The Metalsmiths

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The Emergence of Man

The Metalsmiths

by Percy Knauth
and the Editors
of TIME-LIFE Books

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The Cover: Pulling a red-hot piece of iron out of a bed of charcoal, a Fifth Century B.C. blacksmith prepares to forge the metal into a sickle. A young apprentice stands ready to work the goatskin bellows or add more fuel to the fire. The figures were painted by Michael A. Hampshire on a photograph taken in a thatched La Tène blacksmith shop, reconstructed in Austria from archeological evidence. Michael Hampshire also provided the paintings of an early Near Eastern copperworking operation that appear on pages 45-53.

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Introduction

One of the earliest specialists to step out of the shadows of prehistory is the metalsmith, a man who, even from the beginning, held a curious place in the social order. Sometimes he was held in high regard, sometimes in low—and for obvious reasons. Though he worked hard, his person was dirty; his face was blackened and his clothes burned by the smoke and heat of the fire. On the other hand, the things he made were useful and beautiful, and he had, in addition, the apparently godlike ability to alter the very nature of matter. He could turn dull rock into gleaming metal and could, at will, make his material liquid or solid, rigid or flexible. In very ancient times such changes were regarded as expressions of forces, not infrequently spiritual, within the material itself.

All this made metals both fascinating and mysterious. The Greek philosophers, puzzling over what happened to metals as they were heated and mixed by smiths, conceived their ideas of atomism and of the elemental nature of matter. Other men, less interested in philosophy, were content simply to admire the metals and use them, and by using them to advance what is called civilization. At first they shaped the metals to known purposes; later they conceived new purposes for them—tools for the farmer, pots for the cook, weapons for the warrior, jewelry for the court lady.

The effects of these material benefits obviously have been immense. But the role of technology in altering human affairs has been consistently neglected. And the reason is not difficult to find: The record of man's technological achievements is not written in words but hidden in objects, and because the record is hard to identify, it has not always been preserved.

Much of the history of metallurgy must be reconstructed from data, developed in laboratories, about the composition and microstructure of artifacts. Properly interpreted, the analyses can tell archeologists how an artifact was made and what it was made of. But since the studies are conducted in laboratories, few people are aware that such work, too, constitutes archeological exploration, and fewer still know its lexicon.

I myself learned the language as a metallurgist in industry when, purely as a hobby, I began to look into the history of my profession. I soon found that though the history stretched back over many centuries, the earliest records could not be found in books but only in museums—in the form of art objects.

Perhaps I should have anticipated this fact. A purposeful, utilitarian mind is indispensable in developing an abstract idea to the point of social importance; but the discovery of something new requires the sensitivity and curiosity of the artist. So, metals were not discovered because someone in the Stone Age wanted a better tool; this approach led only to better stones or to sticks that were shaped more ingeniously. No, metals appeared because millennia ago someone's artistic sensibilities were piqued by an interesting and pretty stone. And though a huge industry eventually developed from that first creative impulse, and though metals came to influence almost every phase of human activity, the successive new ways of working with metals almost always involved the decorative arts first. This book sheds light on that fascinating process.

Cyril Stanley Smith
Massachusetts Institute of Technology

Chapter One: The Rise of Metals

The history of metals in the hands of man encompasses fire and pain, frustration and triumph. It is a history of curious, creative men sweating and struggling through thousands of years over materials so mysterious that their craft was held in superstitious awe. But in the end, over a span of some 10 millennia, the men who fired and melted and hammered away their lives in searing heat learned to conquer molten metal and, in so doing, made possible the modern world. Today the structures in which we live and work, the machines by which we multiply our strength, the tools with which we create—all are dependent upon metal.

And yet there was a time—a fairly recent time as human history goes—when man knew nothing of metal. He did grind up certain obviously colorful minerals, such as emerald-green malachite and rusty-red hematite, to use as pigments to decorate his face and his body or to paint images on the walls of caves in which he lived. Today we know that intense heat transforms malachite into copper and that hematite is one of the principal ores of iron; but for all the eons through the Stone Age, man used these minerals only for decoration.

Still, without metals at his disposal man had come surprisingly far. In the Near East, the place where metallurgy began more than 10,000 years ago, Stone Age man was on the brink of establishing the first urban civilizations. On the hills around the Fertile Crescent of the eastern Mediterranean and the Mesopotamian valley he had begun to settle down and establish the first agricultural communities. He planted and reaped wheat and barley, and raised flocks of sheep and goats. He used tools made of stone, bone and wood that were extremely effective and did nearly everything he wanted them to do. Even the most finely honed steel knife, for instance, is no sharper than a knife of obsidian, a hard, glassy rock that is the product of volcanic eruptions.

Consequently, metals entered the mainstream of human life by the back door. Only after many centuries did their potential usefulness become apparent —and then by an evolutionary process that was analogous to man's own development.

"Nearly all the industrially useful properties of matter, and ways of shaping material, had their origins in the decorative arts," writes Professor Cyril Stanley Smith, the noted metallurgical historian. "The making of ornaments from copper and iron certainly precedes their use in weaponry, just as baked clay figurines come before the useful pot. . . . The first suggestion of anything new seems to be an aesthetic experience."

As Professor Smith looks down the long corridors of time he sees in the background of every technological society the figure of a man whose contemporaries regard him, at best, as a fringe member. Motivated by esthetic curiosity, the artisan begins to use metals in a purposeful way. Among metalsmiths, he is the progenitor of all the grimy, brawny, fire-scarred blacksmiths, iron puddlers and steelworkers who came after.

No one knows for sure where the first smiths began to ply their trade. Generally, ancient metal was

This life-sized funeral mask of the Egyptian boy-king Tutankhamen, with whom it was buried in 1343 B.C., is one of the world's most celebrated pieces of metalwork. Made of beaten gold, it has eyes and eyebrows inlaid with lapis lazuli. The enamel-work vulture and cobra on the headdress symbolize the guardian spirits of Upper and Lower Egypt.

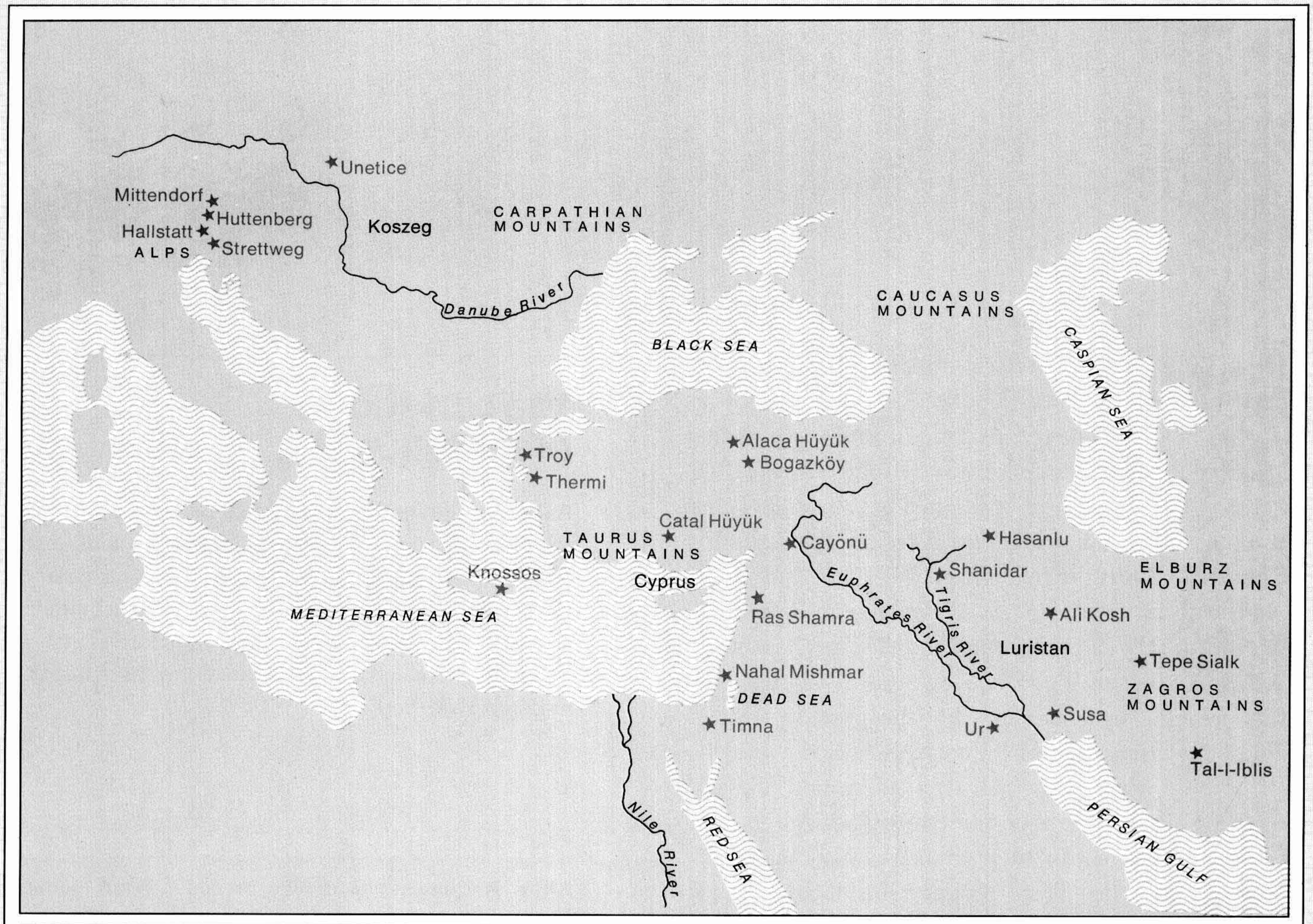
worked cold simply by hammering it with a stone hammer on an anvil of stone—a process that left behind no telltale evidence. Thousands of years passed before fire came to be associated with the softening and shaping of metals. Archeologists cannot even be sure that the sites where they find the earliest artifacts are where the objects were made.

Metals almost at once were so intriguing and therefore valuable that they became articles of barter and traveled widely. Indeed, since ores were not locally available to some of the greatest smiths of antiquity, the raw materials had to be imported. Sumer, the civilization that flourished between 3500 and 1800 B.C. in the broad plain separating the Tigris and Euphrates rivers, brought its metals from the highlands surrounding the plain—from the Zagros Mountains to the east, the Taurus Mountains to the north, perhaps even from the Elburz Mountains that rim the southern shores of the Caspian Sea. And Egypt, although it had rich deposits of gold, had to import all its copper and silver. The desire for metal may, in fact, have stimulated the ancient Egyptians to build sailing craft and become seafarers; for their silver may have come from Syria, and their copper came from the island of Cyprus and from rich deposits of malachite in Israel's Negev Desert *(pages 45-53)*, possibly shipped in ingot form to Egypt through a port in the Gulf of Aqaba.

Just as no one knows for certain where man first used metal, so no one knows what that metal was. Some archeologists think it was copper because of its abundance in regions near where the earliest smiths lived and worked. Others speculate that it was gold because of the way gold catches the eye. Then, as now, men would have seen nuggets of gold glistening in the sand of stream beds or shining among the rocks of rain-washed hillsides. But there is no way of proving this hypothesis with the solid evidence of artifacts, largely because gold has always been considered precious. Most very early gold objects were melted down, either to make something new or, not infrequently, to disguise the fact that the gold object had been stolen. Perhaps more than any other metal, gold has been reworked again and again down through the centuries. Virtually indestructible, gold survives in countless transformations; in fact, it is not farfetched to speculate that at least a part of the gold in the filling of a modern tooth once may have been part of a comb that gleamed in the hair of an Egyptian princess.

Whether gold or copper was the first metal to be used by man, there is no doubt that gold's eternal sheen made it the more desirable of the two for ornamental purposes. The Egyptians particularly valued it. Regarding it as the "body of the gods," they spared no effort to obtain it. One of their richest sources was Nubia, "the land of gold," a bleak, mountainous region to the south that could be reached only by crossing a brutal desert. Here, in what has been called Egypt's Siberia, labored criminals and captives at more than 100 mines. Chained together and kept under constant guard by soldiers, they worked at a variety of chores connected with the mining and the purification of the gold.

The coveted metal lay in veins of quartz. Deep shafts had to be dug into the mountains and the quartz heated to make it brittle enough to remove. Toiling by the light of tiny lamps, men hoed the crumbling stone from the walls of the mines, and children



METALWORKING CENTERS OF THE OLD WORLD

Major sites and important areas of the Old World referred to in this book are shown on a map that extends from the Alps to the Persian Gulf. The key *(right)* indicates the kind of metal—copper, bronze or iron—with which these places were associated. Not all were actually involved in metal manufacture. Some, like the copper-rich island of Cyprus, provided ore for smelting. Others, like Israel's Nahal Mishmar (or Cave of the Treasure—*pages 58-59)* have yielded important metal artifacts without any evidence that the objects themselves were produced there. The map covers roughly 9,000 years—beginning with Iraq's Shanidar Cave, where an oval copper pendant dating from 9500 B.C. was found in 1960 *(page 32)*, and ending with Hallstatt in Europe, an ironworking center active between 750 and 500 B.C.

	COPPER	BRONZE	IRON
Alaça Hüyük	●	▲	■
Ali Kosh	●		
Bogazköy			■
Catal Hüyük	●		
Cayonu	●		
Cyprus	●		
Hallstatt		▲	■
Hasanlu	●	▲	■
Huttenberg			■
Knossos			■
Koszeg	●	▲	
Luristan		▲	
Mittendorf	●		
Nahal Mishmar		▲	
Ras Shamra		▲	■
Shanidar	●		
Strettweg		▲	
Susa	●	▲	
Tal-i-Iblis	●		
Tepe Sialk	●		
Thermi		▲	
Timna	●		
Troy	●	▲	
Unetice		▲	
Ur	●	▲	■

carried the chunks to workers outside. After being reduced in stone mortars to pellets the size of lentils, the gold-bearing quartz was ground to dust by women and old men using primitive stone mills called querns. The dust was then washed on wooden tables set on an angle; the water carried away the particles of quartz and left the heavier gold behind.

In the second major stage of the Nubian operation, the gold dust was melted and purified by heating it for five successive days in clay vessels, along with other substances necessary for the process. In the end all that remained in the vessels was the gold itself, from which most traces of other metals, including silver, had been removed. The melted gold was then shaped into rings about five inches in diameter, and these were shipped on the backs of donkeys to Egypt, often under perilous conditions. Robbers, familiar with the routes, preyed on the caravans; we know that at least one shipment had to be accompanied by a platoon of 400 soldiers.

Once it arrived in Egypt, the gold was solemnly weighed on balance scales reserved for this function only—a more prosaic commodity such as grain was measured by the bushel, while copper was simply counted by the ingot. Once its precise value had been determined, the gold was melted down again and poured into molds of various standard sizes. The hardened lumps were then distributed to individual craftsmen to be turned into the basic materials of their trade. Using equipment as simple as a stone hammer and stone anvil, they beat the gold into a variety of usable shapes—including wire, sheets and tubes—from which to make chains, jewelry, vases, cups, dishes and a host of other precious objects for the pharaoh, the priests and the wealthy citizens of

The Language of Metallurgy

As befits the study of the ancient metalsmiths—among civilization's first specialists—scientists and historians over the years have used a whole special vocabulary to define metalworking materials, tools and techniques. Following is a glossary briefly defining terms that appear throughout the text of this book; all are described in greater detail elsewhere.

Alloy. A combination of two or more metals permanently bound by being melted together; or the binding of metals with nonmetals, such as copper with arsenic.

Annealing. Softening metal by heating it.

Bloom. In early metalworking, the porous, impure mass of iron produced by smelting.

Blowpipe. A tube used to blow air into a fire in order to raise the temperature of the fire.

Carburization. The conversion of iron to steel that occurs when heated iron absorbs carbon in a charcoal fire; sometimes referred to as steeling.

Casting. Forming objects by pouring molten metal into molds.

Chasing. A method of decorating a metal object's surface by incising it with a sharp tool.

Depletion Gilding. A method of chemically treating an object made of a gold alloy to extract from its surface traces of all other elements except gold.

Embossing. A technique for decorating sheet metal with a design in relief.

Fagoting. Welding together carburized iron pieces to form a single, workable piece.

Flange. A raised rib or rim reinforcing part of an object.

Flux. A substance, such as lime or sand, used in smelting to help separate the nonmetallic components of ore from the metal. Also, a nonmetallic substance that facilitates the melting of metal in soldering.

Granulation. A method of decorating the surface of a metal artifact with tiny spheres of gold.

Lost-Wax Casting. A casting technique that uses a wax model as a matrix for shaping the mold; also called cire-perdue.

Oxide. A chemical compound of oxygen and another element.

Pickle. An acidic solution that dissolves unwanted elements from the surface of metal objects.

Raising. A technique for shaping hollow vessels by hammering the sides of a flat sheet or disk upward.

Reduction. The removal of oxygen from an oxide ore in order to produce metal.

Sintering. A technique for consolidating granulated metals that have different melting points by melting only one of them.

Slag. The nonmetallic refuse produced by smelting ore.

Smelting. Extracting metal from its ore by heating.

Tumbaga. An alloy of copper and gold.

Tuyère. A fireproof nozzle, usually of clay, used to direct air blasted by a bellows or through a blowpipe into a fire.

the realm. So great were their skills that many of their accomplishments would be difficult for goldsmiths to duplicate even today.

Gold retained a purely decorative function in the ancient world. Copper, on the other hand, was eventually put to more practical use. It is for this reason that archeologists have identified the first age of metals, beginning around 6000 B.C., as the Copper Age. Such a label is convenient to use—though it has limitations. But then so do the terms Stone Age, Bronze Age, Iron Age. The labels appear to divide history into neat chronological periods, each one identified with the dominant material used for toolmaking.

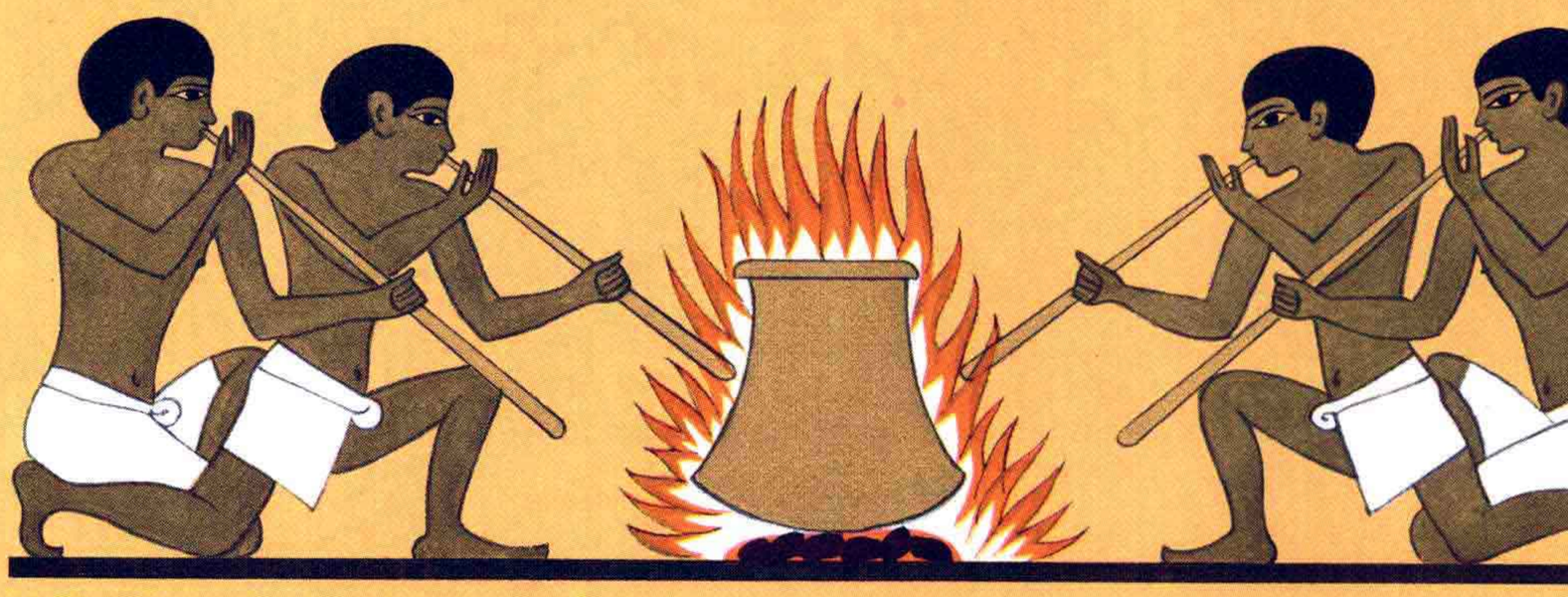
In fact, the early metalsmiths did not move from one material to another in any such orderly fashion. At one place and at one time people might still be working with stone tools, while in another place the standard tool material might be bronze. And in some places men did not move progressively through each of the various ages: China, for instance, never had what could be called a Copper Age, but leapfrogged almost directly from stone to bronze. The same is true of Britain. In Japan bronze and iron appeared almost simultaneously, and some experts think in that part of the world iron may even have antedated bronze. In the New World, however, the dominant tool material continued to be stone until the arrival of the Europeans in the 16th Century A.D.—even though the native peoples of Mexico and Central and South America were not only familiar with metal but were in fact superlative goldsmiths.

Tracing the actual process by which most men learned about metals is as difficult as identifying the first metals they worked. Were metals discovered in-

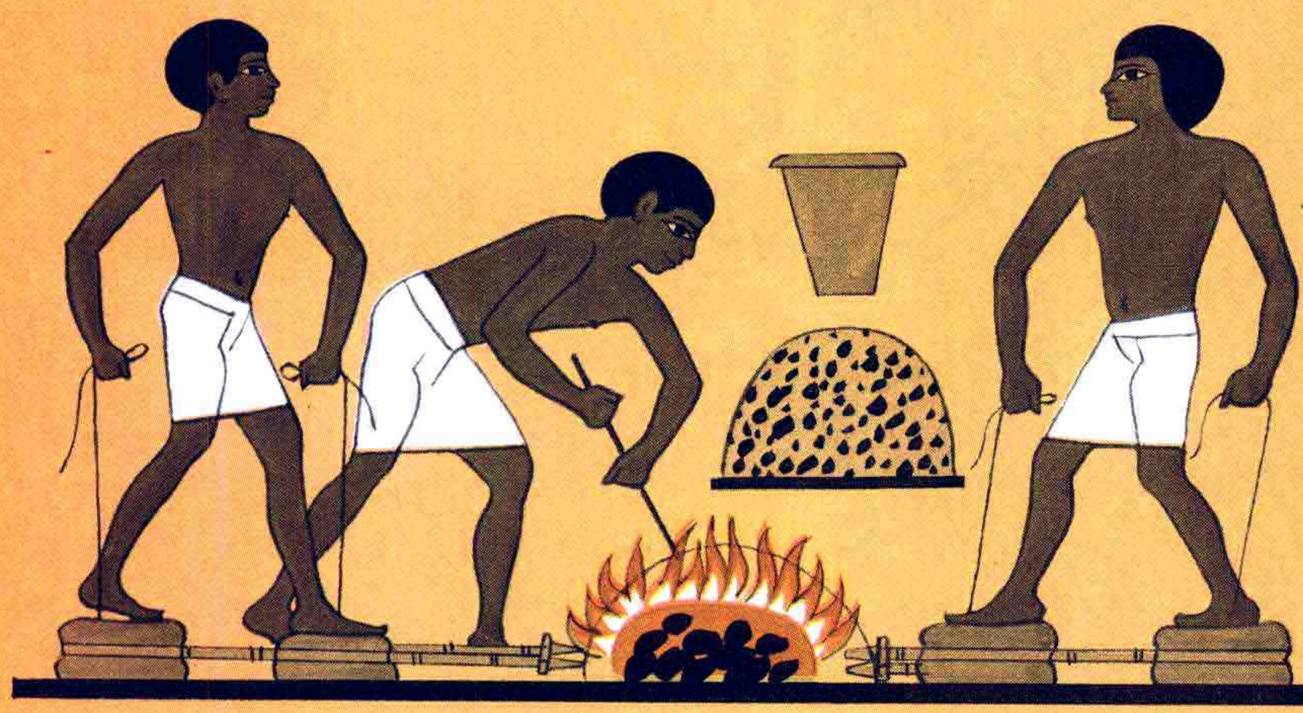
A Gallery of Egyptian Techniques

Of the world's early metalsmiths, the Egyptians were among the most accomplished. These scenes—adapted from reliefs and paintings on the walls of tombs—show workers engaged in a variety of specialized tasks, from the making of fine jewelry *(far right)* to the casting of massive bronze doors *(sequence below)*.

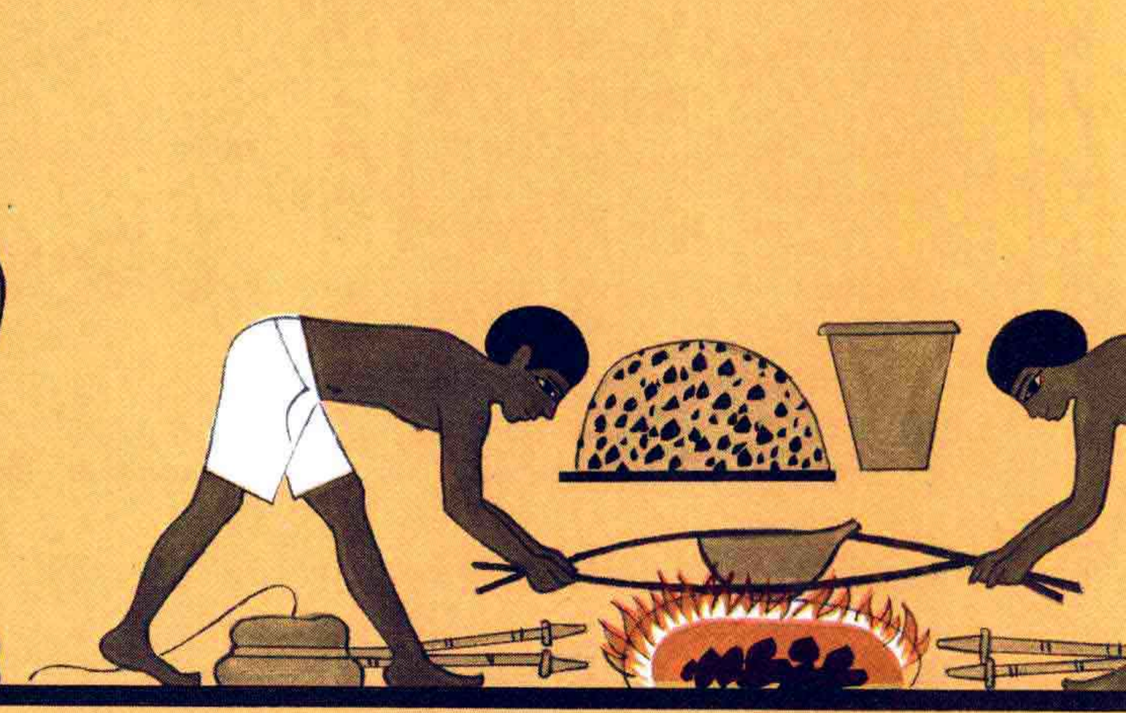
The work was hot and hard. The sweating men, as one Egyptian text makes vividly clear, stank like "the roe of fish," and their heat-cracked hands were so rough as to put in mind "crocodile hide." Yet, they themselves apparently were not dismayed by the demands placed on them by their profession, and their contemporaries honored them for their labor. Goldsmiths inevitably were the most esteemed of all. Often whole families engaged in metalworking, and skills were handed down from father to son through several generations.



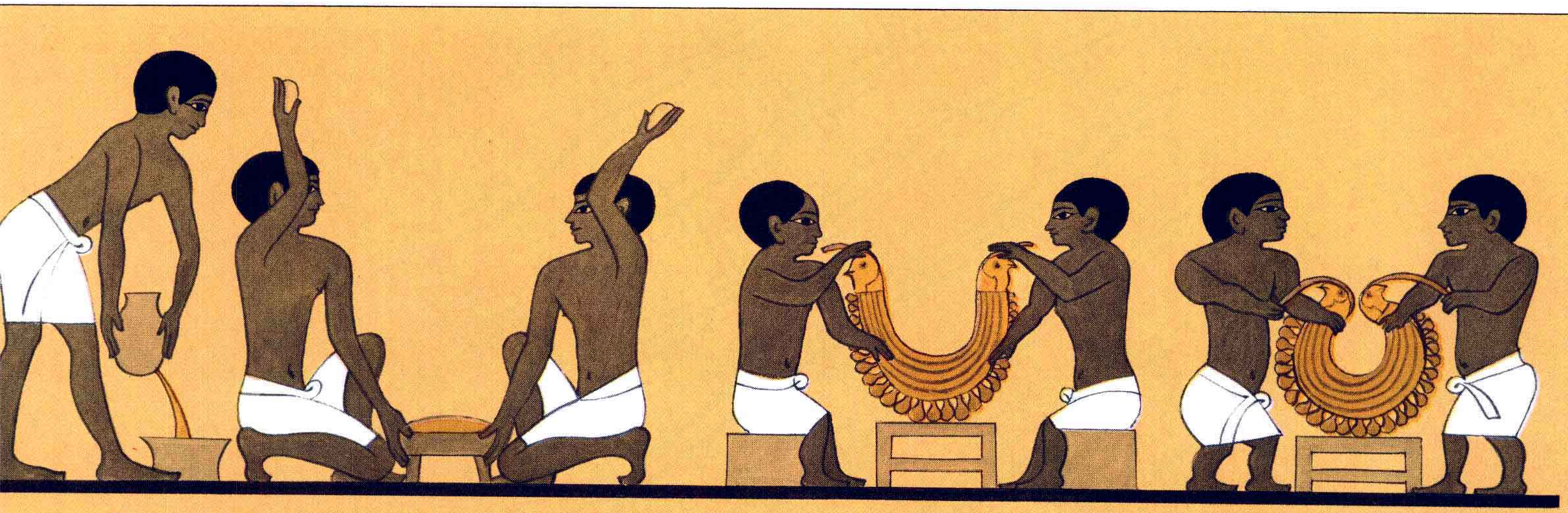
Puffing through clay-covered reed blowpipes, four kneeling workers feed draughts of air into a fire burning under a clay crucible filled with molten metal. Because this operation was both hot and exhausting, Egyptian metalsmiths arranged for it to be conducted by six or more men working in relays.



This drawing, part of a series depicting the casting of bronze doors, shows a worker stirring the coals while two others fan the flames by treading on bellows. They filled the bags with air by pulling on strings and deflated them by stomping on them first with one foot, then the other.



A crucible of molten bronze is lifted from the fire by men using a tonglike contraption made of sticks of green wood. The sticks were freshly cut not only because they were more pliable than dry wood but because the sap made them resistant to fire. Behind the men is a pile of charcoal fuel.



Two steps common in metal processing occupy the workers above. While one man, using palm-sized stone hot pads, pours molten metal from a crucible into a mold, two smiths wield stone hammers to flatten a lump of metal. To make the metal more pliable they will reheat it from time to time.

In the two drawings above, a pair of workers—obviously dwarfs—bend a heavy gold necklace, presumably to make its ends meet at the clasp. In ancient Egypt, dwarfs were reputed to be especially dexterous and therefore were often employed as craftsmen in delicate or complex handicrafts.

Carrying their red-hot crucible to a large clay mold for a bronze door, two metalsmiths pour the molten bronze into one of numerous cup-shaped vents in the mold. Gases escaped through other vents as each layer of molten metal was added to the thickness of layers already solidifying beneath it.

Keeping the smiths supplied with fuel and metals, one man empties a sack of charcoal while two more bring up ingots of copper. Three other workers—marching abreast at upper left—proudly carry the tools of their trade. Sketched beside them are designs for the two halves of the bronze doors.

dependently at several times and in several places, or did the knowledge of them originate in one place and get passed along by example and by word of mouth, through what archeologists call diffusion?

In recent years many archeologists have become convinced that the great milestones in man's progress —events like the cultivation of grain and the birth of writing—took place at different times and in far-flung locations. Formerly scholars held the opposite to be true, that breakthrough discoveries occurred in one locality only and emanated to other places from there. Critics have argued that the earlier view assumes one group of people living in one locality must have been more advanced, more innovative than any other contemporary group. Moreover, recent archeological evidence clearly demonstrates that agriculture and writing were independently discovered by different groups of people living thousands of miles from each other.

Nonetheless, in the case of metallurgy, it now appears that, because of the sophisticated technology required, the craft's development did diffuse from the Cradle of Civilization through the Old World. From the Near East knowledge of metallurgy flowed not only westward into the European continent and from there to the British Isles, as later chapters in this book will show, but also eastward into the Indian subcontinent and perhaps by some unknown route into China and Southeast Asia.

By whatever means the use of metal spread, nothing contributed more than man's growing knowledge of fire. Just as he had found in earlier centuries that fire warmed the cave and cooked his meat, he now discovered, probably by chance, that heat applied to a metal like copper made it easier to shape. This sim-

Text continued on page 21

Metals and Ores that Shaped the World

Modern man is totally dependent upon metals —yet he takes their presence almost for granted. But for people who lived 12,000 years ago certain raw metals meant only ornaments to please the eye. From rudimentary tinkering with shiny baubles in the Near East eventually came simple metal tools *(page 32)*, and a revolution had begun that would forever affect mankind.

Presented here and on the following pages are some of the metals and ores that the first smiths used. A few, like gold *(lower right)*, are available almost pure in nature; others require refining or mixing in order to turn them into a workable material. Not until smelting was invented around 4000 B.C., however, could metal-bearing ores be tapped. With smelting a whole new technology developed that led to the modern uses of metal.

From the earliest days of metalworking, the malleable properties and glittering quality of gold and silver exerted an allure that drew men to them. Many of the oldest "gold" objects, however, seem to have been made of electrum (upper right), a naturally occurring combination, or alloy, of gold and silver. In many areas silver, which is rarely found pure like gold, was considered the more precious metal.