The Cutting Edge

It was one of the most crucial discoveries in all of civilization—finding a natural, common material that could be sharpened to cut, chop and slice, and one that would retain that edge even after use.

Simple stone knives, points, and hand axes are perhaps the oldest tools found among Paleolithic artifacts, nearly 100,000 years old. By the beginning of the following Neolithic Age, about 10,000 B.C., the skill of artisans in creating sharpened stone implements increased dramatically, including the major advance of attaching a handle to the blade. Most stone blades—usually made from flint—were only 3 to 5 inches (7.5 to 13 cm) long, though some up to 2 feet (60 cm) long have been found.

Knives made of bones, shells, obsidian (volcanic glass), and bamboo and other woody substances began to appear in the eastern Mediterranean, the East Indies, and middle America. (The sharpness of some ancient bamboo and obsidian blades rivals that of steel blades!) The edges were sharpened by rubbing the implement in the hollow of a stone—a method still used by aborigines in central Brazil, New Guinea, and Australia.

With the discovery of copper, bronze, and iron from 7000 to 3000 B.C., toolmakers acquired vastly improved materials for creating blades. Most metal blades were carefully hafted to conserve the valuable metal, and their edges were sharpened by hammering (peening), since filing or grinding would have also wasted metal. By 1500 B.C. bronze cutting blades were used from the British Isles all the way to China.

A "sword" consists of a metal blade that can vary in length, breadth, or shape. During the Bronze Age (around 3000 B.C.), the "sword" and "dagger" became differentiated. Smiths created long leaf-shaped copper or bronze blades, bearing hilts that were merely a handle-shaped extension of the blade.

As people became more skilled at working metals, improved techniques for forging blades developed in Europe, India, and China. Bronze blades were cast in one piece in a stone mold, normally in the two-edged, leaf-shaped configuration. Intended primarily for cutting, these swords have been found in excavations throughout Europe. Used during Homeric times, such bronze blades were called ziphos or akinakes by the Greeks; they can also be seen in paintings on Hellenic vases.

The Romans taught the early Britons how to work their native iron. By about 1000 B.C., iron swords were forged similar to bronze blades with an obtuse point and two cutting edges, though the iron was at first too soft a metal to be used as a thrusting weapon and bent easily. Chinese swordmakers spread the craft of making iron blades to Korea and Japan by about 300 B.C.

Throughout the world, swordmakers faced the same problem—a blade hard enough to hold a razor-sharp edge very often shattered when used against a combatant wearing armor, yet an unbreakable blade made of softer metal frequently bent. Swords also had to be light enough to use in battle.

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The next great advance was learning how to turn soft iron into hard steel (carbonized iron). Steel-bladed knives from the Roman period have been found in Italy and Britain, but the technique itself did not become widespread until later. Probably discovered by accident, the earliest methods of making steel consisted of repeatedly hammering powdered charcoal into red-hot iron bars. This caused the iron to absorb the carbon gradually and turn into steel.

Spring tempering, introduced about 900 A.D., allowed swordmakers to produce blades that tapered to a point. This, and the hardness of steel, allowed the development of the heavy medieval sword known from legends of chivalry.

Viking raiders from Scandinavia carried massive blades made from carbonized iron. These swords were so large they were often designed to be wielded with two hands, and had a wide hilt and pommel at the end. The blade was straight, double edged, and pointed; it could be used for both slashing and thrusting.

The patterns of discoloration on many blades, called "watering," have allowed analysts to determine that they were formed by a process known as "strip-welding." In strip-welding, bundles of iron strips were bent over, hammered together, cut, then bent again, over and over again, picking up greater carbonization (improving their strength and temper) each time. Damascus swordmakers became the world's masters of this method.

A later, more refined steelmaking technique involved arranging bars of iron in layers separated and surrounded by charcoal and heating the entire stack for many hours. "Shear steel," famous for its cutting properties, was made this way.

Swordmaking had always seemed a mystical art, with legendary blades such as Siegfried's "Nothung" and King Arthur's "Excalibur." In fact, at least one author has suggested that the story about Arthur "drawing the sword from the stone" is really a garbled account of Arthur learning how to forge steel from iron ore, figuratively pulling a blade out of the rock.

Perhaps the greatest swordmakers of all time appeared in Japan beginning around the 7th century, when the Imperial family were established as the absolute rulers of the country. In order to equip the national army, swordmaking became an important industry.

The Japanese sword had a long slightly curved blade with a single edge. Weighing only two or three pounds, it was made of carbonized iron and designed to be held with a two-handed grip. Other swordmakers in the area between the Caucasus and Carpathian Mountains independently developed the curved blade in about the 9th century, and the technique spread to the Indians and Persians long before the Turks brought their curved scimitar through Europe. However, Japanese masters such as Yoshimitsu and Masamune created blades under carefully controlled conditions that have never been rivaled. An estimated 20,000 master swordsmiths have been recorded through the course of Japanese history.

Legend has it that the first samurai sword was made by the smith Amakuni and his son in 700 A.D. After the emperor returned from a battle, he quietly rebuffed his swordsmith because more than half of the iron blades had broken in battle. Vowing to do better, Amakuni spent 30 days hammering and forging a new series of curved blades from the best sand ore he could obtain. Fellow swordsmiths scoffed at the strange curved blades (until then the blades had been straight, in imitation of those produced by Chinese smiths), but every one of Amakuni's swords remained intact during the emperor's next battle.

Most of the Japanese swordmaking craft

was passed on verbally from father to son, but a few written records remain. These records aren't terribly helpful to modern researchers, though, since the swordmakers had no quantitative measuring instruments. Instructions read: "Heat the steel at final forging until it turns the color of the moon about to set on its journey across the heavens on an early summer evening," or "After the final forging, place the sword in water that has a temperature of water in February or August."

The craftsman first heated, stretched, and folded several pieces of metal lengthwise, then pounded and reheated them. The blade was gradually formed from these combined pieces, and the process took 6 to 15 repetitions, occasionally up to 30. Each time a piece of metal was folded, the smith took great care to exclude all dirt and air, or else the blade would be prone to break in combat. The swordmaker forged blades that had interiors, sides, and edges containing increasing amounts of carbon from the charcoal in the forge.

The swordmaker then surrounded all but the cutting edge of the blade with a paste made of clay, powdered grinding stone, and charcoal, then quenched the blade. Recent research has suggested that this method of quenching toughened the edge and created the graceful curve of the sword itself. Metallurgist William N. Weins of the University of Nebraska describes how allowing the uninsulated edge to heat and cool faster than the rest of the sword could result in the edge of a three-foot sword expanding three-quarters of an inch more than the back, forcing the blade to curve and also leaving the finished edge under enormous permanent compressive forces.

After the final quenching, and after the smith had engraved his signature, the blade was delivered to a sword polisher, who then spent one to two weeks polishing the sword with several grades of stones.

Beginning in about the 10th century, samurai swords grew longer, having a cutting edge of about four feet for fighting from horseback. Later, in the 1500s, swords were used more often in personal duels and shortened again to about two feet. Later, the purpose of swords became more and more ceremonial, and swordmakers used a great deal of their craft to embellish the blades and hilts.

As steelmaking spread worldwide, blade production centers sprang up in areas that offered plentiful timber for furnaces and charcoal, and soft water for hardening and tempering the steel. Animal or water power was often used to turn grindstones for sharpening edges. From about 1200 A.D., important swordmakers settled in London and Sheffield in England, Solingen in Germany, and Thiers and Paris in France.

In 1740, Benjamin Huntsman opened a steelworks in Sheffield, where he produced crucible-cast steel, dissolving the carbon directly in the molten iron. The steel, known as "cutlery steel," consists of iron with between 0.35 to 1% carbon. This type of steel became specially notable for the quality and durability of its cutting edge. By 1928 the manufacture of pure carbon-steel blades was limited to only commercial knives and a few hunting and pocket knives.

Today, most cutlery is made from stainless steel (steel with chromium, nickel, manganese, and silicon) in various grades. Higher chromium content imparts greater corrosion resistance; higher carbon content allows better edge retention but reduces the corrosion protection. Numerous specialty alloys have been adapted for specific cutting purposes. Stellite, a cobalt alloy invented by Elwood Haynes, is used in metalworking tools. Martensitic stainless steel, containing 12 to 18% chromium and 0.12 to 1% carbon, is widely used for table knives and trade knives.

Modern manufacturing techniques are using everything from high-pressure water jets to lasers and diamond knives for cutting other materials. Overall, though, the simple knife blade has changed little over the millennia despite the new materials used to make and retain a cutting edge.

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