in general use in both the West and the East, the new iron weapons were longer, slashing weapons. This weapon was clearly an adaptation of the blade-weapon concept for the Hallstatts' preferred method of warfare: fighting from chariots. Unlike most of their adversaries' rapier-like weapons, the Hallstatt sword was exclusively a slashing sword: the blade was not pointed, varying from rounded tips to squared tips to a "fishtail" look, depending as much upon fashion as function. Blades meant primarily for thrusting would be difficult to manage, and likely even dangerous, to warriors reaching off speeding chariots: a well-placed thrust could lose the weapon, or worse, topple the warrior from the vehicle.

The Hallstatt peoples, in a relatively remarkable demonstration of technological foresight for the era, clearly recognized their advantage with the new metal. The Hallstatt sword made its way around the continent in all four directions, as the new pioneers in swordsmithing exploited their new design for profit in trade. But while bronze swords in the Hallstatt design can be found in almost every corner of Europe, the iron versions of the exact same designs are

found only in a very limited area. It would appear that, while the swords were exported, the new iron weapons were reserved for the local warriors.

The Hallstatt continued to dominate the European sword manufacture for the better part of half a millennium. The new designs have been found over a very wide area of Europe, extending north, south, east and west of the Hallstatt lands. The long blades were tremendously uniform, considering the era: even the ones that did vary differed only by a few inches of blade length.

But the Halstatt sword eventually faded from dominance, probably for reasons of war tactics. With much of European battle tactics involving fighting on foot instead of mounted on horse or vehicle, the dominant blade began to shrink in size, and evolved back to a footman's weapon. The blade became shorter, and re-acquired its point, becoming more reminiscent of the blades more popularly recognized as those of the ancient Greeks.

This evolution was also influenced in no small amount by a relatively new concept: armor. Prior to this point, most of a warrior's garb was ornamental, but rarely defensive, with the obvious exception of the shield. With less of a useful target, the swordsman was required to be more accurate with his blade, and thus needed a smaller weapon for better handling, not unlike the parallel evolution in the East.

The weapons did indeed become smaller, as a result of this newfound need for precision in swordplay. In addition, two new features were developed to give swordsmen finer control in battle. The first was the enlargement of the

pommel, a large rounded piece at the end of the hilt. The pommel had first been introduced as a way to keep the sword from slipping out of a warrior's hand during a mighty swing. But swordsmiths now realized another advantage: a heavier pommel at the end of the hilt pulled the center of mass closer to the wielder's hand, making it easier to control.

A second innovation reduced not only the sword's perceived weight, but its actual weight: the *fuller*. A fuller is a depression along the center of the flat of the blade, usually on both sides. Swordsmiths discovered that the metal in this portion of the blade did not contribute significantly to the sword's strength or toughness, and could therefore be removed without harming the weapon, making it lighter and more maneuverable for a fighter.

La Tène: The Bronze Era Left Behind

Near the end of the Hallstatt era, a new blade form emerged. This new sword, the first legitimate ancestor of the swords used and glorified by the Age of Chivalry, had a blade with nearly parallel edges, tapered only slightly to a rounded tip. This new blade, named for the ancient military-post site where the first specimens were discovered, is labeled a *La Tène* type sword by Oakeshott.

The *La Tène* demonstrated not only a change in the manner of warfare, but an adaptation of the relatively new technology of ironworking. Most of Hallstatt swords, even the iron ones, were fairly faithful reproductions of designs that had been used by bronzeworkers. There are few Halstatt iron artifacts that don't have a bronze analog somewhere on the continent.

The La *Tène* weapons' designers, however, recognized that there are differences between bronzeworking and ironworking that lead to differences in the weapon's properties.

Iron, in contrast to bronze, is a far more malleable metal. This means that iron can be worked simply by heating the metal and pounding it into shape: there is no need to cast the metal, as with bronze. To make a flatter iron blade, the ironworker must simply pound the metal more. This allows for a flatter blade, and therefore for a better cutting weapon.

Iron not only showed its strength in producing cutting weapons; it also showed its deficiencies in creating thrusting swords. Because of the malleability of iron, early weapons made with the new material would bend from a thrust in combat. As a result of this new discovery, the metal and the manner of war interacted closely, through the sword.

One of the principals in the Dark Ages was the Normans, who in 1066 accomplished a previously impossible task. The Normans, after winning part of France and expanding into Italy, attacked and conquered Britain. Norman weaponry, especially their swords, is remembered as the typical weaponry of the era. Their swords were long, straight, and fairly heavy, although not nearly as heavy as one is led to believe. (It takes no superhuman strength to effectively wield a sword of the early Dark Ages, as is often depicted.)

The Decline of the Military Sword

The sword's golden age in Europe – in lore and in practical military application – spanned the 12th and 13th centuries, from the Norman conquest of Britain to the beginning of the High Middle Ages. The knightly sword – the cruciform, or cross-shaped sword, long and straight with a similarly long, straight crossguard – spent several generations where most changes were ornamental.

The most significant events in the era, and perhaps in European military history, were the Crusades. Although much shorter than some think - the four Crusades lasted only ten years combined and were fought by relatively few of high nobility - the Crusades involved a great deal of first contact with a vastly differing style of warfare from the Muslims. The Muslims employed the unfamiliar tactic of mounted archers, which caused a great deal of trouble for European fighters. The Europeans still managed to win and win convincingly in the early stages of the Crusades, but a fallout of support from the nobles sapped the strength of the Christians, and they would eventually fold.

For swordsmiths, however, the fallout was more significant: the High Middle Ages (about 1250 to 1500 AD) marked the commencement of heavy investment in long-distance weaponry. With new plate armor covering knights from head to foot, the infantry was less mobile and more difficult to maneuver into offensive position. As a result, defensive weaponry became far more prevalent, and crossbow men and archers became the principal strength of most legions.

The race between the development of armor to defeat arms and the development of arms to defeat armor became fierce in this era. Plate mail was created near the middle of the 1200's, and the swords would undergo a great deal of growth to counteract the heavy defenses. This would be the first implementation of the two-handed sword and its smaller cousin, the "bastard sword", also named the "hand-and-a-half sword" for its ability to be used with either one or two hands.

Despite these innovations, the sword became less conspicuous in battle. Polearms became even more popular than the pikemen of the early Roman and Greek days. Consisting mostly of relatively stout maces, they were developed with a different philosophy. It was unnecessary to get through the heavy armor, because a serious smash could use the armor to the attacker's advantage by increasing the likelihood of serious bruising or concussion.

After about halfway through the High Middle Ages, short-range weapons such as swords had largely assumed a defensive, supporting role. After the creation of guns and the large-scale implementation of ranged warfare, the only remaining roles of bladesmen were defending the archers and charging the enemy lines to finish off their foes. The sword slowly lost its status, and became increasingly an ornamental weapon, not regaining its status until the Renaissance rediscovered it through academic treatment.

Japanese History

As in any culture, the History and development of the Japanese culture played heavily on the development of the sword. In times of war, either civil or territorial, the technology of the sword developed rapidly to supply the samurai warriors with suitable arms. Swords that broke in battle were not only worthless, but also dangerous to the wielder. In times of relative peace, however, there was little development in terms of the strength and function of the sword. Most of the developments in these periods were great strides forward in the artistic values of the swords. The interaction between technology and society is therefore clearly seen. As the society demanded better forging practices, the smiths would have to develop the technology to provide it to them. Due to the mainly agricultural nature of Japan, the demand was not always high; hence we see lulls in the development of technology. However, when the need arose, the smiths were able to meet the challenge by producing some of the most spectacular blades ever made. The climate of the era, whether war or peace, marked the development of the sword making industry in Japanese history.

For this reason, it is important to get an overview of Japanese cultural and societal evolution. There were several periods in Japanese history that, when divided properly, can explain the surges and lulls in the development of forging technology. Ancient Japanese history is generally divided based on the ruling parties, the form of government, and the tensions of the times, whether war or

peace. Each of these periods had its own demands regarding what it needed for armaments. Swords were not used as much for warfare in the earlier and later parts of Japanese history. In the early development of Japan, bows and spears were the preferred method of fighting, and in the latter periods, guns took the place of swords. It was during the middle periods of Japanese development that the sword took its place as the soul of the samurai. This is also the time period that is considered the golden age of the sword. The transition periods between eras were usually marked by some type of revolt or takeover, which involved having a superior army or weaponry.

Japanese history begins with the early history (before AD 650). There is relatively little known about this era in Japanese history due to the lack of written records. Many accounts that we do have combine the mythology of the times with the actual history, leading to a confusing account at best. Most of what is known about this period is due to archeological studies of the areas in Japan. These studies confirm sections of the accounts with artifacts and are then used to reconstruct what happened. The following is an account based on this type of information, but for the intents of this paper can be considered accurate.

Japan began as nomadic hunting clans dispersed about the island, each one being ruled by its chieftain. Farming was introduced to the island around 300 BC and had replaced hunting as the primary food source by 200 AD. The

early nomadic hunting clans were steadily replaced by small farming communities, requiring fixed plots of land. As agriculture spread so did the need for land. With the land good for farming in Japan being so scarce, this led to clashes among the clans. As the desire for more land and power increased, disputed and wars broke out between the communities. The larger and more powerful communities overtook the smaller ones creating even larger communities. The more powerful members of these communities became the warriors, charged with defending the land. As the communities became larger, so did the scale of the conflicts. As Japan developed through to modern times, it eventually becomes unified under one ruler. This did not end the fighting however. The desire for power and wealth, as in any culture, lead to several civil wars and attacks on other countries.

Mainland Asia was very important to japans early development, which is evident by the many borrowed technologies and crafts from the mainland. Japanese culture developed as a blending of many mainland Asian cultures. Smiths and swords were imported from the mainland during the early stages in its development. Steel and bronze had been introduced to the island, but the more advanced technology and the better materials were still imported from the mainland. As time passed, the link between Japan and the mainland diminished; Japan was able to stand alone as its own imperial country without the need of a fatherland.

Although Japan's early history was marked by several small wars, the demand for, and hence the increase in technology of swords was, very small. This can be directly attributed to the methods of war at the time. Most of the fighting was done with bows and arrows or spears. Fighting in close quarters was not the desired form of confrontation of the day. These other forms of armaments developed during this period, but the art of sword making had not yet begun to flourish. The blades of this time were straight and of poor quality. The slow progress in the technology of swords of this period can be directly attributed to the low demand for them, and the popularity of the other armaments of the time. Although the demand for the sword as a weapon was low during this period, it is interesting to note that it was still highly regarded. In the accounts of the origins of Japanese culture, the sword was considered sacred. The gods descended to rule the island, bringing with them the three sacred treasures. These were and continue to be the necklace, the mirror, and the sword.

The Nara period followed (650-793) and was known as the golden age of religious art, architecture, painting, and sculpture. It was during this period that Buddhism became prevalent in Japan. With the surge in the popularity of Buddhism came a period of religious searching and enlightenment. As with the previous period, there were still strong ties with the mainland. China was the

Mecca of Buddhism and the Japanese priests often made journeys to gain wisdom and knowledge; Chinese priests would establish temples in Japan. The teaching of Buddhism helped to secure the position of the rulers and were thus encouraged; many temples were established early in this period. The Nara period also marked the beginning of the unification of Japan with the establishment of the first permanent capitol. The city itself was a place of splendor previously unsurpassed in Japan; it quickly became the cultural center of Japan. The strong influences of religion, culture, and art lead this to be a relatively peaceful period. Again, the demand for swords was small and little was done in the development of them.

The Heian period (794-1191) began as a peaceful one, but ended in a military takeover. Corruption in government grew rapidly during this period, and the peasants were forced to carry the brunt of the burden. The imperial family imposed heavy taxes in order to maintain their lifestyles; these taxes were passed down to the peasants causing civil unrest. By this time the samurai class had developed enough to allow them to take power. Military leaders gained the support of the fighting class and fought for the right to the throne. Eventually one of these clans rose to prominence; this marked the end of this era and the beginning of the next.

The art of sword making flourished during the later part of this period, probably due in large part to the samurai clan's desire for a better sword. The sword and the bow became the main weapons of the samurai. With the higher demands placed on the functions of the swords, the technology had to move quickly to catch up. The stronger weapons would give one clan an advantage over another, ultimately leading to victory.

The Kamakura period (1192-1376) was marked by the establishment of the feudal government. The more powerful samurai land holders took over power of the country. The government remained military in nature throughout the period, realizing that if they were not, they would be defeated. Due to the military nature of the government, and also several attacks from the outside, a demand for stronger swords arose. Some of the best blades ever made came out of this time period. The masters had perfected the balance between strength and edge; this balance was never to be surpassed. Again, because of the military nature of this period we see large steps forward in forging technology.

The Muromachi period (1337-1573) began with the overthrow of the Shogunate government, but it was reestablished quickly if not wholly. The split leadership in Japan led to several internal conflicts and wars and a great demand for swords. This time however, as swords began to be mass produced, the quality did not go up, but rather declined. The argument can be made however

that the technology of sword making was still improving. The sheer numbers were an amazing feat. Although the degree of craftsmanship of the earlier swords was never retained, the swords were of suitable strength and they could be produced in the quantities needed (Sansom, 1962; Tsunoda, 1960)

Conclusion

Europe and Japan underwent distinct experiences in war, due largely to the diversity of cultures within each area. The heterogeneous Europe found its vortices of political power shifting frequently, and thus remained a hotbed of experimentation and, at times, innovation, particularly in the technologies of the tools of war. From the early Iron Age swords of the Halstatt peoples to the more refined steelmaking techniques of the later Middle Ages, the West saw a wide array of sword types and techniques rise to eminence on the continent. Incursions from other cultures – such as those of Egypt, Macedonia and Persia – continued to introduce new ideas that were sometimes incorporated into the state of the European art.

Japan, on the other hand, was remarkably homogeneous, even for an area as small as she is. There existed more common ground among the people of Japan, and therefore, significantly less war ensued. Those wars that did occur in Japan usually would have more of an idealistic element to them than those of Europe. Because of this, Japanese warfare – and its associated tools, and the

techniques to construct them – witnessed far less experimentation, and more slight refinements of what was believed to be a mostly-perfect process.

Chapter 3: Men of Swords

Introduction

For a sword to be an effective weapon, there must be someone who is able to wield it skillfully. Each culture had its own forms of fighting and warriors. The early European model largely followed that of the ancient Greek warriors and skillful military minds improved upon these techniques as new forms of combat were encountered. It was the Renaissance, however, that turned centuries of swordmaking technology on its head: suddenly swordmaking was adapted to the societal shifts in the perception of sword-fighting.

Japanese warfare was also influenced by its neighbors, but not nearly as much. Early Japanese history involved heavy interaction with the mainland, but as time wore on, the links as well as the influences wore off. Japan was an island that was for the most part left alone in terms of military conquest. Most of the fighting styles encountered were from fellow Japanese. Their form of warfare was developed from the wars fought among them.

Europe

Swords and European war have been practically synonymous from Ancient Greece to the High Middle Ages. Swordsmen were a significant part of the European battle scene until gunpowder weapons began to gain universal usage in the Renaissance era of the 1500's. From Phillip to Alexander the Great to Sir Arthur, no one weapon has remained the weapon of choice for so long, and

considering the present state of flux in technology, of design and counter-design, it is very likely that no weapon will ever do so again. Although over those two millennia, virtually every man to enter battle did so with a sword in hand or nearby, it took until the very end of that era for the actual wielder of the weapon to make an impact on it. Most changes in the construction of the sword were caused by external agents: evolving to keep up with advances in armor, shifting from slashing to stabbing to slashing again in an attempt to determine the best method of destruction, and experimenting with weights, compositions, and balances to try to get the best feel and quickest blade in the war. Very few times have the actual technique of sword fighting been the impetus to change the design. In most cases, the design of the blade has driven the style of the fighting. However, this all changed during the Renaissance.

The development of fencing was revolutionary in the sense that it developed independent of the blade. The sword would no longer define the style of fighting that its owner could employ. Fencing as a study moved very quickly, as will often happen when a well-known skill is suddenly made into a scholarly pursuit. The blade smith struggled to keep up with the study of "swordplay", as it was soon to be called.

Blades that had been growing to match the strength of improving armor suddenly began to shrink, as masters of fence realized that a swifter blade

allowed for a greater use of their skills. With a large blade, the wielder was more limited to taking large, less-controlled cuts at his enemy, putting him in prone positions while he rights his sword for another pass. With a lighter blade that can be controlled easily, the availability of strategy and tactics to the fencer makes the fight more intellectual, which was precisely what the masters of the time wanted.

The new Renaissance ethos placed great value in intellectual breadth and depth, and the masters of fencing were no different. They desired to show themselves as well-rounded persons. This was a far easier task in fencing than in the swordplay with heavier, less maneuverable pieces. With a light saber or rapier, a fencer displayed many sorts of skills: of intellect, of dexterity, of agility, and of strength. Most important was intellectual, as a deficiency in another area could be compensated for through a careful, intelligent design of one's personal style.

Other changes in blades came into play as fencers adjusted their thinking. With agility becoming paramount in the eyes of the swordsmen, the balance of the weapon needed to be as close to perfect as possible. Fencers determined that the sword suffered from very slight off-balancing, and many corrected that problem by moving their hand down the hilt, to the point where the forefinger curled around the other side of the cross-guard. Although that corrected the problem, it presented another one. A less-than-gentlemanly opponent could easily run his blade along his opponent's and slice off the unprotected finger.

Shortly after it was determined that the ideal hand position on the sword left a finger unprotected, hilt makers were requested to fashion a secondary guard for the forefinger. This guard, which came to be known as *pas d'âne* of the sword, is now referred to as the “arms” of the hilt.

An additional problem surfaced that was easily corrected. Resting the forefinger up against the blade was, obviously, a dangerous move for a man involved in a good deal of movement and hand coordination. One quick squeeze or slight shift of the forefinger could draw blood unnecessarily. As a result, soon swords were only constructed in the *ricasso* style, where the first inch or two after the hilt was made blunt. This hardly reduces the effectiveness of a long blade, like the ones being used by fencers.

Scientific studies into effectiveness of sword attacks also revitalized the thrusting attack. Although a swinging, slashing method of attack is certainly more natural to the human arm and shoulder, it was determined to be inefficient. All else being equal, a slashing attack requires more time, putting the attacker in a more prone position, and could be blocked more easily than a thrusting attack. It was also determined that a slash required the attacker to be twice as close to the target as a quick thrusting strike.

These findings belied the evolution of swordsmanship for the last thousand years. Since the Celt-Roman battles, Europe had committed herself more and more to slashing swords. The development of plate armor had seemingly sealed the fate of the thrusting attack: it was nearly impossible to come up with a blade tip sharp enough to pierce a plate of fairly thick metal. The only way to remove a man from his plate armor was to cut him out of it.

And yet, when the fencers realized the clear advantages of thrusting attacks, sword making reverted. Soon, sword makers were back to creating weapons designed to be most effective as stabbing weapons. Scholarly study had undone a thousand years of weapon evolution.

Japan

The Samurai was the warrior of the Japanese culture. What began with the strong military leader being the ruler of the clan was slowly replaced by hired military strength. This class developed out of the need for a full time military. This began as a class whose express purpose was to defend his lord, whatever the cost. Originally, there was a high amount of loyalty to the samurai's lords. The code of the samurai, called the *bushido*, was a code of ethic based mainly on this extreme loyalty to his lord. This was a direct loyalty, unlike many of the military institutions of today. The samurai was committed to his lord and his lord only. Even a higher ranking Japanese official could not command a samurai

against the will of his lord. It is this type of loyalty that created the mystic that surrounds the samurai warrior. The story of the forty-seven Ronin captures the essence of the samurai and his loyalty to his lord.

The forty-seven (Ronin) were grievously incensed at an intolerable insult that had been inflicted upon their personal lord by a higher lord, an insult that had inflamed the lower lord and led him to draw his sword within the castle grounds of Edo (Tokyo), an unforgivable offense. For this offense he had been ordered to commit harakiri, which he did, thus condemning his forty-seven faithful followers to become Ronin, which term designated feudal knights (samurai) without a lord. The injustice of it rankled so fiercely in the collective breast that the Ronin plotted for two years to gain revenge. This they finally achieved by boldly breaking into the higher lord's home on a winter night and beheading him and his surrounding samurai, after which they took the head of the higher lord to the tomb of their own lord, and then announced their deed to the authorities and awaited penalty. This show of self sacrificing loyalty to their personal lord made them national heroes and in recognition of this the authorities graciously permitted all forty-seven of them to commit harakiri in the most appropriate style. (Clark, 1964)

This story tells the tale of the extreme loyalty of the samurai to his lord. They were willing to kill a higher lord and to die to avenge their lord. This story also reflects the attitude of Japanese culture towards the samurai. Because of their act of self sacrifice, the Ronin were allowed to commit harakiri, a ceremonial Japanese suicide. This was a much more noble way to die than to be put to death.

As time wore on, the Samurai class changed from its primarily military nature into a part of the upper class. What began as part time warrior and full time farmers slowly evolved into a highly trained and full time military class. But in times of peace the samurai class had little to do. The majority of the class took the free time to become educated in the arts or in some other field of interest.

There were several schools that trained men in the way of the samurai. These schools taught ways of life, as well as fighting techniques. It was not enough to have great strength to be a good samurai. It was equally important to have great wisdom and understanding of life as a whole.

Strategy is the craft of the warrior. Commanders must enact the craft, and troopers should know this. There is no warrior in the world today who really understands the Way of strategy.

There are various Ways. There is the Way of salvation by the law of Buddha, the Way of Confucius governing the Way of learning, the Way of healing as a doctor, as a poet teaching the Way of Waka, tea, archery, and many arts and skills. Each man practices as he feels inclined.

It is said the warrior's is the twofold Way of the pen and sword, and he should have a taste for both Ways. Even if a man has no natural ability he can be a warrior by sticking assiduously to both divisions of the Way. Generally speaking, the Way of the warrior is resolute acceptance of death. Although not only warriors but priests, women, peasants and lowlier folk have been known to die readily in the cause of duty or out of shame, this is a different thing. The warrior is different in that studying the Way of strategy is based on overcoming men. By victory gained in crossing swords with individuals, or enjoining battle with large numbers, we can attain power and fame for ourselves or our lord. This is the virtue of strategy. (Appendix A)

This excerpt reflects the teaching of the schools of sword fighting in the sixteenth century. By this time, the samurai was a well educated member of society. The schools stressed the importance of not only being a good warrior, but also being a wise man.

The skill of sword play had several parts that needed to be mastered. These included attitudes, motions of the body, motions of the blade, holding the sword, anticipating the opponent moves, and several others. Each skill was practiced repeatedly until the wielder had mastered it. The teachings of a school of the seventeenth century can be seen in appendix A. This required much hard work and dedication on the part of the samurai. Japanese culture had already

taken this into account; the culture on a whole promoted self betterment and the improvement of skills. This was easily extended to the training of the samurais.

The sword would come to be known as the soul of the samurai, a title that it still holds today. The samurais would become well trained in the use of many weapons, with heavy emphasis placed on the equality of them all. Each weapon had its own special function and therefore needed to be mastered. There were two major swords used by the samurai. The pair, known as the daisho, consisted of a katana and a wakizashi. (see figure 1) The Katana was the longer of the two blades (the blade measures 20-28 in.) (see figure 2) and was used as the primary weapon. The Wakizashi was slightly shorter (14-18 in.) (see figure 3), similar in shape and construction, and was used as a secondary weapon. It also functioned as the sword used to commit harakiri. The samurai would leave the Katana at the door when entering a house, but would take the Wakizashi with him and lay it on his right side; leaving both swords at the door showed extreme respect for the owner of the house. (Weland, 1991; Tarassuk, 1986)

The hand guard on the sword, known as the Tsuba, was an ornamental plate that separated the blade from the handle. It was typically made of steel for strength, but was occasionally made with more precious metals, such as gold. The Tsuba could be easily changed from a strong steel one to an ornate gold

one, allowing the same sword to be used for both fighting and ceremony. (see figure 4)

Conclusion

As with many elements to European culture throughout the Middle Ages, a direct comparison between swordsmen of Europe and swordsmen of Japan must take into account the evolution of swordsmanship throughout the era. In the early centuries, a swordsman was a soldier, one of a great number in a company or army. Battlefield sword-wielding techniques were less sophisticated, as the true science of war was the strategic and the tactical: placing your swordsmen, like pieces on a chess board, in the right position to achieve your objectives.

The contrast with the samurai is clearly seen. Japanese warriors on the other hand, were more responsible for themselves. Samurai were trained – physically, intellectually and spiritually – before being thrust into combat with a blade.

In fact, in this sense, the samurai is not unlike the European Renaissance swordsman, of the High Middle Ages. By this point in European history, swordplay had become as great a craft as it was for the samurai. It was studied intensely in the newly intellectually-charged Europe of the Renaissance, and interestingly, the katana and the European sword began to converge.

Chapter 4: Sword Smiths

Introduction

Despite the similarity in the end goal of the sword makers in Japan and Europe, the sword smiths were treated completely differently. The smiths of Europe were generally anonymous, taking little or no credit for their work. This is most probably due to the fact that anyone capable of making their own sword would. Japanese smiths, on the other hand were treated with honor and respect. They were well trained in their profession and were not expected to hold other occupations. This alone could explain the differences in the swords of both areas. The Japanese smith had more time to spend working on and perfecting his art. We can see the results of this in the strength of the blade the Japanese have achieved.

Europe

The sword maker, in general, was rather anonymous through most of the history of Europe. Despite the long history of swordplay in war and the great value of the weapon in society, only a few sword smiths ever gained much notoriety at any time or place throughout the continent. Those few, however, had their work prized all around Europe.

Swords, more than any other weapon, became symbolic and of great

consequence in the European society. Quality blades would last for generation after generation, and be handed down from father to son with the utmost pride. Every sword that became a family heirloom had dozens of stories of conquest and glory attached to it before it was retired, often to be buried with its last owner. Perhaps unfortunately, the pricelessness of a sword is the principal reason that archaeological taxonomies of European swords are so rare and complicated. A sword's origin can be extremely difficult to trace when it passes through the hands of so many, and survives such an extended career of war.

The medieval sword owed some of its longevity to the tactics of war in that day. Most other equipment - the shield, the armor, the helm, the bow - was allowed to take the brunt of the damage in fight. Armor, especially the heavy armor witnessed in the latter days of the Middle Ages, was constructed to a person's exact specifications, custom-fitting, and was rarely handed down in any but the most rare circumstance. Without custom-fitting of heavy plate armor, even slight differences in armor would drastically degrade its effectiveness.

The inability to hand down a shield is readily apparent. Any soldier with moderate experience would find himself using dozens of shields throughout his battle career. The shield, though certainly stronger than its progenitors, could not withstand constant abuse by opponent's swordsmanship. It was even forced to

endure occasional bashing against a foe's armor, further curtailing the life of the shield.

Other items failed to survive more than one master, mostly due to a relative lack of respect afforded them. Most weapons, including polearms and even bows, would wear down from repeated use. They would become too expensive to re-edge or recondition, and, without the legendary status of the sword, would be quickly discarded when a newer weapon presented itself.

This was not the case with the sword. The romance of swordplay, greatly enhanced by the beauty and prestige of the newly-developed style known as fencing, increased the societal value of the sword.. Because of the prestige associated with the ownership of the sword, they were preserved with great pains.

And yet, the makers of the swords of this era were by and large forgotten a relatively short time later. Very few hilt makers are remembered, despite the fact that most swords are recognizable by only the hilt. Some names of top blade smiths can be found, but that only because the smith would often inscribe his name on the blade.

Surely, we can attribute a significant part of that to the Dark Ages, and the lack of record-keeping during that era. Very little writing of any sort took place during the Dark Ages, and certainly a scholarly work like the cataloging of blade smiths and hilt makers would be the least likely sort of writing at all. Without any recorded history, verbal histories can be quickly forgotten, especially as the Renaissance-era Europeans began looking toward the future instead of looking back on a benighted age in human history.

Still, the disturbing lack of credit to the makers of the finest artifacts over the course of almost a millennium of European history needs more explanation. Sword making was merely a profession during much of the Middle Ages, yet, almost paradoxically, the fruit the craft bore would receive a great deal of attention and admiration. The smith is not considered a part of his own work, despite the fact that, as with most creations of an artistic nature, the opposite is very much the case.

Consideration of the matter reveals that, in fact, it is the reasons behind the sword's reverence that eliminates the sword smith from consideration. The sword, unlike most works of art, never enticed the prestige due to solely its artistic nature. Even the blandest sword could become an object of great admiration, because it was the swordsman wielding the weapon who brought it repute. By all accounts, Sir Arthur's "Excalibur" was an unadorned, rather simple

sword when it began its career, and stayed that way for much of its life. The fame it achieved had little to do with the creator of the blade, and everything to do with its wielder.

In fact, the peak of recognition for blade smiths occurred as soon as the sword lost some significance in warfare. In the early years of the Renaissance, when the age of ranged warfare began, swords began to be viewed as artistic more than as utilitarian weaponry. This shift in European perspective of the weapon produced some very fine blades, and some famous makers of those blades and those hilts.

Many of the blade smiths hailed from the Northern areas of Europe, particularly Germany. On the other hand, many of the finest hilt makers resided far south, particularly in the Iberian Peninsula. The geography can be explained by both mineral and mental differences between the two areas. The land of northern Europe was a much greater provider of iron than the south, whose lands provided a greater quantity of finer metals used for hilts, principally silver and gold. In addition, the south was the center of the art of fence, which eventually required adjustments to hilts for improvement in the style.

Among the best known of the hilt makers was Pierre Woeriot of Lyon. His hilts, constructed mostly of gold, were usually composed of nudes and strap

work. Woeriot's designs were published around the middle of the sixteenth century, and he was well-known as the maker of the hilt of the Archduke Ferdinand's sword, a beautifully crafted gold hilt that included an extra guard below the quillons to protect the forefinger and a large, jewel-studded pommel.

Only one significant classification of sword makers and hilt makers have been systematically studied by historians at this time. These are known as the Bavarian court school, and a large number of members of this family have been identified by name. Chief and earliest among them is Othmar Wetter of Munich. His best-known work was one created in 1594, currently displayed in Copenhagen, that shows an exquisitely carved pommel, adorned with a human figure.

Japan

The legend is told of the great sword maker Amakuni who, due to the demands of battle, made great leaps forward in the technology of the Samurai sword.

One day Amakuni and his son, Amakura were standing in the doorway of their shop, watching the soldiers as they returned from battle. The emperor then passed by but did not give Amakuni any sign of recognition as he had done in the on previous occasions. Amakuni had always looked on these gestures as a sign of appreciation for his efforts. Then he suddenly noticed that nearly half of the returning soldiers were carrying broken swords.

Amakuni and his son went about gathering the sword remnants and examining them. It appeared to him that the chief reason for the breakages were that the swords had been improperly forged and that the soldiers had hit hard objects with them. As he remembered the emperor's subtle rebuff, his eyes filled with tears as he muttered to himself, "if they are going to use our swords for such slashing, I shall make one which will not break.

Taking this vow, Amakuni and his son shut themselves away in the forge and prayed for seven days and seven nights to the Shinto gods. Then Amakuni selected the best sand ore he

could obtain and refined it. Steadily, relentlessly, the two worked at their apparently impossible task. Thirty days later, gaunt, weary, but jubilant, the sword smiths emerged with a single bladed sword which had curvature. The other sword smiths believed them to be insane, but they ground and polished the new sword.

In the months that followed, Amakuni and his son continued with their work, turning out many improved types of swords. In the following spring there was another war. Again the soldiers returned, and as he watched them pass by he counted: one, two, three,-- twenty-five, twenty-six, twenty-seven, -- thirty, thirty-one. All the swords were coming back from the front intact and perfect! As the emperor passed him, he smiled and said, "You are an expert sword maker. None of the swords you made failed in battle." Amakuni rejoiced and once more felt that all was right and his life was full. (This legend comes from the smiths of Yamato Province) (Yumoto, 1958)

This legend is a good reflection of the role of the sword smith in Japanese culture. It shows the status that he holds, the influences of religion on his work, and high level of personal responsibility he had for his work. All of these factors played largely in the development of the sword making industry. Each one pushed the sword maker to be the best that he could, constantly improving on his art.

This legend also shows an important part of the methods of improvement of technology in Japan. Amakuni gathered all of the broken sword and examined them, hoping to see what the problem was. He was able to learn from the broken blades and then use the knowledge gained to improve on both the design and the process. By doing this, he was able to improve on the existing design and processes by simply modifying what the problem was. By doing this process continually, all of the problems in the blades would eventually be addressed, leading to the superior blades that the Japanese made.

The interaction between the smith and the emperor tells us a lot about the practices and beliefs of the Japanese. The sword smith was not only the maker of swords, but he was also responsible for their performance. When the emperor returned from battle with broken swords, he shunned the sword maker. The sword smith had great pride in his work and was concerned with its quality as a reflection of himself. The failure of a sword crafted by him in battle was a failure by him. To remedy the problem that the sword smith had created, he locked himself away for months, concentrating his efforts on producing the strongest swords, showing his devotion to his craft. When he made a sword that did not fail in battle, the sword smith received praise from the emperor. After the swords had proven themselves in battle, the maker felt that once again all was right and his life was full. This again emphasizes the high level of personal responsibility that the sword maker felt for each of his creations.

The emperor's direct approval and disapproval of the sword smith reflect the position that he held in society. He was not a lowly peasant that worked in the fields but rather an honored member of the society that was easily recognized by the emperor. A good sword smith was honored and respected for his skill and devotion, and a poor sword smith was despised for his lack of these traits. This shows the importance sword smith in the Japanese culture.

The sword smith was held responsible for his workmanship as a reflection of himself. This sense of responsibility was rewarded with status when the art was mastered. The Japanese society on the whole had a great appreciation for detail and art; this is extremely evident in the work done by the sword smiths. The school or even person responsible for a blade can still be identified by the detail work done in the tempering line of the blade. The ability to achieve this level of mastery, as is seen in swords, was regarded highly by the Japanese culture.

The heavy religious overtones also played importantly in the lives of the smiths. The importance of the gods and prayer to them is emphasized in the making of the perfect sword. It is a task that would not have been undertaken without the blessing of the gods. The smiths took this part of their work extremely seriously. They believed that it was the gods who gave them the ability to make a good blade. If they upset the gods, the long hours of hard work could produce a worthless blade. The legend tells that the smith spent seven days and nights praying to the gods before beginning work on the blade; and when the blades were tested in battle, they were perfect. Occurrences like the one given here perpetuated the idea that smiths were aided by the gods. This claim to divine intervention also helped their status in the society. The closing note of the legend is also a good reflection on the Japanese culture. When the

swords had returned in perfect condition, the smith knew that the gods had blessed him and that all was again well.

The exceptional strength of the swords was developed by the smiths to suit the needs of battle. As warfare developed, so did the need for better armaments. If the sword had not been hit on something hard, the need for a better weapon would not have been manifest. This is a trend that is common throughout Japanese history as well as around the globe. The objective of war is to win, whether the war be for money or on principal; this objective drives the need for the best armament to give that side an edge over its enemy.

Conclusion

The cultural identities of sword smiths of Europe and those of Japan were similar, despite some superficial differences and a significant one. In Europe, where the secrets of weapon smithing were not closely guarded, virtually every man with a smith had some knowledge of sword making. But because of the lack of scholarly study in the Dark Ages, very few, if any, technique innovations improved the overall quality of European blades.

The Japanese sword making skills were not handed out freely, but instead carefully revealed only to sons and close friends. The result was nearly the

same, however: little open discussion of the techniques of sword craft retarded innovation in the field.

Chapter 5: Sword Making

Introduction

The art of sword making progressed differently in both areas. Japanese sword making was filled with legends and religion. The master sword maker would not dare to make a sword without the blessing of the gods. He would offer his prayers and then carry out the work in his religious outfit. In contrast, European sword making was an everyday occurrence. There was little in the way of any set method of crafting a sword. The fundamentals were well known, as far as the actual forging was concerned. But the mystery around making the sword was not there. Japanese living nation treasures continue in the ways of the ancient sword makers. They have preserved the ways for us to see today. The ways of the European sword makers have not been preserved in this way. What we do know about their practices is what we can take from our similar processes today.

Europe

While the swordmakers of Japan immersed themselves in the deeply ritualistic culture of their society when plying their craft, Europeans contrasted that style with a somewhat more outwardly scientific methodology. There is little surviving documentation regarding specific mystical customs in swordmaking, but it would appear that the custom, if any, differed greatly from region to region. Despite its reluctance to accept other scientific theories, the Christian Church, to

its credit, demonstrated willingness to allow the application of science in many everyday fields, including the manufacture of arms and armor.

While the technology of steelmaking had been known in Europe for some time by the Age of Chivalry, one must be cognizant of what "Steel" means in this context. In contrast to the refined, homogenous product we know as steel today, the steel created in the medieval era was a streaky, non-uniform metal, sometimes with portions of the metal varying as widely as wrought iron to medium-carbon steel, even within the same piece.

The course of ironwork in Europe (and elsewhere) produced two processes for adapting iron ore into a metal amenable to working. The earlier process, producing *wrought iron*, was a process where the metal was never liquefied, but was instead held in a furnace in the 2000°-2200°F range, until the silicates were slagged away and the metal was malleable. The later process, producing *cast iron*, required hotter furnaces (usually about 2800°F) and a cast mold, because the process involved melting the metal and casting the iron instead of simply pounding it into shape.

Neither cast iron nor wrought iron is as strong as steel, for opposite reasons. Steel, being an alloy of iron and carbon, needs its ratio of carbon to iron within a certain range to be an effective improvement over regular iron weapons. The processing of wrought iron, in the slagging off of the silicates, would reduce the carbon well below this ideal range. The melting of iron ore for

cast iron, however, would add far too much carbon to the mix. Processes would need to be refined to remove or reintroduce carbon, as needed.

The reintroduction of carbon to wrought iron pieces was a process called *case hardening*, and was a well-known method by the Age of Chivalry. It involved taking the piece and packing it in an organic material, then baking it at high temperatures (a glowing-red heat) for a long period of time. The organic material's carbon leaches into the metal over time, thus *carburizing* the iron piece and steeling it. European steelsmiths found charcoal dust to be a very effective organic material for this process.

Giambattista della Porta of Italy described such a process in his 1558 work, *Natural Magick*:

"Take soft iron armour of small price, and put it into a pot, strewing upon it [soot, and organic powders to supply carbon], cover it, and make a good fire about it: then at the time fit, take the pot with iron pinchers; and striking the pot with a hammer, quench the whole herness red hot in water; for so it becomes hard ... But, lest the rings of a coat of mail should be broken, and flie in pieces, there must be strength added to hardness. Workman call it a return. Take it out of the water, shake it up and down in vinegar, that it may be polished and the colour be made perspicuous: than make red hot a plate of iron and lay upon the same: when it shows an ash colour, cast it again into water, and that hardness abated, and it will yield to the stroke more easily: so of a base coat of mail, you shall have one that will resist all blows."

While wrought iron requires carbon be added, cast iron's very high carbon level requires just the opposite. The most common *decarburizing* method in the Middle Ages was the usage of a *Walloon Furnace*. In such a furnace, air was passed through a stream of the molten metal, which had the effect of limiting the carburizing that naturally took place in the melting of the iron ore.

There were other procedures. The combination of wrought iron and cast iron, to a modern layman, would seem to have the desired effect of normalizing the carbon level of the metal, and such a technique was described by Biringuccio, a well-known artisan from the noted steelsmithing city of Milan. But modern researchers now consider the process to be too difficult for craftsmen of that era to control, and believe the Milanese ironworker probably had developed a Walloon Furnace solution independently, not understanding how his success had been achieved.

After the carburization or decarburization process is complete, the steel piece needs to be hardened, through *heat treating*. This is achieved by bringing the steel above a certain temperature – a bright orange glow – then *quenching* the metal by rapidly cooling it. This process has the underlying chemical effect of locking the carbon into a specific crystalline structure within the metal. A simple quench could be accomplished by plunging the sword into water to cool it. Eventually, this was seen as a little too quick: later swords were quenched in slower-cooling liquids, such as brine or boiling water.

There has been a great deal of recent testing of medieval swords' metallurgic properties, and most have shown that the methods and techniques greatly varied, in strategy and success. Dr. Allen R. Williams, in research for a 1978 paper on the subject, tested eight swords dated from the 11th to the 15th century, found three distinct methods of swordmaking. Five were wrought iron

bars carburized and tempered, two were composites of wrought iron and steel, and one was several pieces of steel welded together.

Sadly, the little first-hand documentation of the work of the techniques does not do much to illuminate us about the techniques used by the swordmakers of Europe. Research has begun to accelerate on this topic within the metallurgy community, spurred on by groups such as the Association for Renaissance Martial Arts (ARMA) and the Oakeshott Institute. But for now, all we really know about the method is that there was no single method, and that the time was one of experimentation and innovation.

Japan

Sword making is an art that progressed slowly in Japan. Due to the highly religious culture of Japan, the making of the sword was complicated with several rituals. There was also little understanding of the metallurgy involved in the sword making. The combination of these factors and others led to the slow development of the forging technologies in Japan.

Because the creation of the sword was a highly religious experience, there were purification rituals that had to be done before any work on the blade could begin. The master sword maker had to conduct a symbolic cleansing ritual in which he would pour cold water over himself. This was followed by a prayer offered to the deity shelf in his forging area; Prayers of this type continued throughout the forging process. The smiths took the religious aspect of sword

making very seriously. They believed that they were helped by the gods in the creation of the blade and did not want to risk angering them. This could lead to a cursed blade that would fail in battle.

After the smith had spiritually prepared himself to undertake the forging of the blade, the skilled work began. The origins of the methods used are not clear, but can be traced back to several centuries of trial and error attempts at a stronger blade. Methods employed by a master sword maker were handed down to his apprentices in an oral manner. The methods were never written down for all to see but were rather kept as carefully guarded secrets. The best of the apprentices would also find a way to improve on the design of their masters thus pushing forward the technology of sword making. This is how the technology progressed; quickly when the demand was high, and more slowly when the current technology seemed adequate.

The first part of making the sword was the selection of the materials. There are many legends told of the materials used in some of the best blades made. They involve blessings from the gods, or even sacrificing animals or body parts to gain favor with the gods to give the blade strength. This was mostly due to the lack of explanation of what was going on with the metallurgy of the blade. The technology of the day did not allow them to account for carbon content or other such factors that would affect the strength of the blade; carbon content of

the steel is not something that could be sent to a lab and analyzed. They had to rely on the things like the location of the ore , and the conditions under which it was heated. They had to become skilled at recognizing the physical properties of the metal in order to get similar results repeatedly. Ore extracted from different regions had different properties when made into a blade. If a region was found to make a good blade, the materials taken from that region would become very valuable to the sword maker. If it was found that adding something to the fire would make a better sword, the additive would become part of the method of that school. These factors weighed very heavily on the selection and initial treatment of the iron ore for the blade.

The iron ore was heated and flattened, quenched, and then broken into equal sized pieces. These pieces are then heated, pounded, and folded until a solid piece of steel of a uniform composition is achieved. This material would start with a carbon content of close to 2% and be reduced through the processes of flattening and folding down to about 0.1%. This step could be very difficult for the sword maker, both to do and to pass along to his students. Flattening it involved folding the metal fifteen to as much as twenty-one times. This would produce as many as 2.1 million layers of the steel in a section that was less than one eighth of an inch thick. If carried out properly, the folding would force the impurities out of the steel.

The feel of the metal had to be continually checked by the smith until he had the consistency that he desired. This process could not be easily reproduced by a series of definite steps either. There were too many variables to get consistent results on a regular basis. It became the work of the skilled masters to judge these phenomena. The temperature of the fire, for one, was judged by the color of the flame; and the temperature of the blade was determined by the color of the metal. The temperature of the quenching mediums used was also described by inexact terms; the temperature of water in February or August. The amount of carbon in the fire that bonded with the metal was not only difficult to regulate, but also a technology that had not yet been invented.

The next part of the making of the blade is what gave the samurai sword its legendary strength and sharpness. Two pieces of steel of different carbon contents were fitted together and pounded out to form the blade. The blade, it was already mentioned, had 0.1% carbon content, and the insert in the back of the blade had close to 0.9% carbon. Again, getting these two pieces of steel to have the right carbon content was a very difficult process and required the experience of a master. The different carbon content was what would give the blade its exceptional strength and hardness. The harder, more brittle metal would be used to make the cutting edge of the blade. The softer, more flexible metal would make the core or back of the blade. (see figure 5)

The next step in the process was preparing the blade for tempering. A layer of clay would be applied to the surface of the blade to insulate it from the fire and the water. The tip would receive little to no clay because they wanted it to harden completely. This is the step in which the maker would create a design on the tempering line of the blade. (see figure 6) When the blade was quenched, it was done so with the sharp edge of the blade pointed down. By doing this, the edge was quenched rapidly producing a martensitic structure. The volume of this structure would expand thus creating the curvature of the blade; because the back of the blade was still hot, it would conform to this shape change easily. (see figure 7)

As the blade was lowered further, the heat from the middle of the blade would pass out through the edge causing it to become tempered martensite. The heat from the blade was channeled through the edge because of the way the quenching was done and because of the way in which the clay was applied. Upon quenching, the clay would buffer the back section of the blade preventing rapid cooling and the formation of martensite. When the back side of the blade finally cooled, it also would expand. But because the edge was already cool, this could not force the blade back straight. Instead, it introduced two sets of compressive residual stresses into the blade - one along the edge of the blade and one along the back.

The tempered martensite would not allow the back side of the blade to expand freely when it cooled. This introduced a residual compressive stress in the back of the blade. Because of the geometry of the blade, this stress resulted in a compressive residual stress in the edge of the blade. The whole of the blade was held in compression that aided in the strength of the blade and in its resistance to cracking and chipping. This combination led to a razor sharp edge that could keep an edge, but a blade that would not shatter upon impact.

The work of the master did not always come out perfect. It was often the case that when the blade was quenched, warpage would occur and the blade would either have to be scrapped or heavily reworked. Several weeks of tedious labor could be lost if this last step of quenching was done improperly. This is why it required the knowledge of the masters to produce the high quality blades. Anyone could pound out metal into the form of a blade, but when the critical quenching was done, only the work of a master would harden properly.

The blade was then carefully shaped using special tools and files to obtain the desired shape. The master then takes the blade and does a final shaping and straightening before the blade is turned over to be polished. As a final step, the master inscribes his name in the tang of the blade. (Yumoto, 1958; Prof Ogalvie; Tanimura, 1980)

After the blade is finished it must be tested. The common logical test of the blade would be to see how it holds up under normal use. It would be difficult to do this test in battle so the Japanese found another method. The blades were tested on prisoners that were sentenced to death or on the corpses of these criminals. This would test the durability and the sharpness of the blade. (Weland, 1991)

Another important aspect of the blade was its balance. If the blade was not balanced properly, it would be useless in battle. The balance point had to be such that the wielder had complete control of the blade and was not weighed down by it. If for some reason the blade was shortened, equal amounts would have to be removed from both ends; this was used to keep the proper balance.

The art of sword making was surrounded by myth and folklore that led the creation of a sword to be a highly religious event. Each sword smith had to appease the gods with, not only the final product, but also with how it was made. To accomplish this, the sword smith had to undergo several rituals before beginning the project and during the project to ensure an excellent blade.

Each school had different techniques that they employed to achieve the desired blade. These techniques were carefully guarded secrets that gave one

school the edge over another. Because of the fierce competition between the sword making schools and the unwillingness to share secrets, technology was slow to change. One school may have found one solution to a problem and another school may have found a solution to another problem. Combined, the technology could have been developed several years earlier. But, because of the culture of the times, the development of the technology was held up.

Another barrier to the transfer of technology was the lack of technical understanding for the process that were used. Looking back, we can see clearly how the different stages of working and tempering were carried out and we can reproduce them very closely and repeatedly. When the technology was developing, there was little or no way of determining exactly what was done or why it had the desired effects. Techniques could only be described in terms of what could be physically described.

Heat the steel at final forging until it turns the color of the moon about to set out on its journey across the heavens on a June or July evening. After the final forging, place the sword in water which has a temperature of water in February and August.(Yumoto, 1958)

The temperatures of the metals were described by color and the temp of the quenching mediums were described by the seasons. This lead to very little in terms of uniformity between different smiths and sometimes even different works by the same smith.

The work itself was a slow tedious process that took many years to master. It involved many hard hours of heating and pounding the iron into the desired shape and the knowledge of when a stage was completed. It took years of trial and error to develop the basic design of the two metal sword, which in turn took years to perfect. Again, much of this time was due to the lack of understanding of what was going on metallurgically on a microscopic level with the alignment of the grains, but even without this knowledge, the results were astounding. The Japanese blade was the perfect balance between strength and flexibility, the yin and the yang that allowed its warriors the edge over its enemies.

The actual making of the sword involved heavy influences from the deities of the day. In order for a sword to be good enough for battle, several deities had to be appeased. Failure to follow these rituals, it was believed, could lead to the failure of the blade in battle. Much of this was simply folklore, but some of these folklore lead to the increase in the strength of the blade. The sword smiths were applying a technology that had not yet been discovered. It can be argued that these smiths then discovered the technology, but by not realizing what they had, these smiths forfeited any claim to the discovery. (Yumoto, 1958)

Conclusion

Although the European and Japanese means to evolve superior weaponry had striking differences, the end product was the same. Both cultures eventually showed significant advances in effectiveness of their swords. However, the aspects of the innovation contrasted each other sharply - a difference that can be traced back to cultural diversity.

The European sword underwent impressive metamorphoses throughout the Middle Ages, as a result of differing views on sword fighting. There were diverging schools of thought about swords: some believed that the heavy, slashing swords were best, other thought that a quick, stabbing weapon was superior. Innovations in sword styles moved quickly because, even in the *study* of weapons, there was a struggle for supremacy.

Japanese swords assumed a fairly standard style early that was adopted throughout their land. Samurai swords, unlike predominant swords in Europe, were unlikely to change substantially in style, probably due to their cultural homogeneity. The Samurai's rich tradition and ritual also allowed for a link to the past much stronger than any found in medieval Europe, further reinforcing the stability of Samurai design.

Chapter 6: Conclusions

As societies, samurai-era Japan and medieval Europe could scarcely have been more different. The former was a geographically small, insular society with limited contact (and even less influence) from the outside world; the latter a sprawling terrain of scores of separate societies, as well as a regular influx of outsiders. The former was ruled by conservative, stable and largely unified regime; the latter a collection of myriad autonomous city-states, all quarreling and gaming for power and influence over the whole. The former, a land enjoying an era of peace only punctuated by clashes between like-minded lords observing identical spiritual practices; the latter, a bloody battleground, it sometimes seemed, of all against all, with opponents from alien cultures and radically contrasting belief systems and values. A survey of the many outputs of these civilizations – be it art, philosophy, science, or technology – would confirm, indeed, that these societies sharply contrasted each other.

And yet, for all the superficial dissimilarities in each culture's myths and practices surrounding swordmaking, each society arrived at the same place at the end of its respective "Golden Era of the Sword." Both the late-samurai-era katana (at least, the state-of-the-art) and the High Middle Ages fencing weapon favored balance over heft, and speed and agility over power. Moreover, the smiths of each weapon discovered, through spiritual ritual or experimentation and innovation, methods to produce a reasonably consistent composition of blade steel, despite their civilization's scientific understanding falling well short of the

necessary sophistication to guess at the underlying chemistry that drove their practices to great blades.

Some of the more fanciful tales of the Japanese katana, perhaps, are wishful thinking inspired by the mystery and mysticism of the great samurai swordsmiths by enraptured Western observers. Perhaps also, the relative contempt towards European blades is similarly unfair. There can be little doubt, however, that the martial history of each society dominated its region of the globe, and that the sword, of all tools of war, deserves a high station in that history. The wielders – and the makers – of that tool deserve credit in that story.

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Mapping cultural dispersal on linguistic phylogeny, we will correlate these expansive processes inferable from the archaeological record with the linguistic spreads visible in Transeurasian language classification. In this way, archaeolinguistic mapping will serve to visualize to what extent the ancient dispersal routes of textile and agriculture overlap and mirror the spreads of the Transeurasian ancestral languages. Analysis. Genes are always inherited by offspring from their parents, and so are languages and material culture in many cases, but not always because social phenomena may disrupt the horizontal transmission. Tools for textile production are expected to become vertically transmitted from parents to their offspring along with the words referring to them. Engineering has its roots in ancient times. Our list of books shows how engineers of the era lay the foundations of the greatest civilizations. Ancient engineers, the creators of many marvels against all the odds, are here to inspire you. By Deniz Sagir. Here, you will learn about all the technology, technique, and craftsmanship behind these holy monuments of the Pharaohs. The study of the book uses many digital analysis tools to provide you with specific information in utmost detail. So, get ready to step beyond the general knowledge about the Pyramids, and explore them thoroughly, discovering the engineering genius behind some of the world's greatest wonders. Not just in ancient cultures, most of scientific progress until the renaissance were the works of religious men/women serving in religious institutions. From automatic doors of ancient temples to star charts for navigation to herbal medicines. Often. If so, you are likely to be in the top 5% of players in this award-winning strategic city building game.