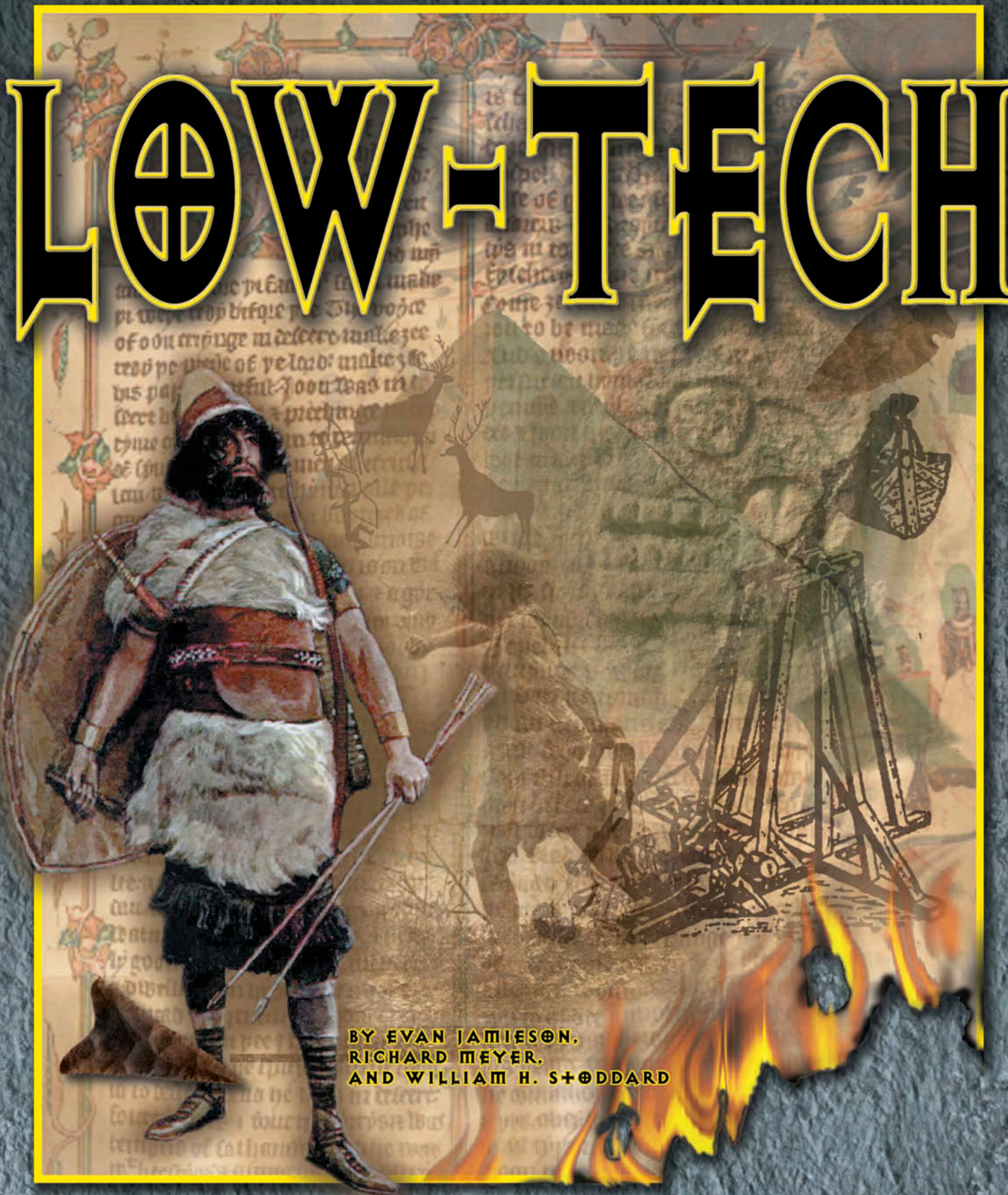
GURPS®

LOW-TECH™



By Evan Jamieson, Richard Meyer, and William H. Stoddard

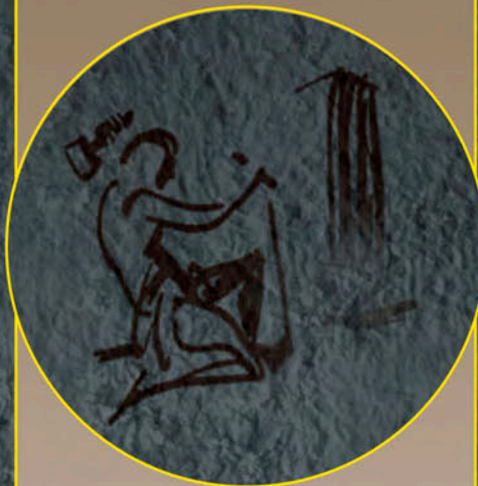
STEVE JACKSON GAMES

STICKS AND STONES...

are only the beginning in *GURPS Low-Tech*! Everything you need for a historical campaign is here, from the first thrown rock to medieval catapults, from loincloths to heavy plate. Extensively researched for historical and technical accuracy, and fully compatible with other *GURPS* material, *Low-Tech* offers you:

- All the hand weapons and ranged weapons from *GURPS Basic Set*, with exotic additions from various ages and countries.
- Over a dozen examples of pre-gunpowder artillery in a variety of sizes.
- Full statistics for many new types of armor, piece by piece, and rules for combining them.
- Options for customizing all this combat equipment to get just what you want, whether it's a spike on your battle axe or a noseguard on your helmet.
- Over 100 other forms of equipment, fully detailed with game statistics, and ready for use.
- Information on travel and transportation, on foot or horseback, in wagons or chariots, or aboard canoes or warships.
- Historical overviews of the Stone Age, the Bronze Age, the Iron Age, and the Middle Ages, including daily life, crafts, government, and the progress of knowledge.
- A variety of new optional rules: hunting and gathering, primitive surgery, making and repairing arms and armor, riding with any equipment or none, harnessing draft animals, using incendiary weapons, and many others!

If you want new options for equipment, and realistic historical guidelines for its use – ***GURPS Low-Tech*** is the source you need!



This book is designed for use with ***GURPS Basic Set***, *Third Edition, Revised*, and ***GURPS Compendium I***. It completes the series that includes ***GURPS High-Tech, Ultra-Tech***, and ***Ultra-Tech 2***, but ***Low-Tech*** may be used independently, in any medieval or earlier campaign.

THE CAVEMEN:

Written by
Evan Jamieson, Richard Meyer, and William H. Stoddard

Edited by
William H. Stoddard and Andrew Hackard

Illustrated by
Eric Hotz

Cover by
Alex Fernandez and Philip Reed

FIRST EDITION, SECOND PRINTING
PUBLISHED APRIL 2004

ISBN 1-55634-343-4

52495

9 781556 343438

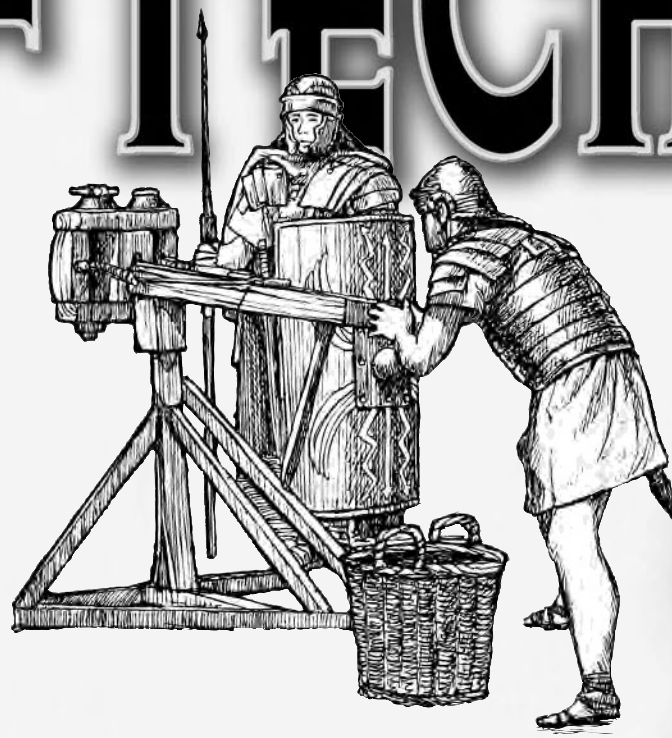
SJG02495 **6526**

Printed in the USA

STEVE JACKSON GAMES
www.sjgames.com

GURPS®

LOW-TECH™



Written by Evan Jamieson, Richard Meyer, and William H. Stoddard

Additional material by Shawn Fisher, John Goff, Dan Howard, Walter Hunt, Bret Indrelee, Phil Masters, David Morgan-Mar, Jason Morningstar, Sean Punch, and Matt Riggsby

Edited by William H. Stoddard and Andrew Hackard

Cover art by Alex Fernandez and Philip Reed

Illustrated by Eric Hotz

Additional illustrations by Donna Barr

Cover and page design by Alex Fernandez

Production and layout by Russell Godwin

Production assistance by Remi Treuer

GURPS System Design by Steve Jackson
Managing Editor ➨ Andrew Hackard
Line Editor ➨ Sean Punch
Production Manager ➨ Monique Chapman
Art Director ➨ Philip Reed
Print Buyer ➨ Monica Stephens
Errata Coordinator ➨ Andy Vetromile
Sales Manager ➨ Ross Jepson

Lead Playtester: Shawn Fisher

Playtesters: David Ackermann, William Allman, Thomas Barnes, Glen Barnett, Frederick Brackin, Nelson Cunnington, Andy Dokachev, Mike Dokachev, Jessica Dokachev, Aaron Falken, John Freiler, Richard Gadsden, C.R. Holden, Bob Huss, Jon Lay, David Levi, M.A. Lloyd, John Macek, Jim MacLean, John Morrow, Sean Nealy, Robert Prior, Tracy Ratcliff, Emily Smirle, Brian C. Smithson, David P. Summers, David Thomas, Chad Underkoffler, and Don Wagner.

Special thanks are due to Peter V. Dell'Orto, Master of Arms, whose help in organizing and playtesting the material on weapons and armor was invaluable.

ISBN 1-55634-343-4

2 3 4 5 6 7 8 9 10

STEVE JACKSON GAMES

CONTENTS

INTRODUCTION

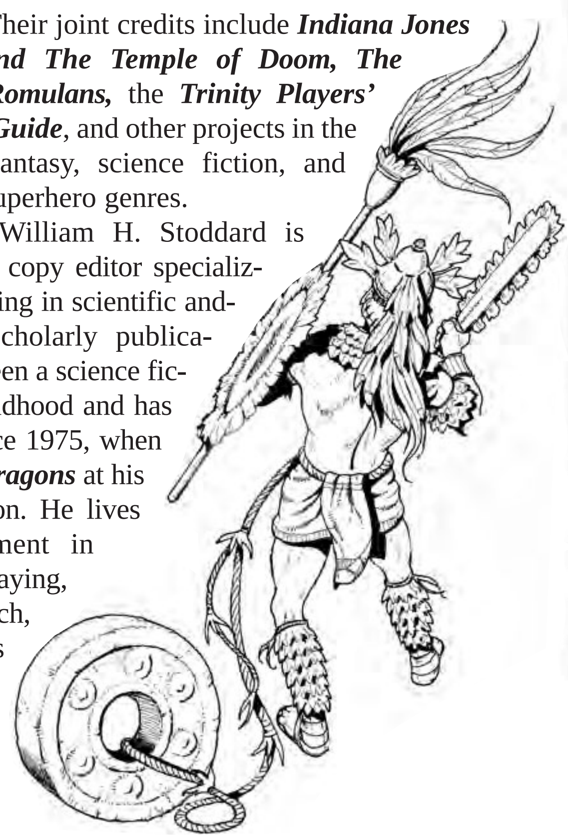
GURPS Low-Tech examines the vast period from the dawn of man to the end of the Middle Ages in the year 1450. It completes the series of ***GURPS*** books that detail the technology of past, present, and future campaign settings. ***GURPS High-Tech*** covers the period from 1450 to 2000, while ***GURPS Ultra-Tech*** and ***GURPS Ultra-Tech 2*** catalog and describe the futuristic devices of science fiction.

Separate chapters in ***GURPS Low-Tech*** cover the Stone, Bronze, Iron, and Middle Ages in human history. Although arms and armor make up much of this book, each chapter also describes tools and personal equipment. For the GM, each chapter summarizes advances in agriculture, metallurgy, transportation, and medicine, and identifies societal changes that transformed daily life.

GURPS Low-Tech provides rules for a wide range of tools, weapons, and devices, but it cannot be exhaustive. The bibliography provides a starting point for further explorations of this subject.

About the Authors

Richard Meyer and Evan Jamieson are Boston area gamers and freelance authors. Richard Meyer is starting his third decade as a creator of FRP games and supplements. His past credits include the ***Thieves' Guild*** series and ***Free City of Haven*** as the former president of Game-lords, Ltd., the ***Mech-Warrior*** roleplaying system for FASA, and over 30 other products. Since 1985, he and Evan Jamieson have written supplements as part of the consortium *Adventure Architects*. Their joint credits include ***Indiana Jones and The Temple of Doom, The Romulans,*** the ***Trinity Players' Guide***, and other projects in the fantasy, science fiction, and superhero genres.



William H. Stoddard is a copy editor specializing in scientific and scholarly publications. He has been a science fiction and comics fan since childhood and has played roleplaying games since 1975, when he discovered ***Dungeons & Dragons*** at his first science fiction convention. He lives in a book-crammed apartment in San Diego. Other than roleplaying, his favorite hobby is research, which helped a lot with his work on ***GURPS Low-Tech***! His other projects for Steve Jackson Games include the Origins Award-winning ***GURPS Steampunk***.

About GURPS

Steve Jackson Games is committed to full support of the ***GURPS*** system. Our address is SJ Games, Box 18957, Austin, TX 78760. Please include a self-addressed, stamped envelope (SASE) any time you write us! Resources now available include:

Pyramid (**www.sjgames.com/pyramid/**). Our online magazine includes new ***GURPS*** rules and articles. It also covers ***Dungeons & Dragons, Traveller, World of Darkness, Call of Cthulhu,*** and many more top games – and other Steve Jackson Games releases like ***In Nomine, Illuminati, Car Wars, Toon, Ogre Miniatures***, and more. And *Pyramid* subscribers also have access to playtest files online!

New supplements and adventures. ***GURPS*** continues to grow, and we'll be happy to let you know what's new. For a current catalog, send us a legal-sized or 9"×12" SASE – please use two stamps – or just visit **www.warehouse23.com**.

Errata. Everyone makes mistakes, including us – but we do our best to fix our errors. Up-to-date errata sheets for all ***GURPS*** releases, including this book, are available on our website – see below.

Gamer input. We value your comments, for new products as well as updated printings of existing titles!

Internet. Visit us on the World Wide Web at **www.sjgames.com** for errata,updates, Q&A, and much more. ***GURPS*** has its own Usenet group, too: rec.games.frp.gurps.

GURPSnet. This e-mail list hosts much of the online discussion of ***GURPS***. To join, point your web browser to **www.sjgames.com/mailman/listinfo/gurpsnet-l/**.

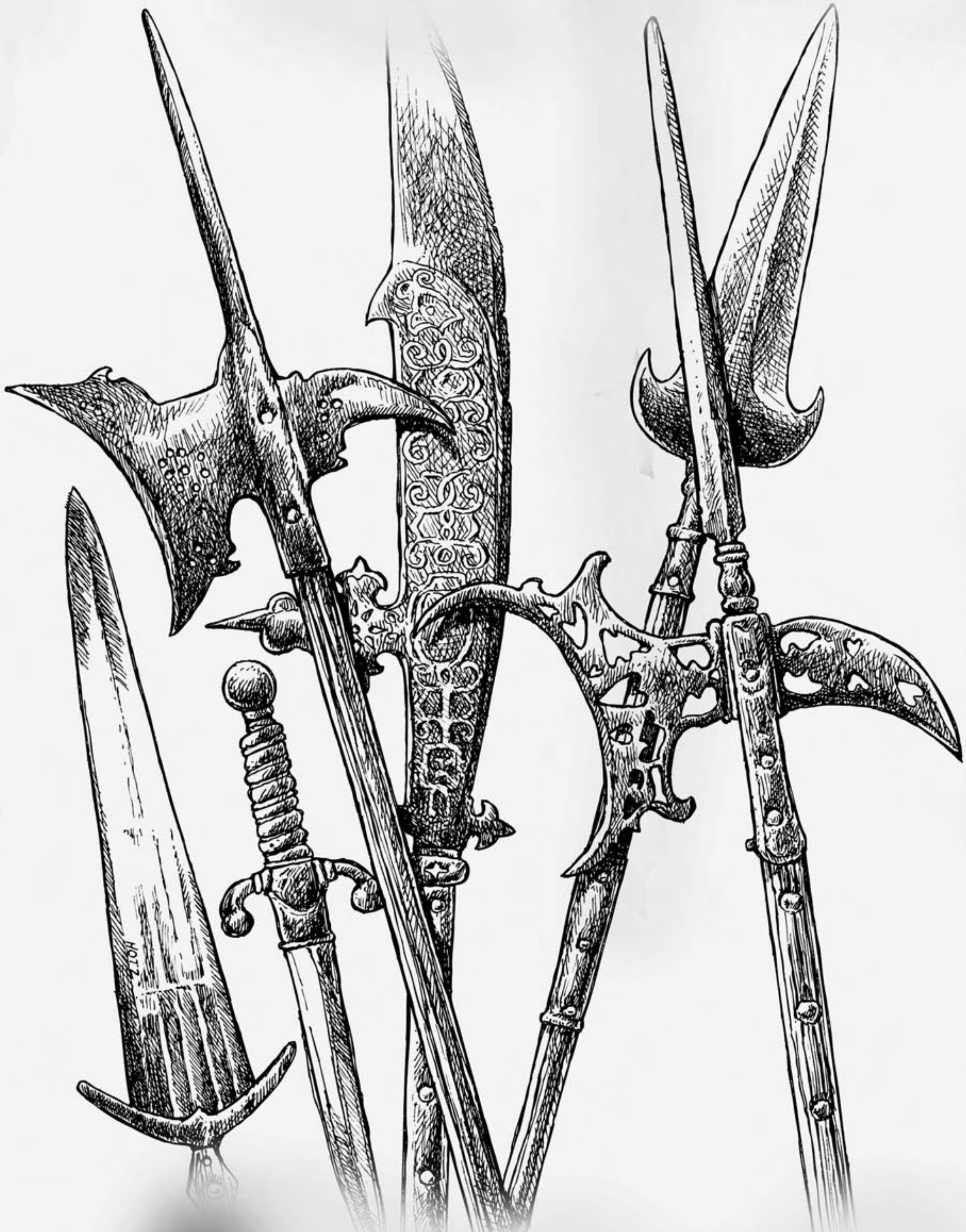
The ***GURPS Low-Tech*** Web page is at **www.sjgames.com/gurps/books/low-tech/**.

Page References

Rules and statistics in this book are specifically for the ***GURPS Basic Set***, *Third Edition*. Any page reference that begins with a B refers to the ***GURPS Basic Set*** – e.g., p. B102 refers to page 102 of the ***GURPS Basic Set***, *Third Edition*. Page references that begin with CI indicate ***GURPS Compendium I***. Other references are EG to ***GURPS Egypt***, GR to ***GURPS Greece***, and VE to ***GURPS Vehicles***. The abbreviation for *this* book is LT. For a full list of abbreviations, see p. CI181 or the updated web list at **www.sjgames.com/gurps/abbrevs.html**.

CHAPTER I

CULTURES AND CIVILIZATIONS



"Us put 'un up like this-yur, an' 'ee wurked all right; us put 'un higher an' 'ee didden wurk so gude, so us put 'un back where 'ee be, an' let 'un bide."
– J.G. Landels, ***Engineering in the Ancient World***

When archaeologists began to classify ancient artifacts, they recognized distinct stages in the growth of technology. C.J. Thomsen classified the material in the Copenhagen Museum (opened 1819) into ages of Stone, Bronze, and Iron; his student J.J.A. Worsaae showed that the three technologies occupied successive strata in excavations. In 1865 a British archaeologist, John Lubbock, divided the Stone Age into the Old and New Stone Ages. Anthropologists studying present-day non-European societies borrowed this classification for their own purposes.

GURPS classifies early technology into the same stages, or Tech Levels (TLs), with one more added: The Middle Ages. The Stone Age is TL0, the Bronze Age is TL1, the Iron Age is TL2, and the Middle Ages are TL3. But there's more to technology than materials. A fuller classification needs to look at several other technologies.

Tech Levels 0-3

Here are the typical forms taken by several major technologies at the TLs this book discusses:

TL	*Materials*	*Energy*
0	Wood, leather, stone	Fire
1	Bronze, ceramics	Draft animals
2	Iron, concrete, glass	Water mills
3	Steel	Windmills, horses with horse collars

TL	*Tools*	*Construction*
0	Hand tools	Shelter
1	Machines	Monumental architecture
2	–	Keystone arch
3	–	Dome

TL	*Transportation*	*Warfare*
0	Walking, sledges, boats	Stone weapons, shields
1	The wheel, the sail	Metal weapons, armor, chariots
2	Riding	Infantry formations, artillery, galleys
3	Stirrups	Armored cavalry

TL	*Food*	*Medicine*
0	Hunting, gathering, horticulture	Herbs
1	Agriculture, herding	Military surgery
2	Two-course rotation	Bleeding and purging
3	Three-course rotation	Amputations, extracts

Historical Periods

In Near Eastern and European history, the timeline of technological development is as follows: TL0, before 4000 B.C.; TL1, 4000 B.C.-1200 B.C.; TL2, 1200 B.C.-500 A.D.; TL3, 500 A.D.-1450 A.D. Different dates may be relevant to other civilizations. The highlands of New Guinea were scarcely explored until after World War II, when Europeans and Americans moving from TL6 to TL7 made contact with villages still at TL0.

Before TL0

Some earlier ***GURPS*** material considered "TL0" to mean literally "no technology." As a result, some equipment used by Stone Age people was classified as TL1. In ***GURPS Low-Tech***, such inventions are reassigned to TL0, along with other well-documented achievements of Stone Age peoples, ancient or recent. "No technology" can be shorthanded as "TL(-1)" if necessary. Don't use this value in numerical formulas; TL(-1) means, literally, no technology. (Stretching the point, the termite probes used by chimpanzees might count as late TL(-1).)

"Take What You Like," Said God

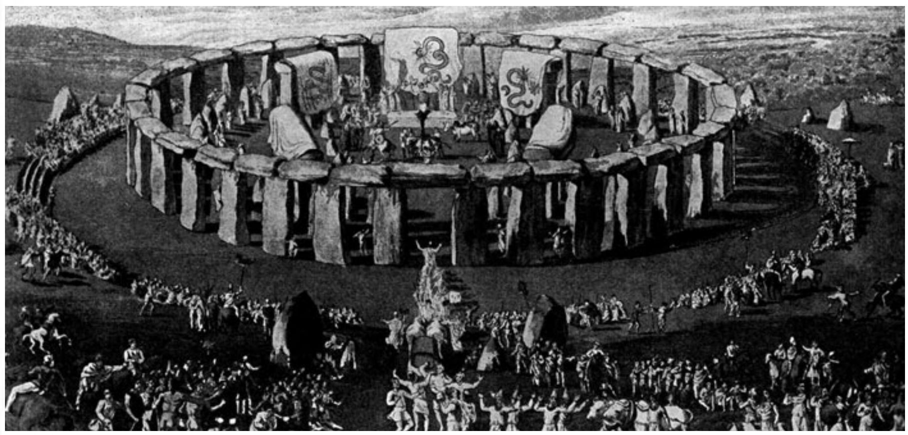
Players in low-tech campaigns will want their adventurers to own or invent higher-tech devices. Let them. (See pp. B186-187.) At the experimental stage, there is little standardization; each new example of an invention will be unfamiliar, giving -2 to skill rolls (see p. B43). If the device is invented during play, no one is skilled in its use or able to train anyone else. Its use starts out at the default level and it takes 200 hours to learn the skill at the 1/2-point level. The process should be roleplayed, with careful attention to mishaps.

Prices in $kins

Some previous ***GURPS*** treatments of Stone Age peoples (see pp. D86-87 and D112-114) cited prices in $kins. This does not reflect the actual value of any animal skin, nor do incomes in $kins reflect the economic output of Stone Age tribes . . . it was a matter of flavor. Since the $kin and the $ are both arbitrary units, ***GURPS Low-Tech*** uses the $ for all prices, to keep things simple.

Variations

No system of tech levels can perfectly describe the course of human inventiveness through the ages. We can divide technological progress more finely, as when we distinguish between the Old and New Stone Ages. Inventions aren't perfected in an instant; early experiments that go nowhere lead to inefficient and unreliable forms of a technology, which give way much later to the mature form. And societies may not have the same TL at the same time. This problem is especially acute for TL3 and earlier; there were literally hundreds of different societies at TL0, past and present, and several different civilizations at TL1-3. Since TL dates are based primarily on Europe and the Near East, they work best there; other societies, such as China or the Aztecs, can be tricky.



A society has an overall TL based on its average stage of advancement. But it can be *advanced* or *retarded* in a specific technology (see p. S168); for examples, see the sidebars (pp. 6-7). In formulas based on TL (see, for example, p. B128), use the overall average, unless the relevant field is the one where the society is advanced or retarded. A society using a device from a given TL may not have that TL itself; the society may be advanced or retarded in that particular field.

To clarify the TL of a device, distinguish between experimental and prototype devices and devices in regular use. For example, the ancient Romans built water wheels, but most of their grain was ground by slaves using hand mills; the water wheel was possible at TL2 but only in full use at TL3. For a more extreme example, Hero of Alexandria demonstrated steam power at TL2, but the steam engine became useful only at TL5, in the 1700s. Here is a scheme that can be applied to such questions:

The proper TL of a technology is generally the TL where that technology is a mature development in regular use. (E.g., "gunpowder is TL4.") A technology might be a new development, in the testing stage, one TL earlier. (E.g., "the first attempts to use gunpowder were TL3.") In the late phases of the TL where an item is first tested, it may exist as a rare experiment. (E.g., "the cannon-lock handgonne is late TL3.") Finally, the first prototypes to enter production typically emerge early in the proper TL. (E.g., "the first matchlocks were early TL4.")

To sum up, don't get preoccupied with any single technology in deciding a society's TL. It's the overall level of capability that's important. And don't assume that all technologies progress in lockstep; a society can have one or two devices that are advanced beyond, or not as advanced as, its overall TL. TLs are meant as guides, not straitjackets.

Some Anomalies

To illustrate the questions that can arise in assigning a tech level to a society or period, here are several cases where the boundaries between TLs are ill-defined. GMs who need to make judgment calls can look here for precedents.

Stonehenge

All over western Europe, there are ancient monuments constructed from large standing stones. Stonehenge is the best known (see pp. PM18-27). Some of these take the form of megalithic stone tombs used for group burials. Others take the form of large tables of rock known as "dolmens" or "menhirs." The ability to erect these huge structures is comparable to the feats of Egyptian, Babylonian, or Mayan architects, who were TL1. But the European builders didn't create cities, walls, or roads. Their monuments can be considered prototypes of later architecture and engineering, making these societies late TL0 in construction.

The Walls of Jericho

Archaeologists working at the site of Jericho discovered that its oldest relics date to 7000 B.C., long before any other cities were built (see pp. PM64-65). The original city had massive walls 23' high, enclosing 10 acres. A ditch 10' deep surrounded the walls, and a round tower 33' high and 43' in diameter looked out over them. The 2,400 inhabitants supported themselves by wheat farming and hunting gazelles with bows and arrows. As an actual fortified settlement, Jericho is considered to be TL1 in construction, making the TL0 culture that built it advanced in architecture.

Polynesian Voyages

Between 1500 B.C. and 1000 A.D., the Polynesians colonized every habitable island in the Pacific Ocean and made contact with South America, where they acquired sweet potatoes. Their canoes had sails, which are TL1, and they were capable of open-sea navigation, typically TL2, not just as a rare adventure but as a mature technology which stayed in use for many centuries. But they did not have bronze or iron, draft animals, or writing, and they built no cities. Overall, they were TL0, and very advanced in navigation.

Continued on next page . . .

PRICES

The price of any item in this book is a convenient fiction. Past civilizations had various media of exchange, from gold to cocoa beans; many tribal societies had no medium of exchange at all. Relative prices and incomes changed according to the tech level, the availability of natural resources, and the preferences of different cultures – and, within a culture, from place to place or season to season.

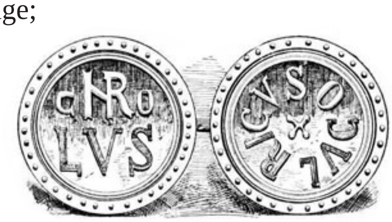
To avoid these complexities, prices are given here in the standard ***GURPS*** unit, the $. Suggested starting wealth is $500 at TL0, $1,000 at TL1, $2,000 at TL2, and $5,000 at TL3. Only 20% of this should be spent on adventuring gear, except for nomadic hunter-gatherers, other wanderers, or heroes with the Poor disadvantage.

GMs using ***GURPS*** historical supplements should rescale according to the starting wealth for those cultures. For example, an Egyptian campaign with starting wealth $500 (p. EG83) could divide all prices by 2. Certain classes of commodities may be ruled to be cheap, expensive, or unavailable. A GM who prefers to focus on matters other than economics may simply use the prices in ***Low-Tech***. Similar adjustments may be made to the incomes listed in the Job Table below. Incomes, unlike starting wealth, do not vary between TLs; lower-TL people have fewer material assets for their wealth level.

Many TL0 societies have no monetary system, as discussed in Chapter 2 (pp. 22-23). Use ***Low-Tech*** prices during character creation to determine what possessions a TL0 adventurer has; a player should expend all starting wealth on possessions. At the GM's option, 1 character point can be exchanged for additional possessions worth $250 (per p. CI17).

TL1 societies have media of exchange, but not coinage. Gold, silver, or other commodities are exchanged by weight. A character with unexpended starting wealth may carry it about as metal ingots or simple jewelry such as rings. The $ can be equated to a weight of metal or any other sort of monetary commodity.

TL2 and TL3 societies possess coinage; often the local king's face was stamped on a piece of metal as a guarantee of its weight and purity. At these TLs, the $ can be equated to some number of coins of a particular denomination. Many people in such societies – especially in rural areas – may go months at a time without handling actual money.



SOME ANOMALIES (Continued)

MAYAN COMPLEXITIES

The ancient Mayas lacked metallurgy, draft animals, and the wheel, technologies characteristic of Old World TL1 societies. However, they practiced large-scale agriculture supported by irrigation, they built cities, and they kept written records. In short, they were an early civilized society, best classified as TL1, but retarded in materials and transportation, which were TL0. To complicate the situation further, their mathematical notation included a symbol for zero, a TL3 innovation, so they must be classed as very advanced in mathematics.

MEDIEVAL MEDICINE

Western Europe in the Middle Ages made significant advances beyond the ancient world, justifying its classification as TL3 overall. But medicine and surgery were not even as good as in ancient Assyria; medieval European surgery was TL1, making Europe retarded in medicine. The Muslim world provides a better touchstone for the actual medical capabilities of TL3. (See pp. WWii32-33 for an example. This is a change from ***GURPS Arabian Nights***, which suggests that the Muslim world in the Middle Ages is TL4 in medicine.)

CHINESE ADVANCES

Of the key inventions that characterize TL4, the Chinese developed gunpowder no later than 1040 A.D. and were using cannons by 1280 A.D. Three-masted junks came into use not long after 1000 A.D.; experiments with movable type (though not the printing press) were made in the same period. Given these advances, a case can be made for China's having reached TL4 by 1250 A.D., 200 years ahead of Europe.

From a global rather than European perspective, 1250 A.D. could be the starting point of TL4, just as 1200 B.C., when iron came into use in the Near East, is the starting point for TL2 worldwide. The relative populations of China and Europe in this period support making China the center of world history in the Middle Ages.

Job Table

Job (Required Skills)	Monthly Income	Success Roll	Critical Failure	TL
Poor Jobs				
Construction Laborer (ST 11+, Masonry 9+)	$60	ST	-1i, 1d/-2i, 2d	1-3
Litter Bearer (ST 12+, HT 12+)	$10 + living expenses	Savoir-Faire (Servant)	-1i/1d	1-3
Miner (ST 11+, HT 11+)	$75	ST	-1i, 1d/-2i, 3d	1-3
Wet Nurse (female and lactating)	$50	HT	milk fails, LJ	1-3
Struggling Jobs				
*Apprentice (Craft skill 8+)	$30 + living expenses	HT	-1i/1d	1-3
*Barbarian Raider (Riding 12+, Bow 12+, Horse Archery maneuver 12+)	$150	Best PR	-1d/3d	3
*Basket Maker (Weaving 11+)	$100	DX	-1i	0-3
Bearer (army auxiliary) (ST 10+, HT 10+)	$20 + living expenses	ST	-1i/LJ	1-3
*Carpenter (Carpentry 11+)	$100	PR	-1i	1-3
Fire Brigade (HT 11+)	$90	ST	-1i, 2d/-2i, 3d	2
*Fuller (PS (Fuller) 11+)	$100	HT	-1i/-2i	1-3
*Gatherer (Survival at 11+)	$150	PR	-1i/-1i, 1d	0
Groom (Animal Handling 11+)	$50 + living expenses	PR	1d/-1i, 1d	1-3
*Herdsman (Animal Handling 12+)	$90	PR	-1i/-2i, 1d	1-3
*Peasant Farmer (Agronomy 10+)	$100	PR	-1i	1-3
*Potter (Pottery 11+)	$120	PR	-1i/-3i	1-3
Sailor (Seamanship 11+)	$60 + living expenses	PR	-1i, 1d/-3i, 2d	1-3
*Seamstress (Needlecraft 11+)	$100	PR	-1i	1-3
*Silk Harvester (PS (Sericulture) 10+)	$90	PR	-1i/-3i	2-3
*Teamster (Animal Handling 12+, Teamster 11+)	$110	Teamster	-1i, 1d	1-3
Rower (Seamanship 11+)	$80 + living expenses	PR	-1i, 1d /-2i, 2d	2-3
*Wine/Olive Presser (Mechanic (Machinery) 11+)	$110	PR	-1i/LJ	2-3
Average Jobs				
Army Surgeon (First Aid 12+, Surgery 12+)	$100 + living expenses	Worst PR	-1i/-2i, 1d	1-3
Blacksmith (ST 13+, Blacksmith (Iron/Steel)12+)	$300	PR	-1i/-1i, 2d	2-3
*Brewer (Distilling 12+)	$240	PR	-1i	1-3
Caravan Employee (Animal Handling 11+, Packing 11+)	$240	Best PR	1d/-1i, 2d	2-3
Cartographer (Cartography 13+, Area Knowledge 13+)	$75 + room and board	Best PR	-1i/-3i, accuracy challenged	3
Chariot Runner (Running 12+, Spear Throwing 11+)	$100 + living expenses	Worst PR	-1i, 2d/-3i, 3d	1
*Cooper (Cooperage 11+)	$300	PR	-1i/1d	2-3
Copyist (Literacy, DX 11+)	$160	DX	-1i/LJ	2-3
*Dyer (Dyeing 11+)	$200	PR	-1i	1-3
*Field Worker (Agronomy 12+)	$200	PR	-1i/Exile	0
*Fine Pottery Maker (Artist 11+, Pottery 13+)	$300	Best PR	-1i/-3i	1-3
*Fisherman (Survival or Boating 11+, Fishing 12+)	$200	Fishing	-1i/1d	0-3
*Glassblower (Glassblowing 12+)	$200	PR	-1i/1d	2-3
*Hunter (weapon skill 11+, Tracking 12+)	$300	Tracking	-1i, 2d/-2i, 3d	0-3
Illuminator (Literacy, Calligraphy 13+, Illumination 13+)	$60 + room and board	Best PR	-1i/LJ	3
Mahout (Animal Handling 12+, Riding (Elephant) 12+)	$220	Best PR	-1i, 1d /-2i, 3d	2-3
Marine (Seamanship 10+, Bow 11+, melee weapon 11+)	$100 + living expenses	Best PR	2d/-2i, 4d	2-3
*Miller (Mechanic (Millwork) 10+, PS (Miller) 12+)	$200	Best PR	-1i/-2i	2-3
*Money Changer (Cyphering 12+, Detect Lies 11+)	$300	Worst PR	-1i/-4i	2-3
Postal Courier/Messenger (Hiking, Riding (Horse), or Running 12+)	$280	PR	1d/3d	2-3
*Potter (Pottery 11+)	$300	PR	-1i/LJ	0

Job (Required Skills)	Monthly Income	Success Roll	Critical Failure	TL
Professional Soldier (two weapon skills 12+, Shield 12+, Savoir-Faire (Military) 10+)	$120 + living expenses	Best PR	2d/-2i, 4d	2-3
Schoolteacher (Literacy, Teaching 11+)	$300	PR	-1i/-3i, accused of heresy	1-3
Ship's Pilot (Seamanship 11+, Area Knowledge 14+)	$300	Best PR	-1i, 1d/-3i, 2d, vessel damaged	1-3
Siege Engineer (Engineer (Primitive Machines) 12+, Mechanic (Primitive Machines) 12+, Gunner (Catapult) 12+)	$120 + living expenses	Best PR	1d /-2i, 2d	1-3
*Tanner (Tanning 11+, Leatherworking 10+)	$200	Best PR	-1i/-1i, 1d	1-3
*Trapper (Survival 12+)	$250	Survival	-1i, 1d/-2i, 2d	0-3
*Weaver (Weaving 11+)	$200	PR	-1i	0-3
*Woodworker (Carpentry 11+, Woodworking 13+)	$240	Best PR	-1i/-2i, piece ruined	1-3
Comfortable Jobs				
*Alchemist (Alchemy 12+, Glassblowing 11+)	$500	Best PR	-2i, 1d/-5i, 2d	3
*Armourer, TL0 (Stone Knapping 13+)	$400	PR	-1i/LJ	0
*Armourer, TL2+ (Armoury 12+)	$500	PR	-1i/-2i, 1d	2-3
*Bronzesmith (ST 13+, Blacksmith (Copper/Bronze), Metallurgy 12+)	$480	Best PR	-1i, 1d/-2i, 3d	1
*Builder (Carpentry or Masonry 12+, Architecture 10+)	$500	Best PR	-1i/-2i, 1d	1-3
Charioteer (Animal Handling 12+, Teamster 12+)	$250 + living expenses	Teamster	-2i, 2d/-3i, 2d	1
*Clockmaker (Engineer (Clockwork) 12+, Mechanic (Clockwork) 13+)	$600	Best PR	-1i/-4i	3
*Coppersmith (ST 13+, Blacksmith (Copper/Bronze) 11+)	$500	PR	-1i, 1d/-2i, 2d	0
Master of Weights and Measures (Literacy, Cyphering 12+, Law 11+)	$600	Best PR	-1i/-3i, public scandal	1-3
*Megalith Builder (Architecture 12+, Masonry 11+)	$600	Best PR	-1i/-3i, 2d	0
*Merchant Factor (Merchant 13+, Area Knowledge 12+)	$600	Best PR	-2i/-4i, loss of reputation	3
*Miner (ST 11+, HT 11+)	$500	ST	-1i, 1d/-2i, 3d	0
*Physician (Herbalist 12+, Diagnosis 10+)	$600	Best PR	-1i /-2i, disease caught	1-3
*Professor (University) (Teaching 13+, any science 12+)	$350	PR	-1i/LJ, accused of heresy	3
*Scribe (Literacy, Calligraphy 12+, Cyphering 11+)	$400	Best PR	-1i/LJ	1
*Sericulturist (PS (Sericulture) 14+, Merchant 11+)	$350	Best PR	-1i/1d × 10% of total assets lost	1-3
*Shipbuilder (Shipbuilding 13+)	$480	PR	-1i/-6i	1-3
*Ship's Captain (Shiphandling 13+, Navigation 13+)	$600	Best PR	-2i, 2d/ship sinks, 3d for all aboard	1-3
*Vineyard Owner (Agronomy 14+, Merchant 11+)	$350	PR	-3i/1d × 10% of total assets lost	2-3
Wealthy Jobs				
*Armourer, TL1 (Armoury 12+)	$1,000	PR	-1i/-2i, 1d	1
*Banker (Accounting 14+, Detect Lies 12+, Merchant 12+)	$1,500	Best PR	-3i/1d × 10% of total assets lost	2-3
*Caravan Master (Area Knowledge 12+, Leadership 12+, Packing 15+)	$900	Best PR	-2i, 1d/-4i, 2d	2-3
Chariot Warrior (Bow 12+, Savoir-Faire (Military) 12+)	$800	Best PR	-1i/-2i, 3d	1
Government Official (Status 3+, Literacy, Administration 14+)	$1,200	PR	-1i/-3i, tried for misconduct	1-3

*Freelance job; increase/decrease income 10% per point of success/failure.
Key for Critical Failure Results: For two entries separated by a slash, use the second result only when a natural 18 is rolled.
LJ = Lost Job, i = month's income lost, d = dice of damage taken.

CHAPTER II

THE STONE AGE:
TECH LEVEL 0

"Farewell, Romance!" the Cave-men said;
"With bone well carved He went away.
"Flint arms the ignoble arrowhead,
"And jasper tips the spear to-day."
– Rudyard Kipling, "The King"

Tech Level 0 covers the three periods of the Stone Age – the Paleolithic, Mesolithic, and Neolithic – as well as the Chalcolithic ("copper-stone") period, in which metalworking originated. Most of what is known about the technology of these eras is based upon physical evidence from archaeological digs. A certain amount of speculation and extrapolation is necessary, particularly regarding items made from materials that are not suited to long-term preservation.

In addition, a number of peoples throughout the globe survived into the modern era with minimal contact with the outside world. The Inuit of Alaska, the aborigines of Arnhem Land, the Bushmen of Africa, and the Papuans of the New Guinea highlands are examples of hunter-gatherers or horticulturalists. Their cultures provide insights into the daily life and technological capabilities of TL0.

The Stone Age encompasses several major advances in technology. The agricultural revolution at the start of the Neolithic is as important as the urban revolution at its end (see pp. 14-20). The categories of early, middle, and late technology apply very sharply here. Early TL0 is the lower and middle Paleolithic (before 200,000 B.C.); middle TL0 is the upper Paleolithic and Mesolithic (200,000-8000 B.C.); late TL0 is the Neolithic and Chalcolithic (after 8000 B.C.). Though all these stages are included in TL0, their differences are comparable to those between successive TLs in historic times. The capabilities of skills should be limited to those actually used in each period.

Man and His Environment

The most basic question about a human society is how people meet the basic survival needs, such as food, water, and protection from the elements. In TL0 societies, nearly all of these come from resources in the local environment. People mostly provide for themselves, so nearly everyone is familiar with basic survival skills. ***GURPS*** already provides a simple treatment of this topic (see p. B128); the following rules provide a more detailed treatment for campaigns that focus on survival or everyday nomadic life.

Environments are graded as desolate, poor, typical, good, or excellent. For any environment better than desolate, roll once a month against the average Survival skill of adult tribe members (-2 for poor, +2 for good, +4 for excellent). On a failure, the area drops one grade and the tribe will probably move on; on a critical failure, the area drops two grades and the tribe must leave immediately to get away from a fire, flood, or other disaster. Tribes in desolate environments must stay on the move constantly, with no roll.

Tribal peoples commonly spend half their day seeking food, an average of 5 hours. This may be spent in gathering, fishing, hunting, or tending traps. The time for a single attempt to find food depends on the environment: desolate, 1d hours; poor, 1d-2 hours (minimum 1); typical, 1 hour; good, 1/2 hour; excellent, 1d attempts per hour.

Life of the Wandering Hunter-Gatherer

Through all but the last few thousand years of prehistory, all of man's ancestors lived as hunter-gatherers. Stone Age hunter-gatherer bands are small, close-knit units ranging in numbers from 10 to 70, depending on the amount of food available. Division of labor is largely sex-based. The men go out to hunt or scavenge meat, while the women remain closer to the base camp, foraging for other food and tending the children. The women commonly provide from 1/2 to 2/3 of a tribe's food, giving them an important say in the selection of new campsites.

Contemporary hunter-gatherers such as the aborigines of Australia and the Bushmen of the Kalahari Desert spend 4-6 hours each day on gathering food and making and repairing tools. This leaves considerable time for socializing, leisure, and ritual.

By the time of *Homo sapiens neanderthalensis*, interest grew in art and music, which intensified with the emergence of anatomically modern humans (*Homo sapiens sapiens*). Cave paintings, stone engravings, and figurines of stone, ivory, antler, and bone have been uncovered, along with simple horns, drums, and flutes. Man celebrated his victories in picture and song, developed religious ceremonies to encourage the success of the hunt or the changing of the seasons, and buried his fellow tribesmen with ceremony and respect.

The factor that restricts typical hunter-gatherers most sharply is that they are nomadic. They can own no more than they can carry. Many of the women have babies or toddlers who need to be carried all or most of the time. Anyone creating a Paleolithic tribesman needs to consider not only starting wealth, but the actual weight of possessions; it's best if they add up to no more than light encumbrance in warm climates, or medium encumbrance in cold climates.

The Ice Man

In 1991, hikers in the Upper Oetztal valley of Italy made a startling find – the mummified corpse of a Neolithic traveler. Resting at 10,500 feet, the mummy and his gear were preserved in a glacier for over 5,000 years. A dream come true for paleoanthropologists, the discovery of "Oetzi" gives us a window into life and death at TL0.

An old man for his era, Oetzi was perhaps 45 and was relatively healthy when he died of exposure. Given the location and circumstances of his death, he was probably a local shepherd who strayed too far into the high valley. His clothing and equipment would be typical of late TL0.

Like a TL7 mountaineer, Oetzi layered his clothing – he wore a waterproof fiber cloak with fur and leather garments underneath. He was dressed for the cold from his head (snug in a bear fur hat) to his toes (warm and dry inside leather footwear with grass liners). Among his possessions were a flint dagger with ash handle, a yew bow, and a quiver containing 14 arrows. His most prized possession was probably his yew-hafted copper axe. A pouch contained flint tools, leather and sinew for repairs, and tinder. Oetzi wore a wooden backpack frame and carried two bark containers. On a thread of sinew were lumps of the fungus *Piptoporus betulinus*, a mild antibiotic and purgative Oetzi may have used to control whipworm, from which he suffered.

His body was marked with 57 small tattoos, placed over arthritic joints and sites of injury – perhaps in an attempt to alleviate chronic pain. Oetzi's hair was contaminated with arsenic, suggesting that he was involved with local smelting and may have fashioned his own axe head.

Continued on next page . . .

Gathering

Each attempt at gathering is represented by one skill roll, normally Survival. A successful Survival or Botany roll turns up one meal of edible vegetable matter, or two meals during the peak growing season. Leaves, stems, buds, roots, mushrooms, seeds, sap, fruit, or nuts may be found, depending on the geographic area. A critical success provides double yield, while a critical failure yields food that is mildly poisonous or has other inconvenient effects, such as the accidental discovery of a new psychoactive drug. A typical poison causes -1 HT on a successful HT roll, 1d on a failed roll.

People in many TL0 cultures eat insects such as grubs, termites, and grasshoppers. A Survival roll allows the gatherer to collect one meal. Near water, one can find crustaceans such as crayfish and crabs. Gatherers near a seacoast can gather mollusks such as snails, clams, and mussels at a rate of two meals per successful roll for 2 hours after each high tide.

Gatherers may search for birds' nests, beehives, or the dens of small animals. Locating these may require several skill rolls – Tracking to follow a creature, Vision or Naturalist to locate its lair, Climbing to reach a nest or hive located in a tree, etc. Moreover, the gatherer may have to wait for the inhabitants to depart before he can collect the prize. Nonetheless, the effort can be worth it, yielding 1d meals of eggs, meat, or honey.

Hunting

Hunting is a combination of several skills and abilities. Tracking, Survival, Naturalist, and Mimicry can be used to locate game. Stealth, Animal Guise, and Camouflage enable a hunter to get close enough to attack. And Combat/Weapon skills are employed to make the kill.

To find game, roll against the hunter's best game-finding ability; any parties traveling together roll once using the highest skill in the group. On a normal success, the hunter locates small game; success by 5 or more reveals tracks or other signs of a large animal, while a critical success provides a sighting of big game.

Small game consists of small mammals and birds, usually hunted with missile weapons: the blowpipe, bow and arrow, sling, or throwing stick. Once he sights prey, the hunter may attempt to close with it, requiring one or more contests of skill between his Stealth, Animal Guise, or Camouflage and the animal's Sense roll (typically 12). If he is undetected, the hunter may proceed until he is in range to make his attack and have the benefit of surprise on his first shot. If the hunter is detected, the animal bolts; the hunter can make one attack, suffering whatever range penalties apply. A successful kill yields half the animal's weight in edible meat (1d meals); butchering takes 10-30 minutes.

If the hunter can close, he can attack with a hand weapon, or attempt to snare the animal with a stick noose (see p. 107), using Garrote skill at -2. Even if the hunter loses his grip on the stick, the noose remains around the animal. If the animal does not escape (roll vs. DX-3) it may eventually strangle anyway (on a roll of 1 on 1d, the animal dies in 2d minutes; on a 2 or 3, in 2d hours). Of course, the hunter will need to track it.

Hunts for large animals, especially dangerous ones, should be roleplayed. If the hunter finds tracks or other visual signs, he may recruit a hunting party before setting out in pursuit. Getting within visual range of the animal may take from 30 minutes to 2-3 days, depending on the age of the tracks, the difficulty of the terrain, and the results of the Tracking skill rolls.

Many TL0 hunters use dogs to help track their prey. If the Tracking skill of a dog (typically 16-18) exceeds that of the hunters and any hunter has Animal Handling-12+, use the dog's skill for Tracking rolls. Each additional dog adds to Tracking skill; add +1 for 2-5 dogs, +2 for 6-9 dogs, and +3 for 10 or more dogs.

Once the hunting party reaches a range of 2d-2 × 10 yards, treat the final approach to attack range as a Contest of Skills as described for small game above, with rolls every 10 yards until the hunter is discovered or ready to attack. If dogs are used as trackers, a stealthy approach is virtually impossible, as the dogs will bark and alert the prey (though a party can use this to their advantage, splitting their forces so that the noise of the dogs flushes the target toward the other half of the party). If the target senses the hunters and flees, GMs should allow the hunters a parting shot. Predators and aggressive herbivores such as Cape buffalo may choose fight over flight, attacking immediately. They may even circle around after flight to find and attack the hunters.

Hunters may also chase potential prey. A typical strategy is to let the prey get away, running at top speed, and pursue it at half speed. The prey will become too fatigued to run long before the hunters do.

The edible meat from a successful attack is half the weight of the target animal. Butchering takes 1 man-hour per 100 lbs. of whole body weight. Each pound of meat counts as one meal. Many remaining parts are useful – skin for leather (see p. 19), bones for construction and weapon tips, sinews for bowstrings and bindings, intestines and stomach linings for containers, horns for glue, etc.

The Ice Man
(Continued)

Oetzi — **60 points**

Age 45; 5'4''; 120 lbs.; a bearded man with numerous small tattoos.

ST 10 [0]; **DX** 12 [20]; **IQ** 10 [0]; **HT** 11 [10].

Speed 5.75; Move 5.

Dodge 5; Parry 6.

Advantages: Alertness +1 [5]; High Pain Threshold [10].

Disadvantages: Stubbornness [-5]; Unluckiness [-10].

Skills: Animal Handling-12 [8]; Area Knowledge (South Tyrol)-10 [1]; Axe/Mace-12 [2]; Blacksmith-10 [2]; Bow-11 [2]; Flint Sparking-13 [2]; Herbalist-9 [2]; Hiking-10 [1]; Knife-12 [1]; Leatherworking-10 [1]; Mimicry-10 [1]; Naturalist-8 [1]; Stealth-11 [1]; Stone Knapping-10 [2]; Survival (Woodland)-10 [2]; Tracking-9 [1].

Languages: Neolithic South Tyrol (Native)-10 [0].

Further Reading: Spindler, Konrad, *The Man in the Ice: The Discovery of a 5,000-Year-Old Body Reveals the Secrets of the Stone Age*. WGBH Public Television: *NOVA* Episode No. 2518: "Return of the Iceman."

Food and Water

An active adult needs at least three meals and 2 quarts of water per day, and a child roughly half that. Any less causes starvation or dehydration over time (p. B128). On a typical day, a nomadic group has all its adult women and adolescent girls gathering food (about one-fourth of its number), while its adult men (about one-sixth of its number) hunt or fish. If big game is available, about half the men may be looking for it, while the other half stay closer to the base campsite and have access only to smaller prey. These figures are subject to adjustment for specific campaigns.

Continued on next page . . .

Food and Water
(Continued)

Water Supplies

Prehistoric campsites must be close to permanent water sources, if any are available. In arid climates, foraging for water can prove a challenging Survival task. In the Kalahari Desert of Africa, for example, many areas are virtually without surface water 10 months out of the year. The Bushmen who live there use great ingenuity to find additional water wherever possible. Small amounts are collected from hollow trees, or from "sip-wells" (hollowed reeds joined together into 5' lengths and sunk into the moist sands that indicate ground water close to the surface). Tubers are dug up, peeled, and grated, and a potable liquid is squeezed out of the pulp. In such areas, finding water requires daily rolls against Survival.

Storing Food

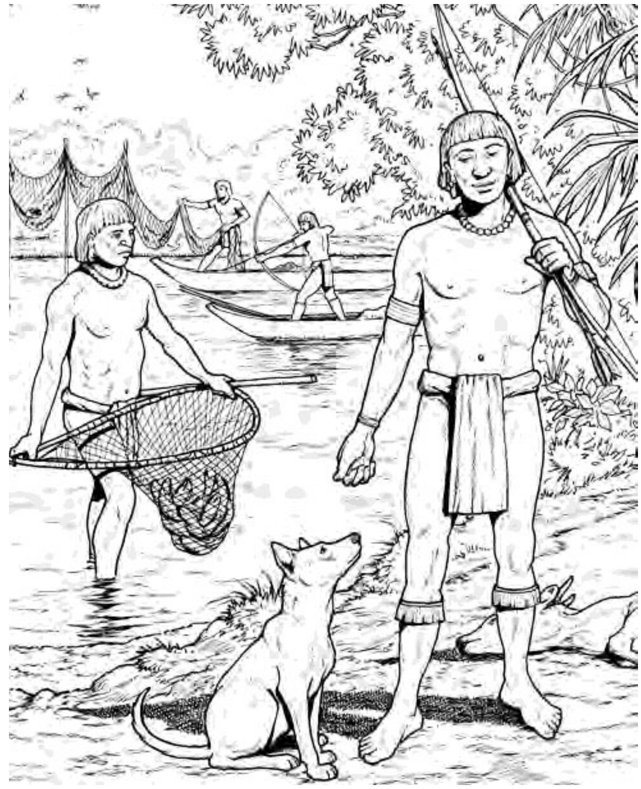
Meat and fish should be eaten the day they are caught, though they are still edible the next day (roll vs. HT to avoid loss of 1 HT). To keep them edible longer, they can be salted (using 1 lb. of salt per 5 lbs. of meat or fish) or smoked over a steady fire, either of which takes 3 days. In hot, dry climates they can also be sun-dried, taking 6 days; this works for fruit as well. These processes remove most of the water, reducing weight and volume 50% for the same number of meals, an added benefit for nomadic tribes. Meat may spoil much faster in the tropics or much more slowly in arctic climates; see p. BE84 for details.

Trapping

An alternative means of obtaining meat is setting traps and snares. Use Survival skill for simple snares and box traps for small game, and Traps skill for traps deadly enough to capture, maim, or kill human-sized or larger game – deadfalls, tiger pits, etc. In addition, Naturalist skills can help determine good locations to set traps, while Camouflage skills may be useful in concealing the trap from animals with good eyesight (such as humans). A sampling of traps that might be used by TL0 man:

Continued on next page . . .

Fishing



Bodies of water often provide fish to catch. All rolls are based on Fishing skill; roll at -5 if wholly unequipped, or at -2 when using improvised tools such as a sharpened stick for a spear.

Fish can be caught by hand along undercut river banks or in very shallow ponds. A fisherman also can muddy the water in small pools – causing fish to come up to the surface to breathe – or attempt to use a light, bait, or lure to bring them close enough to be clubbed. Fish can be speared or harpooned in shallow water or from a boat or raft. The fisherman can also use a line and baited hook or nets made from vines or plant fibers. A large net or fish trap made of branches or woven grasses, placed where it effectively blocks the course of a river or stream, can produce weeks or months of food supplies from a few days' effort (see the *Fish Wheel* sidebar, p. 17). Smaller traps can be used to catch crustaceans such as lobsters.

A successful roll catches 1/2 meal of edible fish, plus a further 1/2 meal per point by which the roll is made. Thus a roll of 7 against an effective Fishing roll of 12 would yield three meals of fish. A critical failure on any roll means the area is fished out for the remainder of the day. Two fishermen handling a large net together have triple yield.

Horticulture

Farming began in the Neolithic when gatherers harvested wild cereal grains that grew in temperate climates after the end of the last Ice Age. Farming communities arose among many unconnected cultures within a few thousand years.

The earliest farming communities were concentrated in areas most able to support them – river valleys with rich soils periodically replenished by alluvial deposits. These regions include the Tigris and Euphrates, the uplands of the Levant, and the fertile loess lands of the Yellow and Wei Rivers in China. Farming initially spread to new patches of very fertile ground, skipping over long stretches of uncleared woodland. Grains – such as wheat, barley, and millet – and legumes were the earliest staple crops of Neolithic agriculture. Later domesticates included other grains such as rice and maize; vegetables including squash, peppers, and potatoes; and a wide array of nuts.

In the absence of draft animals, primitive farmers break the soil with digging sticks or stone hoes. Crops are harvested by hand or with sickles or digging sticks (see pp. 29-30).

Technologies

Man's early technology did not advance at today's breathless pace. Innovation could, and often did, take centuries.

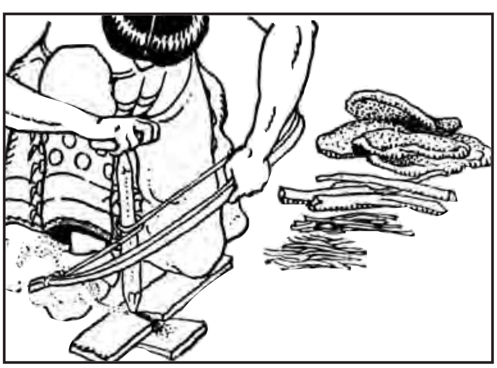
Fire

Roughly 1.5 million years ago, humans began to make an opportunistic use of natural brush fires for light, warmth, and protection from predators. By 700,000 B.C., man learned to build stone hearths to contain a fire and to sustain a blaze by adding fuel, but still could not start a new fire.

An existing fire can be transported to a new location, a skill that is especially important to people who cannot kindle fires on their own. Early TL0 cultures carry burning brands; in effect, these are torches (see p. 31). More advanced TL0 cultures carry hot coals in clay pots or hollowed-out animal horns, packed above and below with layers of fine ash. Such containers, handled carefully, can be carried several days (make one DX roll per day, at -2 per point of Move above 2).

By 500,000 B.C., *Homo erectus* learned to make fire by striking a piece of flint against another stone, particularly one containing iron pyrites, producing a spark that ignited tinder placed below. Characters using this technique roll once every 10 minutes vs. Flint Sparking skill (p. CI152) to start a fire. Modifiers are +3 if a partner blows on the smoldering kindling; -5 if the kindling is wet; -3 if it is damp.

Homo heidelbergensis (300,000-35,000 B.C.) used an improved fire-making technique, the bow and palette method. This technique employs a flat wooden palette with circular indentations or grooves. A slender stick is placed into the indentations and rapidly rotated between the palms of the hands or vigorously rubbed back and forth in one of the grooves to generate a smoldering heat through friction. This heat sets fire to tinder, in the form of dry moss or bark. The bow and palette technique produces results much faster than the flint-sparking method (skill rolls vs. Bow and Palette may be made once per minute). Modifiers are +3 if a partner blows on the tinder; -5 if the tinder is wet; -1 if it is damp; -3 if the palette and spindle are wet.



Once started, a fire must be fed. Make a Survival roll for each hour spent foraging for fuel. Terrain modifiers are applied: -5 for barrens, desert, or arctic; -4 for swamp or marsh; -3 for tropical jungle or bog; -2 for rainforest; -1 for tundra or grassland; +1 for scrub; +2 for temperate or arboreal forest. A successful roll obtains enough fuel to keep a fire from completely dying out for 12 hours. In addition, each point of success produces fuel to feed a large fire suitable for warmth and cooking for 1 hour. A failure obtains no fuel.

Trapping (Continued)

Snares generally consist of simple loops of rope set along the ground and camouflaged; when prey steps into the loop, it tightens around the leg of the prey and prevents its escape. Snares are most effective along game trails or near the entrances to dens. Basic snares are suitable for small game animals and herbivores, but larger predators can break free by gnawing at the rope. Snares for humans or other large prey, therefore, are set to jerk the victim completely off its feet. A simple snare can be set up in about 5 minutes and a trap-line of 10 snares in about 1 hour. An initial Naturalist roll (defaulting to Survival at -2) is made for each trap-line to determine the desirability of its location and used as a modifier for all future success rolls. A normal success gives no modifier, a critical success a +2, a normal failure a -2, and a critical failure a -4. One Survival roll may be made for each set of ten snares laid. On a successful roll, one snare (plus one additional snare per point of success) has been sprung, yielding one meal per snare.

Box traps come in many types – cages, boxes, sacks, etc. The basic idea is to lure the animal into the box and shut the entrance behind it. Most commonly, box traps are set with bait tied to a trigger that is sprung when the animal takes the bait. Box traps take 2-4 man-hours to construct, and do no damage to the trapped animal; if they are unwatched, the animal may break free, destroying the trap in the process.

Deadfalls have similar trigger mechanisms. One end of the deadfall is placed on the ground and set with bait; when triggered it drops the other end – typically a rock or heavy log – onto the prey. A deadfall takes 1-2 hours to construct, with damage dependent on the weight of the deadfall and the distance it is dropped (see p. B131). The farther the deadfall is from the bait, the more chance the prey has to dodge.

Pit traps are sometimes dug to catch large animals such as pigs or tigers. See pp. B90-91 for digging times, and add 10% to the time indicated to camouflage the opening. When an animal encounters the trap, a contest of skills between its Vision (+3 if the animal is alert, +5 if it has cause for suspicion) and the hunter's Traps or Camouflage skill determines if it falls in. The pit must be large enough to hold the beast and deep enough to prevent it from climbing back out. (In the case of a creature with leaping ability such as a tiger, it must also be small enough to prevent the animal from getting a running start). Victims of a pit trap take falling damage; a pit trap with sharpened stakes in the bottom causes the victim to hit 1d stakes, each of which does impaling damage equal to falling damage.

With an axe, one can cut off branches or fell an entire tree for fuel (see sidebar, p. 39). Fresh-cut green wood does not burn well; if a fire is fueled only with green wood, a Survival roll is needed to keep it from sputtering out. A critical failure results in smoke inhalation (see p. B132). Woodcutting does not become common until the Neolithic, after 8000 B.C.

Homo heidelbergensis maintained regular hearth fires at campsites and cooked his meat. *Homo sapiens neanderthalensis* built fires in stone-lined pits that held in heat and cooked vegetables as well as meat. Finally, *Homo sapiens sapiens* boiled water by dropping heated rocks into animal-hide bags or by hanging a bag over a small fire.

Crafts

Stone Age societies use a variety of materials, including stone, bone, wood, leather, and rarer materials such as native copper. Neolithic societies begin to make pottery as well. But these materials either are available in nature or can be made easily from common raw materials. There are few specialized industries producing materials for others to use. Similarly, most tools are made by the intended users, often on the spot, and often are discarded after a day or two.

Stone Knapping

Stone Knapping represents the TL0 equivalent of Armoury. A character possessing this skill can fashion tools and weapons from stone, wood, and bone. Other stoneworking skills include Jeweler, for beads and ornaments; Masonry, for stone structures; and Sculpture, for figurines.

The earliest stone choppers, produced as early as 2,300,000 B.C., are known as Oldowan (for the Olduvai Gorge where they were first found) or "pebble tools." To create a pebble tool, the edge of one stone is struck against another, knocking off flakes until a jagged edge is produced. These multipurpose choppers are typically palm-sized or smaller, and commonly made from flint, though other nongranular igneous rocks such as basalt and obsidian are also used.

Stone items produced between 1,400,000 and 300,000 B.C. are described as Acheulean. The characteristic stone tool of this period is the hand axe, initially produced by the stone on stone flaking technique. By the later stages of this period, a soft hammer made of antler is often used to retouch and sharpen a tool after the hammer stone has created the initial rough shape. The earliest examples of other types of stone tools, including scrapers, cleavers, chisels, and even anvils, date to this period.

Roughly by 200,000 B.C., stone knapping methods were revolutionized by the Levallois technique. In this technique, the maker plans out his finished core tool before beginning. The flakes to be removed are flattened on one side and rounded on the other so that they can be detached from the core by a single blow. These flakes are fashioned into smaller cutting or scraping tools. The implements that can be manufactured include knives, spear-points, and burins (small pointed tools used in the fine working of stone and bone).

Starting in 40,000 B.C., stone blades were lashed onto or set into wooden handles, converting hand tools into more versatile weapons. Flake tools were refined by a new knapping method called pressure flaking, in which a pointed wood or bone implement is used to shape and sharpen the edge.

During the Mesolithic period from 13,000 to 8000 B.C., the stone knapper's expertise extended to the production of blades no more than an inch or two long. These miniature tools, known as "microliths," are ideally suited for use as spear points or arrowheads. Even more revolutionary were tools in

Domestication of Animals

In the later Mesolithic, man began to domesticate wild animals. This started at roughly the same time on several continents with different animals. Domestication is more than simple taming; tame animals are captured in the wild and trained, but domesticated animals are bred in captivity and undergo genetic change as a result.

Dogs are believed to be the first animal to have been domesticated, between 9500 and 9000 B.C. Dogs help hunters track and bring down game, and they guard human settlements and warn of approaching danger. Nonetheless, their main importance during the first stages of domestication is as food.

The next phase of animal domestication began during the Neolithic (7000-6500 B.C.) and involved pigs, goats, cows, and sheep. It is not certain which species was domesticated first. Neolithic domesticated animals were kept solely for meat. A Neolithic herd of 30 cattle generates over 2 tons of meat annually while maintaining a stable herd size. Over 50 acres of meadow and cropland are needed to support such a herd.

TL0 cultures sometimes domesticated other species that played an important role in their economies. Two examples are the breeding and raising of silkworms in China, beginning around 3500 B.C., and beekeeping in Egypt, which preceded the first recorded histories of the Old Kingdom.

Cutting Trees and Clearing Ground

With a polished stone axe, a man with ST10 can clear 50 square yards of deciduous forest in an hour, producing 1,200 lbs. of wood. Cutting down a 12"-diameter oak tree takes about 30 minutes; cutting down a 12"-diameter pine tree takes about 10 minutes. This process provides fuel and helps prepare the ground for slash-and-burn cultivation. A single axe can cut down 100 trees before it needs to be resharpened.

Paleolithic stone axes, with irregular edges, make shallower cuts and are more likely to become wedged in a cut; increase the time required to cut a tree using such tools by 50%. More importantly, they lose their edges more quickly. A chipped stone axe becomes dull after cutting 50 trees and cannot be resharpened, at least not into an axe.

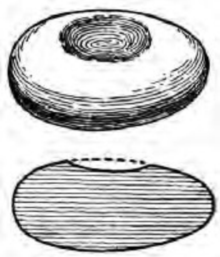
Hand Axe

Paleolithic Scraper

Flint Arrowhead

Pick

Neolithic Mallet

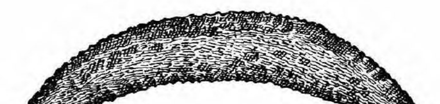


Pebble Cup Mortar

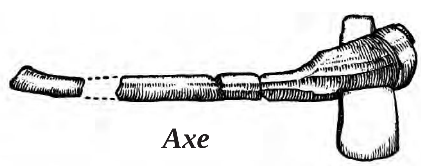
Neolithic Axe-heads

Obsidian Spearhead

Flint Dagger



Saw



Axe

which a number of microblades are fastened onto a bone or wooden handle with tar or glue. These tools, which include harpoons for fishing and hunting and the first sickles for harvesting wild grains, provide a more precise cutting edge. Also, if one of the blades breaks, it can be replaced without making a whole new tool.

Finally, in the Neolithic, ground and polished stone tools were made by sprinkling one stone with water to keep the heat of friction down, then rubbing it against another for hours to wear the worked stone into a useful shape. Grinding allows the knapper to make flat or smoothly curved surfaces. This led to new tools such as mortars, pestles, querns, and metates (all used in grinding grain) and lapidary works of art such as stone beads and figurines. Grinding can also be used to make stone tools such as axe-heads.

The Fish Wheel

Fish wheels are a particularly useful TL0 food-gathering technology native to the Pacific Northwest. The wheel is placed at the edge of a river just below a bend. It has four spokes radiating from a log axle, which is attached to the center of a raft and turned by the current. Each spoke is equipped with a top-sided basket woven from willows; as each basket rotates into the air, an angled plank on the bottom of the basket forces the fish inside to drop into a wooden box. The next basket is then lifted out of the water and dumps its catch into the box, and so on.

A fish wheel takes 40 man-hours to construct, weighs about 500 lbs., and costs $200. Fishing rolls using a fish wheel during peak times are at +4. A successful roll generates 100 meals of edible fish per hour, plus an additional 10 meals per point by which the roll is successfully made. A critical success generates 400 meals of fish per hour, while a failure places the wheel in a bad location where it catches no fish. A critical failure destroys the wheel. The effectiveness of the wheel declines under conditions other than the intense traffic of the spawning season.

Fire and the Landscape

The use of fire enabled human beings to transform their environment on a large scale. Until very recently, Australian aborigines regularly burned off the land, both to kill snakes and to produce new growth that attracted herbivores; archaeological evidence in North America and Europe indicates similar practices.

The use of fire became more intensive after the domestication of plants. As farming expanded into woodland regions, a technique known as slash-and-burn agriculture developed. Slash-and-burn is best suited to areas with poor soil, from the coniferous forests of Finland to tropical rain forests; it is a technique for concentrating nutrients. A patch of forest known as a swidden is cleared by burning, and the farmers carry the ashes to a small area where crops are planted. Newly cleared areas generate good yields for 1-2 years, but raising crops depletes soils quickly, and farmers must relocate. Typically a decade or more must pass before the same area can be cultivated again.

Irrigation

A number of horticultural societies practice irrigation on a small scale to increase crop yields (see p. 34). There is evidence that the practice began before actual agriculture, with some hunter-gatherer societies supplying water to wild plants.

Sources of Stone

Stone tools can't be made from just any rock. Chipped tools need crystalline materials. These stones fracture conchoidally when struck – that is, the shock of the blow travels through the stone in a predictable, controllable cone. Obsidian is the best natural material for this, followed by fine-grained flint, chert, chalcedony, and a variety of other stones. A determined knapper can make a tool from almost anything but sandstone or coarse limestone, but the coarser the material, the more work it takes and the worse the finished tool will be.

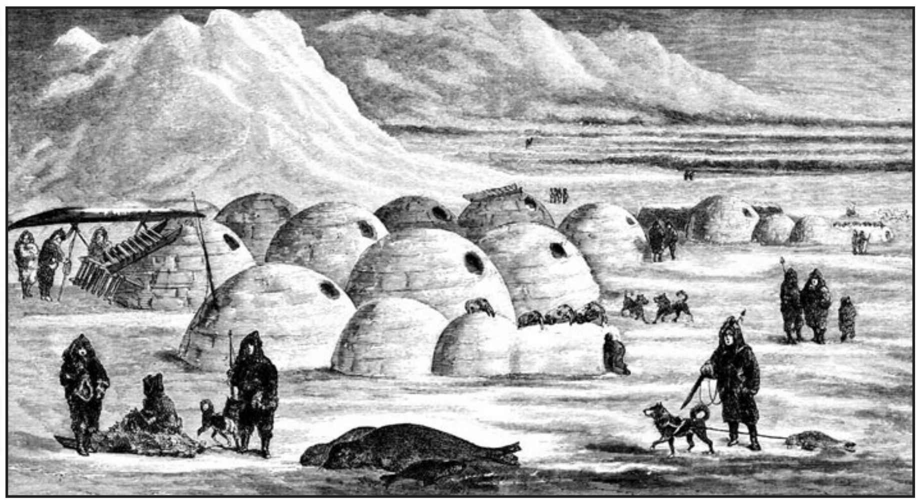
Ground stone tools need materials less prone to fracture. Bowls and querns are made from soft stones, such as soapstone and pumice. Axes need hard stones, the harder the better. Many metamorphic rocks have been used, but the best material is jadeite, used by Aztecs, Incas, and Neolithic Europeans for axe heads.

The use of stone increased during the Neolithic, to the point where local sources in many areas were depleted. As a result, the first specialized industry emerged: flint mining. Mining and quarrying using bone, antler, or wood tools is slow. An antler pick can break up ordinary soil at 0.15 × ST cy per hour, clay or other hard soil at half this rate, and hard rock at 1/4 speed. Wood or bone shovels can move 0.075 × ST cy of sand or loose soil per hour, ordinary soil at half speed, clay that has been broken up with a pick at full speed, or broken up rock at half speed. Digging costs 1 Fatigue per hour in sand, 2 in ordinary soil, 3 in clay, or 4 in rock.

The Mines of Grimes Graves

One large flint mine was operated at Grimes Graves, in Great Britain, between 2300 and 1700 B.C. About 34 acres were mined, with shafts going as deep as 40'. Side tunnels 3' high radiated out from the bottoms of these shafts. Ropes hauled loads of flint to the surface, leaving still-visible marks on the shaft walls. Pieces of flint were shaped into the rough form of hand tools and then traded, gradually spreading over a wide area.

The time required to produce a stone tool rises as the techniques become more sophisticated, but the value of the end product increases. The successive techniques produce more cutting surfaces from the same weight of stone: 9" per pound for the Oldowan technique, 54" per pound for the Acheulean, 72" per pound for the Levalloisean, and up to 216" per pound for Mesolithic microliths. A sharp flake can be knocked off a core with a single blow, but a more durable shaped tool takes time. Acheulean core tools can be produced at about 30 seconds per inch of edge. Levallois flake tools take about 1 minute per inch. Add another 1 minute per inch if fine pressure flaking is required, as with a projectile point. Blade tools take about 2 minutes per inch (most of which is spent preparing a core). The Neolithic grinding technique makes less efficient use of stone, producing 54" of cutting edge per pound. Preliminary shaping takes only 1 minute per inch of cutting edge, but grinding takes 30 minutes per inch of cutting edge. Resharpening a ground stone tool takes 10 minutes per inch of cutting edge.



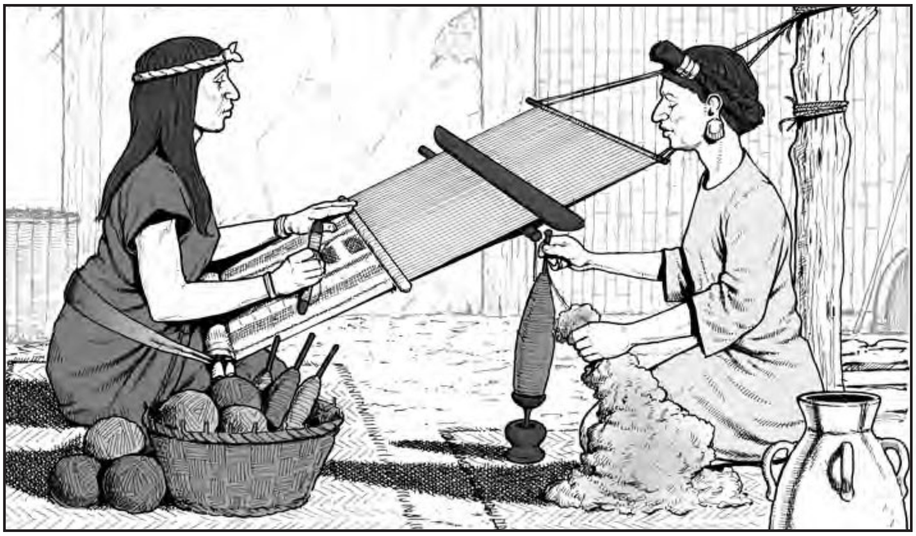
Woodworking

The effectiveness of polished stone tools made wood a major structural material in the Neolithic. Skills used to work with wood at TL0 include Carpentry, to split logs or make houses; Sculpture, to make human or animal figures; Shipbuilding, to make canoes; Stone Knapping, to make wooden shields or hafts for tools and weapons; and Woodworking, to make bowls and other containers.

While "wood" is treated as a single material in these rules for simplicity, each type of wood has different properties, including density, hardness, elasticity, and heat conduction. Cultures from the Neolithic through the Middle Ages select specific woods for each type of wooden object; the English yew bow is a familiar example. Any woodworking skill includes the ability to judge which woods best serve a given purpose.

Leather

The preparation of hides begins with the removal of any attached flesh, leaving only the skin. Then the leatherworker drives out the water content by various techniques. Simple drying in the sun or over a fire is an early method, though one that produces fairly stiff leather. The Inuit and some other peoples soften hides with oil or brains, which are high in fat content. Treatment with urine can also draw water out of the tissue, as well as slowing decay. Leather can be used for clothing, containers, fastenings, tents, and boats (see p. 27).



Fiber

The handicraft of making rope and string from twisted natural fibers can be traced to the Upper Paleolithic, roughly 20,000 B.C. The oldest fossilized cord-age, found in the caves of Lascaux, France, dates to 15,000 B.C.; images of partially unraveled string are several millennia older. One can make a simple cord from animal hair or plant fiber by rolling it between the hands or against the thigh. Suitable plants include flax, hemp, nettles, jute, sisal, papyrus, coconut, maguey, and yucca. For greater strength, two or three cords can be twisted together, with the overall bundle twisted opposite to the individual cords to prevent unraveling. This technique is sufficient to make anything from fine thread to heavy rope.

A more efficient technique came into use in the Neolithic: the spindle. This is a short stick that is set spinning and dropped, with already-spun thread wound around it. The end of the thread is allowed to slide out through the hand, and new fibers are fed into the spindle, then twisted by its motion. When the spindle reaches the ground the spinner rewinds the thread and repeats the process.

In the Mesolithic, nets came into use for hunting and fishing. This was probably the first venture into weaving, which turns one-dimensional cordage into two-dimensional surfaces. More elaborate weaving, using hand looms or ground looms, only became common in the Neolithic, when people lived in settled villages. Fossilized cloth from this period is often astonishingly elaborate, woven in patterns of squares, triangles, or stripes. and decorated with fringes or beads. It takes 5-10 hours to spin the thread for an hour's weaving, depending on how thick the thread is. Another form of weaving is basket-making, used to produce containers, mats, and even boats.

Containers

Hunter-gatherers use small containers to carry water, food, and even hot coals as they travel. Settled peoples need larger containers to hold long-term stores of food. A variety of materials serve these purposes.

Waterskins are rawhide bags with waterproof linings made of animal bladders, stomachs, or intestines. Waterskins hold 1-5 quarts of liquid and may be equipped with a loop so that they can be hung from a belt or pole.

In Mesoamerica, people hollowed out gourds to use as containers for liquids. Gourds are as watertight as skins but hold less (1-2 quarts). Smaller drinking gourds are used during meals; in other cultures, drinking vessels of horn may be used.

Bridges

An important form of construction is the rope bridge, used to cross narrow valleys or canyons. A simple rope or pair of ropes, one for the feet and one for the hands, can serve this purpose, though a Climbing roll is needed to use it (at -2 for hand over hand, or unmodified with a second rope for footing). More elaborate bridges use thin woven rope stretched horizontally between two thick parallel ropes to provide footing. With the increased use of wood in the Neolithic, bridges can be built with wood planks to serve as a walkway.

How much a suspension bridge can support can be calculated as follows. Assume, for example, a 100' gap to be bridged with a 1" rope. The rope cannot be made perfectly taut; assume an extra 15% length to allow for this, or total length 115 feet. The rope has a strength of 1,800 lbs. The rope weighs 34.5 lbs., so it can support over 1765.5 lbs, or over 8 men.

The same calculation can be made for a rope-and-board bridge. Two ropes can each support 1,800 lbs.: the two ropes weigh 69 lbs., and 115' of boards 1" thick and 2' wide weigh 575 lbs., for a total of 644 lbs. The bridge can thus support 2,956 lbs., or over 14 men.

The Beginnings of Astronomy

A number of archaeological sites have turned up pieces of stone or ivory into which series of lines were carved. Often these appear to be records of the phases of the moon. The use of tally marks represents the beginnings of arithmetic as well.

Late Stone Age constructions such as Stonehenge appear to serve astronomical and calendrical purposes; sunrise in a place marked by a specific stone indicates that a certain season has begun. Their construction reflects a concern with marking seasons for agricultural purposes, later embedded in ceremony and mysticism which called for larger structures.

Signals

In general, the only way for information to travel in the Stone Age was by human messenger. But human inventiveness devised several ways around this limitation.

Smoke signals are best known from their use by Native American tribes in recent historic times. Sending such a signal requires deliberately building a fire with green or damp wood. The dense smoke is then broken into separate puffs with a hide or blanket. The column of smoke is visible at a range of several miles.

By night, signal fires replace smoke signals. Settled peoples sometimes stockpiled wood in high places for such beacons. The approximate range in miles at which the fire can be seen equals the square root of its elevation in feet; ranges up to 50 miles are achievable.

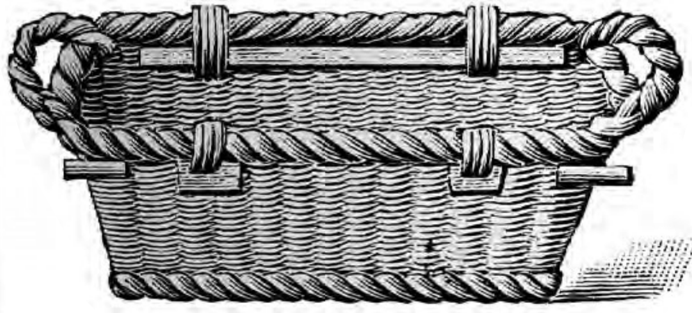
Finally, a variety of musical instruments produce sounds which are louder or carry farther than the human voice: drums, flutes, and animal horns were all used for this purpose, and remained in use on battlefields until the 19th century.

These methods cannot carry an unlimited variety of messages. Beacons seldom got more complex than "one if by land, two if by sea." Smoke signals or musical instruments might carry a dozen prearranged messages, but not as many as 100.

Memory and Lore

In the absence of writing, memory is vitally important. Nonliterate cultures commonly have a variety of techniques for making things easier to remember. One of the most common is the creation of rhymes and chants containing essential information. The skill of Bardic Lore can be used to recall such information, modified for obscurity (+5 for information constantly in use, -5 for obscure information). New information can be encoded this way and added to Bardic Lore with a Poetry roll. The composer of a verse is not subject to penalties to Bardic Lore skill to remember it!

Genealogies are a typical example of the sort of information that becomes Bardic Lore; they normally require an unmodified roll. A recital of one's genealogy to captors or other enemies allows an influence roll (see p. B93) against Bardic Lore. A favorable reaction indicates that they are long-lost relatives, have a debt of honor to your family, or something similar. A critical failure may remind them of an old feud!

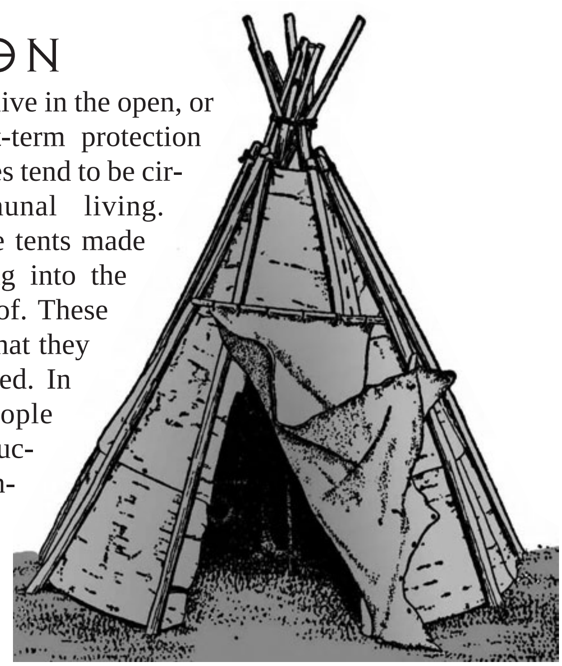


People used baskets both in advanced Neolithic settlements such as Çatal Hüyük and in the hunter-gatherer cultures of the Americas. They are made from coiled bundles of straw or grass that are intertwined or sewn together and are remarkably airtight and watertight. Smaller baskets often have a strap or vine and are worn like a shoulder bag; others can be large enough to serve as a backpack. A skilled basket weaver requires 1-3 hours to produce a quart container, 6-8 hours to produce a gallon container, and up to several days to complete larger baskets.

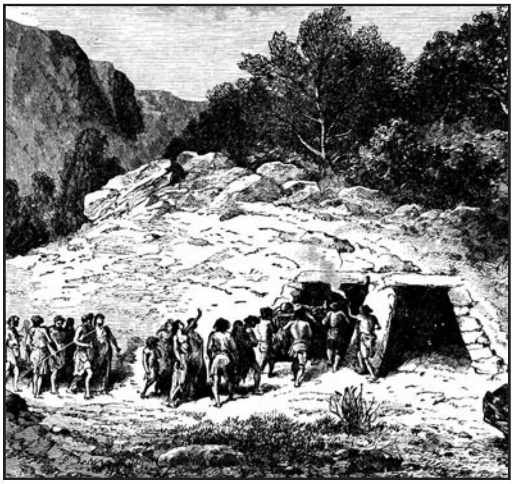
In the early Neolithic, earthenware pottery containers revolutionized storage. The first pieces consisted of long rolls of clay that were coiled on top of one another and sun-dried. Around 6,000 B.C., several cultures experimented with baking pottery pieces in a shallow hole by lighting a wood fire over them for about 2 hours. Fire-baked earthenware is harder and sturdier than sun-dried pottery, but many pots (50% plus or minus 5% per point of success or failure on a Pottery roll) crack or break in the process.

Pottery became an art as well as a craft. Pieces were decorated with designs incised into the clay before firing or painted on afterwards; pottery can be buffed or glazed to a shining surface. Each culture developed its own style, making pottery a trade good on a regional scale, though it must be carefully transported to avoid breakage.

Construction



Most bands of hunter-gatherers live in the open, or in structures constructed for short-term protection against the elements. These structures tend to be circular and designed for communal living. Commonly, shelters consist of huge tents made from hides or of oval hollows dug into the ground and covered with a hide roof. These shelters have the added advantage that they can easily be transported or replaced. In temperate climates, primitive people make buildings of a light superstructure of twigs and daubs over a foundation of circular stone footings; in subarctic climates, they build semisubterranean structures of driftwood and sod. Base camps are also set up in naturally protected areas such as caves. Construction of this type expanded greatly during the last Ice Age, as man's greater control over fire enabled him to empty deep caves of predators and convert them to his own use. Men equipped these caves with communal hearths for cooking and heating, while their entrances had windbreaks of branches and skins.



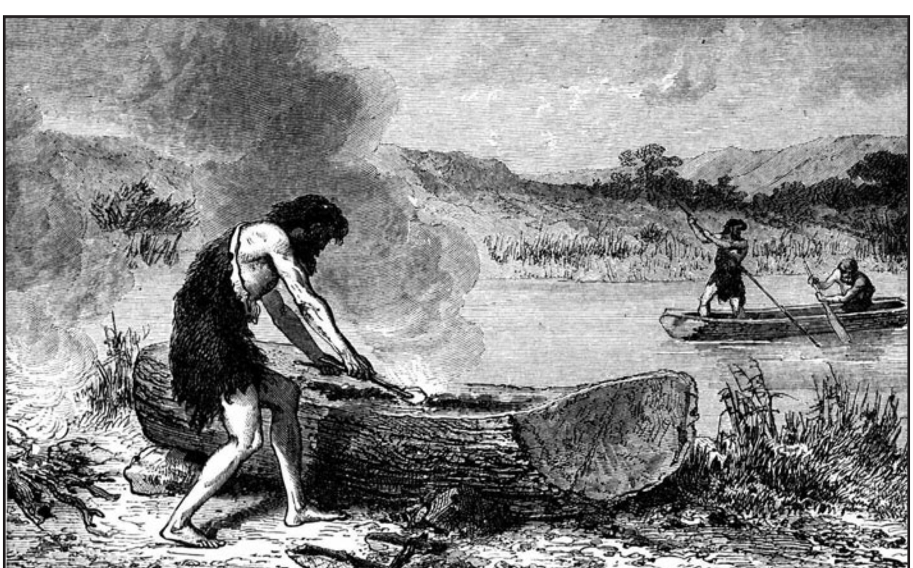
The most common residential construction material in early Neolithic settlements is known as "mud brick" and consists of wet earth that is molded into shape and then sun-dried. The finished bricks were built into walls using more mud as mortar. Mud brick is a cheap material, with two substantial drawbacks. The first is that mud-brick structures melt in a heavy downpour and have to be rebuilt. The second is that once mud has been used to make bricks, it cannot be used for that purpose again. Typically, one builds new structures directly on top of the old.

Transportation and Travel

In most Stone Age societies, land transportation was by walking (see pp. B187-188). A message traveled as fast as a man could run. A few societies used sledges or other vehicles with skids; these work best on ice, and they first came into use during the Ice Ages.

Land travel is almost all off-road, at speeds varying with the terrain: 20% of normal speed on very bad terrain, 50% on bad terrain, 100% on average terrain, 125% on good terrain. Around a settlement, there may be paths; treat these as very bad roads, with no effect on movement except in very bad terrain, where they allow 33% of normal speed. (See pp. B187-188.)

Water travel, when it is possible, is considerably easier. Rafts and boats were available in many TL0 societies and could transport heavier loads than sledges. But TL0 mariners mostly stayed within sight of land. (The range in miles at which a landmark can be seen is approximately the square root of its elevation in feet.) The skill of Navigation is not available; voyagers use Area Knowledge of local shores and harbors, with long-distance modifiers (p. B151) if out of sight of land.



Health and Medicine

Ill health is quite common at TL0. People are usually too dispersed to sustain a constant level of disease in the population, but other conditions make up for this. Intestinal parasites may be the rule rather than the exception; sufferers may be Unfit, or suffer reduced HT. Rheumatism is so frequent in early remains that scholars once believed that entire races of primitive man did not walk upright. Characters with rheumatism can have Hunchback, Bad Back, or both, depending on the severity of their ailment. Large indoor fires for cooking and heating cause respiratory ailments that can be simulated by the Unfit or Very Unfit disadvantages. Advantages such as Rapid Healing, High Pain Threshold, and Toughness are useful and probably relatively common. TL0 people begin aging rolls at ages from 20 (for *Australopithecus* species) to 40 (for *Homo sapiens sapiens*).

However, a number of medical and surgical techniques are available at TL0.

Treatment of wounds consists of cleaning by various methods; such cleaning restores one hit point. Cleaning may include herbal antisepsis, washing with fresh urine, or deliberate introduction of maggots to consume dead tissue. The cleaned wound may then be bandaged or left in the open air. Anyone with First Aid skill can perform these techniques; on a critical failure *only*, the victim loses 2 hit points.

The skill of Surgery normally has First Aid as a prerequisite; the TL0 equivalent of Physician, Herbalist (see p. CI150), is only marginally relevant to surgical procedures. Surgical procedures documented at TL0 include circumcision, dental extraction and drilling, opening abscesses, excising tumors, amputations, and even trepanation of the skull. Human remains from the Neolithic show evidence of healing after trepanation, indicating that many patients survived. Trepanation is used to treat skull fractures (a successful Surgery roll prevents death from brain injury) or severe headaches, especially after a head injury.

Continued on next page . . .

Health and Medicine
(Continued)

Most surgery inflicts bodily injury: 1d for minor surgery such as dental extraction; 2d for amputation at the elbow or knee (or lower); 3d for amputation at the shoulder or hip. On a successful Surgery roll, count one of the dice as an automatic 1; on a critical success, damage is 1 point per die. On a critical failure, roll damage normally and double the result. Treat trepanation as minor surgery, but on any failure, apply the usual ×4 multiplier for brain hits. Very minor procedures such as circumcision do not cause significant injury, but a failed Surgery roll causes bleeding (see p. B130).

Surgery skill is modified by the patient's behavior and the depth of the incision. There is no modifier if the patient is completely still; -1 if the patient makes small involuntary movements; -3 if the patient is held down by force; -6 if the hold fails and the patient moves violently. There is no modifier for superficial surgery; -1 for oral surgery; -2 for work in an incision into the body; -3 for work with probes.

For a patient to hold still requires a Will roll; patients with High Pain Threshold are exempt from this requirement. Success by 4 or more points allows a patient to remain completely still; any success limits motion to small involuntary movements. Modifiers are -2 for surgery on the torso; -4 for surgery on the head, hands, or groin; -5 if the patient has Low Pain Threshold; +1 if the patient is drugged; +5 if the patient is unconscious. Holding a patient still requires assistants with total ST at least 3 × the patient's ST.

If the Surgery roll fails, further rolls may be attempted at -1 per attempt; each roll causes 1 hit additional damage and requires an additional Will roll for the patient to hold still. If the Surgery roll succeeds, the patient must heal normally from the surgery and from any original injury.

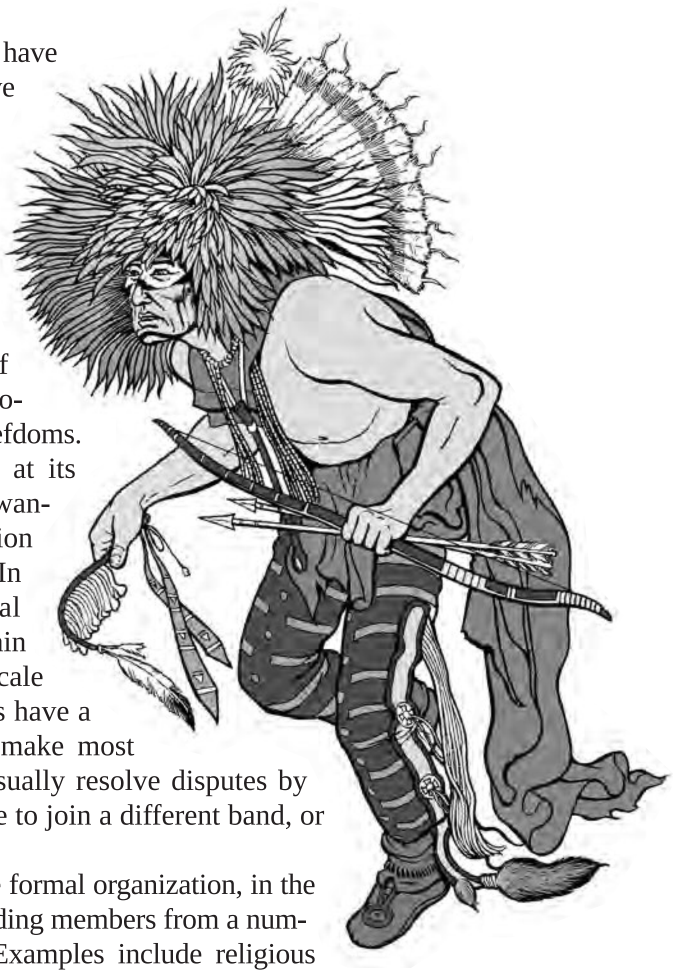
Herbalist skill includes the use of natural plants for several purposes. In various regions, opium, marijuana, or betel leaf serve as analgesics, or coca as a local anesthetic; all these plants are also used ritually and recreationally. Herbs are used to encourage sweating, sneezing, vomiting, urination, defecation, or menstruation, and to treat various ailments (see pp. CII168-171). As a simple procedure, allow a successful Herbalist roll to restore 1 HT.

Geophagy, or eating clay, can limit the toxic effects of digestive poisons. Allow +1 to HT rolls to resist such a poison. Some Neolithic peoples build sweat lodges, where heated rocks produce steam. Sweating gives +1 to HT to recover from many infections; it also is done simply to get clean.

Social Organization

The most basic fact about TL0 societies is that they are small. People know everyone else in the community by face, name, and reputation. The political, economic, and military organization of such societies reflects this smallness.

Bands, Tribes, and Chiefdoms



Most recent TL0 societies have been stateless; that is, they have not had a person or organization with the power to compel obedience from the entire society. One can reasonably guess that the same was true in TL0 societies of the distant past. Rather than states, such peoples had three other forms of organization, which anthropologists call bands, tribes, and chiefdoms.

A band is human society at its simplest: a few families who wander about together for protection and mutual aid in hunting. In many such societies, several bands come together at certain times of the year for large-scale hunts or other activities. Bands have a strong sense of equality and make most decisions informally. Bands usually resolve disputes by having member of a band leave to join a different band, or by an entire band splitting up.

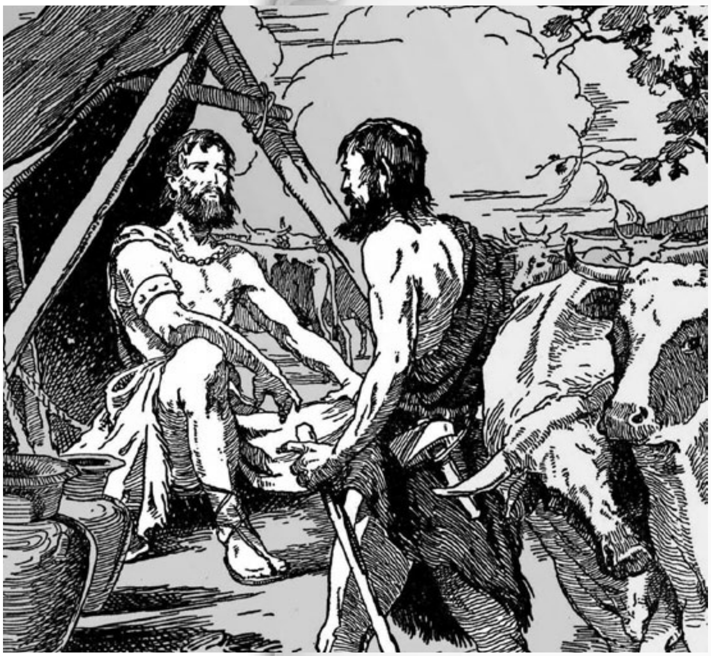
A tribe has somewhat more formal organization, in the form of organized groups including members from a number of bands or households. Examples include religious cults and "age-grades," which include all the men (or women) in a certain age range. Tribal organization is more common in settled societies.

A chiefdom is still larger and has an official leader, usually a wealthy and influential man who collects and redistributes the products of his followers' work. Such societies are small enough to work on the basis of personal ties between the chiefs and their followers; in some cases every person has a defined rank, starting with the chieftain in first rank and working down. Ambitious men compete for prestige, often by displays of generosity and elaborate ceremonies. This pattern first emerged among "big men" in tribal societies but persists even in true chiefdoms where rank is mostly hereditary.

Stone Age Economics

In moneyless societies, economic exchanges are very personal, and trade is as much social as economic. While barter appears at times, gift exchange is more important in many moneyless economies.

In a gift economy, people give goods without establishing what they may get back. A gift obligates the recipient to give a return gift, but the obligation is purely social. Someone who expects a gift can badger, cajole, and drop unsubtle hints, but he can require neither a specific gift nor a timetable for repayment. If he doesn't get what he wants, the worst he can do is accuse the giver of stinginess. This is more formidable than it sounds. In a gifting economy, somebody with a reputation for stinginess will have a hard time getting any kind of aid, material or otherwise, from others.



This leads to a very different attitude toward wealth. Community leaders are "big men" who use their wealth by *giving it away*. By giving gifts, they demonstrate generosity and obligate the recipients to give them more gifts in return, which means that they will have even more to give away.

Moneyless economies have no common measure of value. Money users can regard quantities of any goods as equivalent ("Three hundred cheeseburgers? That's a month's rent!"). In moneyless economies, that's rarely the case. Before currency, an item's $ cost is only an approximation of its value; players and GMs may think of goods as having a $ value, but characters won't.

The situation is further complicated by "spheres of exchange." Goods are often divided into low-prestige (common tools, staple foods) and high-prestige (livestock, gold, spouses) spheres. Goods can be exchanged within a sphere, but, barring exceptional conditions, not for goods outside the sphere. Exchanges of high-prestige goods have strong social and political overtones. You may trade coconuts with anybody, but only trade pigs with friends and potential allies. If desperate or ignorant characters attempt to trade goods across spheres of exchange, roll against Savoir-Faire at -6 to trade low-prestige goods for high. Even if the trade is accepted, the trader gains a Reputation as foolish, rude, or both. It's easier to trade high-prestige goods for low (Savoir-Faire -3), but the social consequences are similar.

Archaeological evidence shows that most trade takes place between adjacent tribes. Goods can travel a long way; turquoise beads from Arizona and New Mexico were used as trade goods in Alaska, for example. But the normal path is a succession of short hops between neighboring communities. Trade caravans are virtually unknown.

Warfare

Virtually nothing is certain about the practice of war – its frequency, strategy, or tactics – during the Stone Age. A number of anthropologists have assumed that warfare did not exist in prehistoric times. Reinforcing this viewpoint are the customs of a number of contemporary TL0 cultures, which engage in ritualistic combat where posturing and shows of bravery (in effect, Intimidation rolls) are critical and blows are seldom struck. Nonetheless, archaeological evidence from a number of burial locations (in Egypt, Eastern Europe, and Russia) reveals that early man did fight and kill his fellow man in battle.

Like trade, warfare at TL0 typically takes place between adjacent communities. Long-range military expeditions are rare.

Settling Down

Not all hunter-gatherers are nomadic. Access to a very rich food source, such as salmon in the Pacific Northwest or grain in Near Eastern river valleys, can store up enough food in a season to feed a community year round. Even without a single rich resource, hunter-gatherers in an area with excellent resources (see p. 11) may only need to move once every several years; the Jomon of Japan were such a culture, whose relics include some of the oldest pottery known.

Neolithic cultivators necessarily settle in one place, at least from planting to harvest. The first cultivators limited themselves to the very richest soil, which could be cropped year after year; the repeated migrations of swidden farmers were a response to the need to occupy poorer soil.

The results included the accumulation of possessions and the construction of durable shelter and storage areas. The ability to store up wealth made possible the emergence of big men and chieftains able to gather and redistribute it. Settled peoples could also support specialized craftsmen. Societies became more complex, with larger differences in wealth and power. No one in a nomadic society is worse off than Struggling or better off than Comfortable, but a chieftain in a settled society may be Very Wealthy, while an enslaved war captive may be Dead Broke.

Arms and Armor

Stone Age weapons ranged from the first hand axes to an explosion of weapons technology at the beginning of the Neolithic, when the bow, sling, dagger, and mace came into use. Some weapons went through multiple iterations, increasing in power, range, and/or accuracy. Hand-to-hand and ranged weapons are discussed below in the general order in which they were invented.

Detailed statistics for these weapons appear in the Appendix (pp. 106-112).

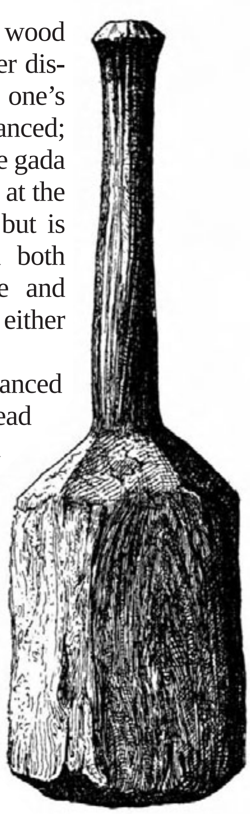
Hand Weapons

Hand weapons at TL0 are made of wood, bone, or stone, using the Stone Knapping skill (see pp. 16-18 and p. CI137), which is the TL0 version of Armoury.

Hand Axe

The hand axe is not actually an axe, as it has no haft. Its main use is as a tool (see p. 29). However, it can be pressed into use for close combat, using DX or Brawling skill.

Club/Mace



A club is a piece of wood used to strike at a greater distance than the reach of one's arm. Most clubs are balanced; the knobbed club and the gada have most of the weight at the end. A staff is similar, but is normally grasped with both hands near the middle and used to strike or parry to either side.

The mace is an enhanced club in which a stone head is mounted upon a wooden handle, typically by grinding a hole through the head. Maces at TL0 have round heads, which are slightly less effective than the flanged or spiked heads of later metal maces. "Round" need not be taken literally; the stone tomahawk is effectively a small round mace. Stone maces have been found at Neolithic sites scattered around the ancient Mediterranean. In the Chalcolithic, copper was also used for mace heads.

Axe

Axes date from 10,000 to 7500 B.C., when man began to attach hand axes to wooden shafts by lashing them to the shaft with sinew, hollowing a hole in the shaft, or inserting the weapon head into a socket of bone or antler. This placed the power of a swinging attack behind the blow. In the Neolithic, axe-heads of ground stone made it possible to inflict greater damage with a blow.

Spear

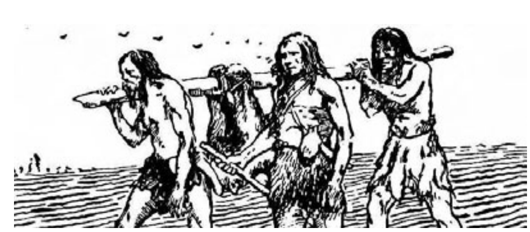
Spears are thrusting polearms, initially developed by *Homo erectus* as a hunting weapon that allowed the hunter to strike his prey from farther than arm's length. Spears can be used as one- or two-handed weapons or thrown (see *Ranged Weapons*, p. 25).

The first spears were simply 6' to 8' lengths of very hard wood (yew, ash, etc.) whose tips were sharpened to a point. The tips of such spears could be held in fire to harden them for enhanced damage. *Homo sapiens neanderthalensis* equipped spears with small flint points. By the last Ice Age, a leaf-shaped spear point had evolved which maximized damage capability.

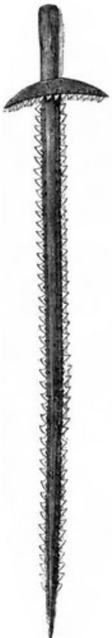
Blades

With increased skill as a tool maker, *Homo sapiens sapiens* could fashion a stone blade two to three times the length of a spearpoint. Such blades are fragile and often have to be replaced, especially the very sharp blades shaped from obsidian. Obsidian was particularly prized as a medium for knives and arrowheads; it was a trade item for cultures that possessed abundant supplies, such as Çatal Hüyük in Anatolia (see p. PM65).

The first knives were made without hilts. One side of the blade was left dull so that the wielder could grasp that edge. These early blades were cutting rather than stabbing weapons. By the Mesolithic and early Neolithic, knives had wooden or bone handles, allowing both the edges of the blade to be sharpened. In addition, the first leather sheaths were developed to carry or store a knife when it was not in use.



Blades made from copper began to appear in the late Neolithic and Chalcolithic periods. Such blades could not exceed 27" to 31" in length, due to the inherent softness of the metal.



Longer blades can be made using the Mesolithic technique of assembling a cutting edge from short segments. The *macauitl*, used by the Aztecs, was such a TL0 "sword," with a 3' wooden blade and pommel. Chips of flint or obsidian were glued into grooves along the edges. A similar invention was the *terbutje* of Kiribati, in which shark's teeth were sewn into place with hair or vegetable fiber. In general, these were purely cutting weapons, though an occasional macauitl had a point that could impale.

The shark's teeth or stone blades tend to break off and shatter in combat, making frequent repairs necessary. A macauitl or terbutje can take 30 points of damage before losing its cutting edge (after which it functions as a club). A blow through cloth, flesh, or bone causes 1 point of damage, wood causes 3 points, and metal does 5 points. Striking stone shatters the side which hits (i.e., 50% of the current points). Assess the same damage when parrying a weapon made of these materials (e.g., parrying a metal sword causes 5 points of damage). A critical failure on a parry destroys the remaining blades.

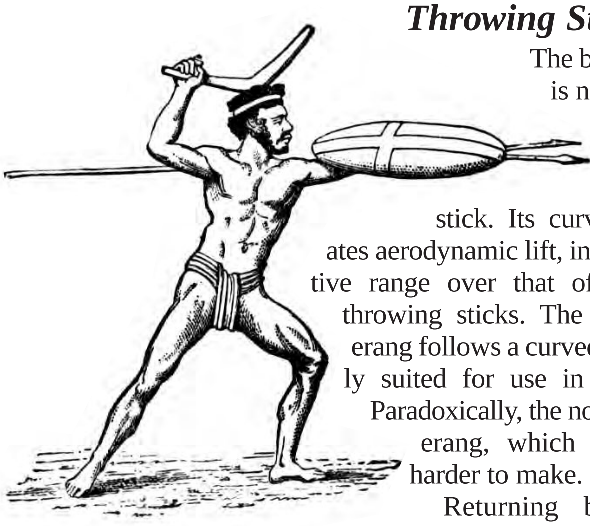
Garrote

A short leather cord or thong is useful as a strangling weapon. At TL0 this technique is more often used in hunting than against human victims. The stick noose (see p. 107) allows the same technique to work at a greater range. Treat these weapons as garrotes, but at -2 to Garrote skill.

Ranged Weapons

As efficient as early hand weapons were, it did not take man long to discover that *ranged* weapons were even more useful.

Throwing Stick



The boomerang, which is native to Australia, serves as the best example of the throwing stick. Its curved shape generates aerodynamic lift, increasing its effective range over that of simple straight throwing sticks. The returning boomerang follows a curved flight path poorly suited for use in hunting or war. Paradoxically, the nonreturning boomerang, which flies straight, is harder to make.

Returning boomerangs are designed to flush prey out of cover rather than for direct attack. A successful Throwing Stick roll with a returning boomerang brings the prey toward the hunter. Treat this like a feint (p. B105).

Bolas

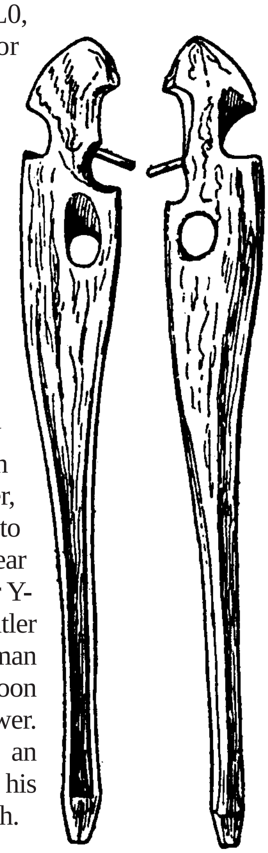
Developed well over 25,000 years ago, the *bolas* consisted of a pair of rounded stones, covered with leather and joined by a thong, that were thrown at the legs or wings of the intended target. The thrower grasps the handle and jerks back the individual strands to straighten them. He then whirls the bolas over his head and releases it. Effects are described on p. B49.

The modern-day Tehuelche tribe of Patagonia employed a single-strand bolas, the *bola perdida*, that was hurled to injure rather than entangle the target. This weapon uses the Sling skill rather than the Bolas skill (see the weapons table, p. 112).

Sling

The first slings were developed in the late Paleolithic or Mesolithic. Examples dating back to about 7000 B.C. have been found among the ruins of Çatal Hüyük. Slings consisted of a simple leather strap that was whirled above the head and used to fling rocks at an enemy. At TL0, slings use small round stones for ammunition.

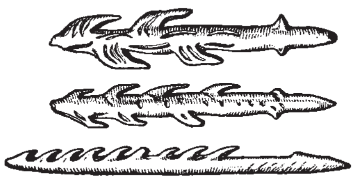
Spears and Harpoons



A prehistoric warrior typically enters a battle or hunt carrying three to four spears in his off hand. He throws all but the last as he closes on a target, then uses the final spear as a thrusting weapon.

A spear thrower can increase the range and power of spears or harpoons. The *woomera*, used by Australian aborigines, is a modern example of a standard spear thrower, while the Aztec *atlatl* was designed to throw smaller darts. The basic spear thrower is a short (9"-12"), straight or Y-shaped length of wood, bone, or antler that acts as an extension of the human forearm. The butt of the spear or harpoon fits into grooves carved into the thrower. As the hunter releases the spear in an overhand throwing motion, he flicks his wrist, giving the weapon an extra push.

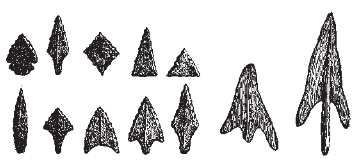
To minimize total load carried, many Australian aborigines used a multipurpose woomera. In addition to throwing spears, it could be used as a digging stick, a fire stick, a handle for a stone chisel blade, and a percussion instrument. This combined woomera weighs 3 lbs. and costs $40; it is otherwise as in the weapons table (p. 112).



Reindeer Horn Harpoons

Harpoons first appeared around 16,000 B.C. in the south of France. They were weapon heads of bone or antler primarily designed for throwing, attached to a wooden haft and also tied to a thin line. They were especially designed for use against aquatic creatures such as fish, seals, or whales. Harpoons make the hunt more efficient, because the animal straining on the line attached to the head cannot easily get free. Most harpoon heads are barbed, in order to cause additional damage if they come free.

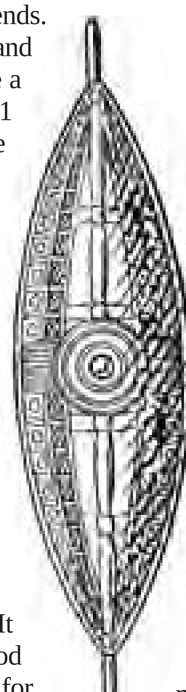
Short Bow



The short or self bow was invented around the end of the Paleolithic (12,000-10,000 B.C.). The idea spread quickly around the Mediterranean and into Africa, Asia, and the New World.

The bow can propel an arrow much farther than a spear delivered by a spear thrower. Moreover, since each bowman can carry 20-30 arrows into a battle, compared to two or three spears, the bow greatly increases the volume of fire that can be directed against an enemy during combat.

TL0 short bows are made from a single piece of wood, typically a length of sapling, which is notched at both ends. If the bowyer must find his own wood, it takes 1/2 day and a roll vs. Naturalist skill to find a tree suitable to make a bow. Once the tree has been cut down, it takes at least 1 month for the wood to dry before it can be used. If the bowyer has a prepared piece of wood, it takes 1 hour and a roll vs. Stone Knapping skill to shape the bow, and another hour to finish it. Some bows have horn nocks. It takes 2 hours to make nocks and attach them. A bowstring of animal gut, flax, or hemp is fitted to the notched ends. Making a bowstring requires no skill roll, but takes 10 minutes.



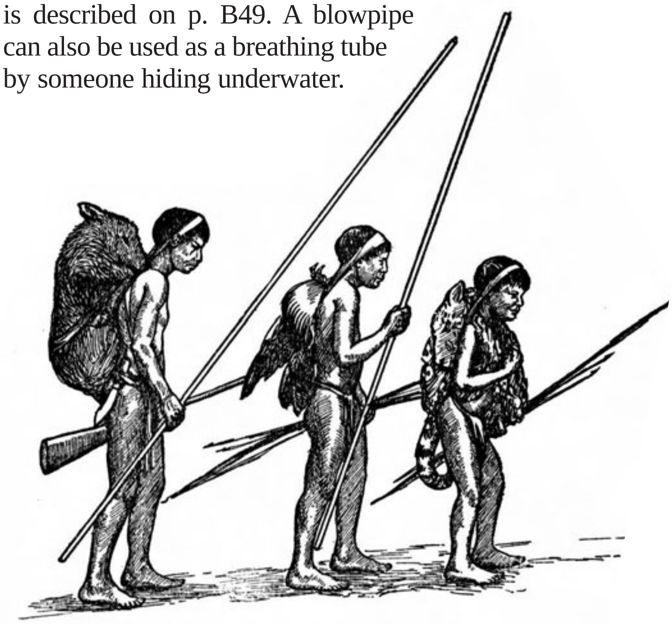
Arrows in this period consist of slender shafts of hardwood or reed. They are sometimes fletched with feathers tied on with thin sinew or glued on with hide glue. Normal arrows also bear pointed heads made of stone (typically flint) or bone. Some cultures employ simple one-piece shafts of bamboo or cane sharpened to a point at one end and notched at the other.

Arrows are typically made in batches of 10-20. It takes 1/2 day and a roll vs. Naturalist skill to find wood of the right sort to make arrows. A successful hunt for birds such as eagles, geese, or turkeys can find feathers to make fletches. Each bird provides feathers for 50 arrows. A stone knapper can make an arrowhead in 10 minutes. Once these materials are gathered, it takes 30 minutes and a roll vs. Stone Knapping skill to make each arrow or bolt. Most of this work involves cutting and shaping the wood for the shaft. Repairing a damaged arrow takes 10 minutes.

Arrows may be carried either in a shoulder quiver (0.5 lbs., $10, holds 12 arrows) or in a hip quiver (1 lb., $15, holds 20 arrows).

Blowpipe

A blowpipe is a hollow tube used to fire small darts. It is a popular weapon for hunting arboreal game (birds, monkeys, etc.) as well as a weapon of war. Its use is described on p. B49. A blowpipe can also be used as a breathing tube by someone hiding underwater.



Shields and Armor

There is no archaeological evidence that prehistoric warriors equipped themselves with any kind of armor or shields. Native American tribes of the North American plains and the Pacific Northwest and the islanders of the South Pacific constructed shields and armor from natural materials – leather, plant fiber, even wood and bark. GMs can introduce such equipment into a prehistoric campaign at their own discretion.

In addition to the standard wood shield, TL0 shields can be made of wicker or of heavy leather stretched over a wooden frame. These shields provide normal passive defense (PD) based upon shield size, but are lighter and less durable.

Clothing made of skins or furs may be heavy enough to provide some protection. The Appendix (p. 116) includes three options: light clothing (loincloth and boots), medium clothing (add tunic and leggings), or heavy clothing (add coat). Light or medium clothing may be combined with a cloak.

Vehicles

In the late Paleolithic, *Homo sapiens sapiens* began to journey longer distances and to move cargoes heavier than his own shoulders could bear. Transportation advances came first in the form of watercraft, then sleds, sledges, and travoises. Examples of such vehicles are listed in the Appendix (pp. 118-120).

Water Vehicles

The first aids to water travel were simple floats: small ones that a swimmer might cling to for added buoyancy, or large ones that he might straddle. In time these gave rise to the first watercraft: rafts and boats. Floats may be solid pieces of a material that is lighter than water, or they may be hollow containers whose buoyancy comes from the air inside them. (See *Equipment*, pp. 30-31, for floats of both types.) Several floats of either type can be fastened together to form a raft; log rafts were common, but some cultures built rafts with bundles of reeds, inflated animal skins (such as the Mesopotamian *kelek*), even clay pots. Most rafts have no hydrodynamic streamlining, but some cultures built "raft boats" with logs or reed bundles fastened together at the front and fanning out toward the rear. True boats are hydrodynamically streamlined with watertight hulls and gain buoyancy from the air space inside the hull.

Construction

Many TL0 watercraft are canoes: long cylinders, often with the ends raised out of the water. Their shape comes from the trees that supply their raw material and cannot be altered much in construction; it makes for good speed but poor stability.

Dugout canoes are made from the actual wood of the tree. A whole or half log is hollowed out with stone, shell, or bone tools or with fire. In some cases the hollowed wood is softened and the sides are forced out, making the boat wider. The commonest softening technique is filling the boat with water heated with hot stones or by tropical sunlight; other methods include simple soaking, hanging the boat over a fire, tarring the interior, or filling the boat with seal oil that was set on fire. Pacific islanders and some other cultures developed the outrigger, a smaller log fastened alongside the canoe for stability; this led to double canoes held apart by wooden beams, sometimes with a light platform supported on the beams. Another method for making larger dugout canoes is sewing two logs together end to end.

Bark canoes are made from the bark of trees. If the tree is somewhat curved the ends may naturally rise out of the water; otherwise they need to be closed off, either with a mixture of grass and clay or by sewing. A very light internal framework is usually added. Such boats were used in Scandinavia, Siberia, the Americas, and Australia. Canadian and Siberian canoes could be 35' long.

Sewing is also used to construct hide boats from animal skins. Like bark canoes, these usually have internal frameworks, and since they are often sewn from multiple hides, the framework determines the actual shape of the boat. They are not limited to long cylinders, like canoes, but can be circular (the coracle of the British Isles or the Mesopotamian *quppu*), elliptical, or "boat-shaped," either broad (the *currach* of the British Isles or the Arctic *umiak*) or narrow (the Arctic kayak). Hide boats are light, and the kayak is extremely maneuverable. Less common variations are the basketry boat, used in Arabia and Southeast Asia, and the pottery boat, used in India. Pottery is too breakable for use in rocky or swift-flowing streams.

Propulsion

Two main forms of propulsion are used in TL0 watercraft: poling and paddling.

Poling requires a stable platform to stand on, such as a raft (9 sf per man), and a pole long enough to reach the bottom. Pole lengths range from 12' to 20'. Since the pole must be at an angle to the vertical to apply horizontal thrust, the maximum depth is actually less, 10' to 17'. Poles can also be used horizontally to fend off obstacles.

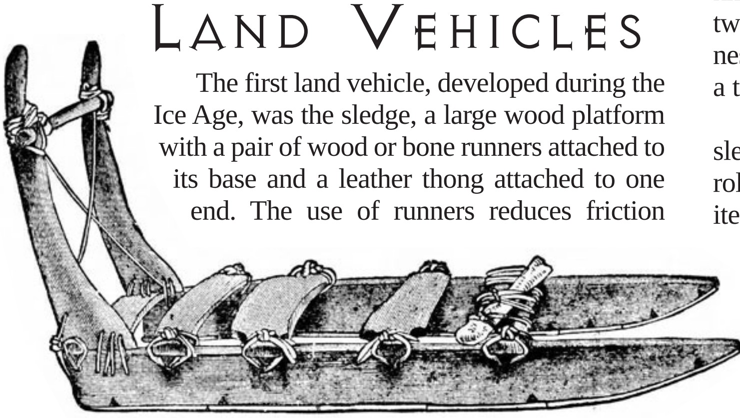
Paddling is used throughout the world. The paddle is usually held in both hands, with the lower hand providing power and the upper hand serving as a fulcrum and keeping the paddle steady. One paddle is used alternately on the left and right sides. Paddlers need to be 3' apart; the total length of a paddled boat is commonly 5' or more per man (that is, paddlers occupy up to 60% of the length).

Human Occupancy

Rafts normally have no seats for their crews, who simply sit or stand on the upper surfaces. Allow one crewman or passenger per 9 sf. The same space can be used for cargo; one passenger can be replaced with 200 lbs. of cargo.

Boats are much more stable if their center of gravity is lower; their crews spend most of their time sitting down or crouching. Very light frames may provide backrests, and brush in the bottom of the boat may help the crew stay dry. The kayak used by the Aleut and Inuit had hide covering the top of the craft, with a small hole for the boatman's legs; this kept water out if it capsized, letting it be turned upright again with a Boating roll.

Land Vehicles



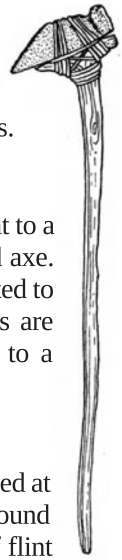
The first land vehicle, developed during the Ice Age, was the sledge, a large wood platform with a pair of wood or bone runners attached to its base and a leather thong attached to one end. The use of runners reduces friction between the load and the ground; divide weight by 4 on snow and ice. A lighter vehicle, the sled, can be drawn by a team of dogs.

North American Plains Indian tribes employed a device known as a *travois*, a platform of logs or netting supported by two long trailing poles, the forward ends of which can be harnessed either to a man or to a dog. Divide weight by 3 when a travois is used.

During the Neolithic period, a modified version of the sledge was developed, as lengths of tree trunk were used as rollers to propel a cargo platform across level ground, not limited to snow and ice. The haulers must periodically stop and move the rollers in front of the load, or extra men must be available to do so continuously. A few cultures laid rollers along the entire length of a frequently used roadway. Divide the effective weight of a load supported on rollers by 5.

Tools and Equipment

Craft Tools



The items in this category are used to make other objects by shaping available natural materials.

Adze

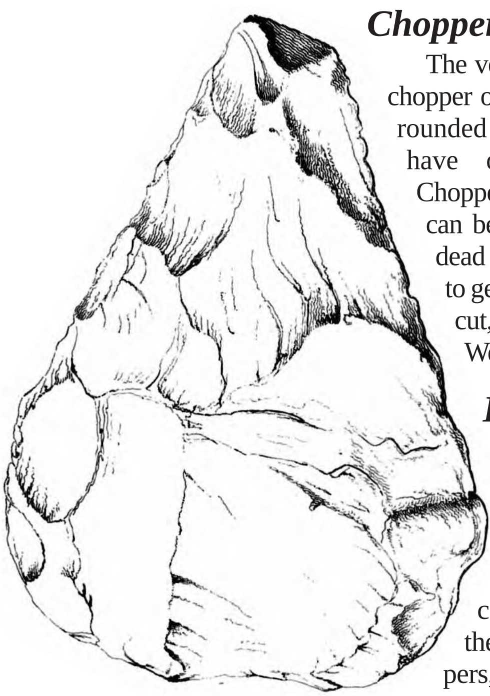
Any stone tool whose cutting edge was brought to a sharp point, in contrast to the wider face of a hand axe. From the late Paleolithic period on, adzes were hafted to some kind of wood or bone handle. Hafted adzes are used to trim timber and to plane wood surfaces to a smooth finish. Weight: 4 lbs. Cost: $50.

Bow Drill

A bow-shaped piece of ivory, wood, or antler tied at each end by a thong. The thong is then wrapped around a wooden spindle tipped with a sharpened point of flint or metal. The point of the spindle is set in a socket and held in the teeth. Moving the bow back and forth in a sawing motion rotates the spindle. This tool is used to drill holes in ivory or timber. Weight: 1 lb. Cost: $45.

Burin

First created in the Upper Paleolithic period, these tools were especially designed for working bone, antler, and ivory. Burins were the first tools designed not for direct use but to make other implements. They have a sharp-pointed end for engraving and a blunt scraping edge used as a chisel. Burins are used to produce specialized tools and finely detailed harpoons and to carve and engrave jewelry. Weight: negligible. Cost: $40.



Chopper

The very earliest tool, the chopper or pebble tool was a rounded rock chipped to have one sharp edge. Choppers are up to fist-sized. They can be used to skin and cut up a dead animal and break its bones to get at the marrow and to crush, cut, or scrape other materials. Weight: 1 lb. Cost: $10.

Hand Axe

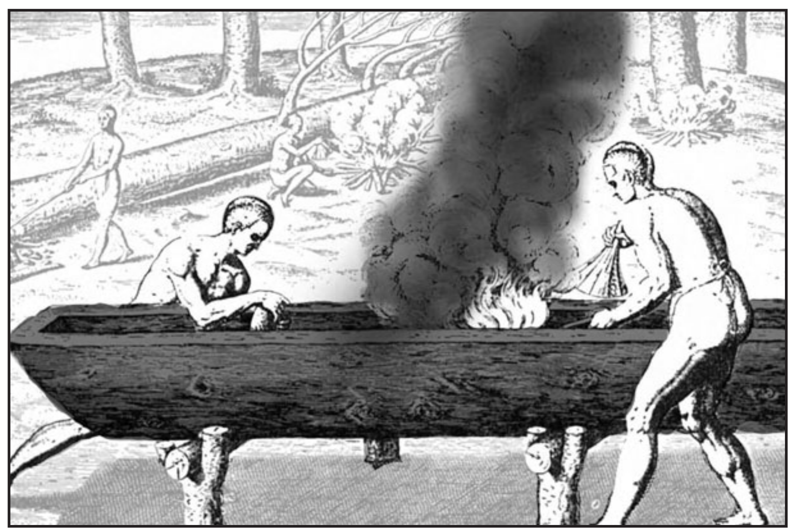
The hand axe was a large stone with a sharp edge around most of its circumference, with one side left dull so that it could be held. It performs the same functions as choppers, but more efficiently, having longer and better edges, and also has enough length to serve as an improvised weapon, using Brawling skill. Weight: 2.5 lbs. Cost: $40.

Needle

Invented about 16,000 B.C., needles were made from splinters of bone 1 1/2" to 3" in length. A burin was used to drill the eye of the needle, and the tip was rounded to a circular point. Needles enable man to stitch skins and furs together using sinew as thread, tightly enough to make the finished product insulated and watertight. They are used to make cold weather clothing, tents, floats, and waterskins. Weight: negligible. Cost: $100.

Saw

The saw was invented in Egypt around 4000 B.C. The first saws consisted of 12"-18" copper blades with wooden handles. Based on pictorial evidence, these saws were pulled through timber to make a cut, rather than pushed as saws are today. Weight: 3 lbs. Cost: $150.



Scraper

This class of tool dates back more than a million years. Flint scrapers often contained straight, convex, and concave edges on the same tool. From the late Paleolithic on, scrapers were equipped with handles of wood. Scrapers are used to dress animal skins by removing the flesh and softening the hide through repeated working. A practiced worker can prepare one square yard of skin per hour. Weight: 1 lb. Cost: $50.

Spindle

The spindle is a short length of wood used to aid the spinning of fiber into thread (see p. 19). Weight: 1 lb. Cost: $5. The fiber is sometimes paid out from a distaff, held in the other hand. Weight: 2 lbs. Cost: $5.

Survival Gear

The items in this category are used for protection from the weather or natural hazards, or to obtain food.

Cold Weather Gear

Inhabitants of arctic climates (see pp. CII133-135) will carry a number of items of standard equipment, designed to be lightweight and functional:

Show shovels, made of wood or antler and hide, are used to dig in snow at 0.075 × ST cy/hr. Digging without a snow shovel is at half speed. A Survival roll (-2 without a shovel) allows digging a snow cave for protection against sunburn and wind chill; the required volume is 1 cy per occupant for a temporary shelter, 4 cy per occupant for a long-term one. Weight: 1-2 lbs. Cost: $15.

Snow knives, made of bone or wood, are used to cut blocks of compacted snow (0.075 × ST cy/hr). These can be used to build shelters with a roll against Survival-2 or Masonry, taking 2d man-hours per person accommodated. Internal temperatures can reach 40°F. A snow knife is too flimsy for use as a weapon. Weight: 1 lb. Cost: $10.

Snow goggles are made of wood with narrow eye-slits; they provide protection against snow blindness. Vision is at -3 while they are worn. Weight: 1 lb. Cost: $15.

A parka is a garment made of two layers of sealskin or caribou hide; the inner layer is made of inward-facing fur to trap heat. Such garments give +5 to HT or Survival rolls to withstand exposure. Weight: 10 lbs. Cost: $100. The waterproof outer layer made of bird skin or from sea mammal intestine gives the same bonus when the wearer is immersed in water. Weight: 1 lb. Cost: $50.

Mukluks are boots made of moose or caribou hide and lines with moss. They protect the feet against frostbite. They are very quiet and give +2 to Stealth for walking on snow. Weight: 2 lbs. Cost: $50.

Moving through snow is extremely tiring; treat each 1” of snow as 5 lbs. of encumbrance. Snowshoes increase the effective area of the feet, letting the wearer walk on top of the snow at -2 Move (minimum 1). For long-distance travel, reduce speed to 60%. Weight: 4 lbs. Cost: $10.

Digging Stick

The digging stick was a fire-hardened piece of sharpened wood, used to dig up roots or to turn earth and prepare it to receive seeds. Digging sticks were used in Mesopotamia, Egypt, and Mesoamerica, and may have also been employed in the Indus Valley. A digging stick can turn over 0.06 × ST cy/hr in sand or loose soil, or 0.03 × ST cy/hr in ordinary soil. Weight: 1-3 lbs. Cost: $10.

Firemaking Equipment

As described on p. 15, the two common methods of firemaking in this period were flint sparking and the bow and palette. A flint sparking kit consists of two striking stones (one flint, one iron pyrite) and a small quantity of tinder; it weighs 1 lb. and costs $6. A bow and palette consists of a slender wooden stick and a flat wooden palette that is engraved with circular indentations or grooves; it weighs 1 lb. and costs $36. A fur or hide carrying case is often used to protect fire kits during foul weather.

Fishhook

Invented around 12,000-10,000 B.C., these sharpened hooks of bone or shell were attached to a line of gut and a wooden pole. A roll is made each day a fishhook is used; on a 17 or 18, the hook is broken or lost. Weight: Negligible. Cost: $50.

Floats

Floats of a variety of types are available at TL0. In the water, floats provide buoyancy that subtracts from encumbrance until (encumbrance - buoyancy) = 0. Buoyancy beyond that needed to cancel encumbrance gives a bonus of +8 × (excess buoyancy/swimmer’s weight), to a maximum of +8.

The buoyancy, the weight when carried on land, and the cost are as follows, for floats of size 1 cf (for larger floats, multiply by volume in cf):

Inflated skin: buoyancy 60 lbs.; weight 2.5 lbs.; cost $12.50.

Clay pot: buoyancy 55 lbs.; weight 7.5 lbs.; cost $2.

Wood block: buoyancy 32.5 lbs.; weight 30 lbs.; cost $8.

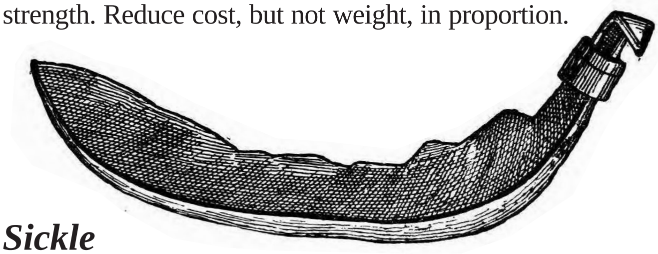
Reed bundle: buoyancy 47.5 lbs.; weight 15 lbs.; cost $2.

A log can also be used as a source of buoyancy, though it limits the user's ability to swim. A log 12" in diameter provides 25 lbs. of buoyancy per foot of length, and weighs 25 lbs. per foot.

Rope

A handmade rope 1" thick can support 1,800 lbs. safely; a 10-yard length of such rope weighs 9 lbs. and costs $15. For thinner or thicker ropes, multiply weight, cost, and strength by the square of the diameter in inches; for example, a 3/8" rope weighs 1.26 lbs. and costs $2.10 per 10-yard length, and can support 253 lbs. The thickest rope a man can grasp and pull is 2.5".

This assumes a rope made of tough fiber such as coconut husk or papyrus. Rope made from ivy or other vines has about half the strength; rope made from green grass has 1/5 the strength. Reduce cost, but not weight, in proportion.



Sickle

Sickles were first used to harvest grain during the Mesolithic Age, when they were most often made of sharpened stone set into wooden handles. Weight: 5 lbs.; Cost: $20.

Sleeping Fur

Used to keep warm during the night, a sleeping fur typically weighs 8 lbs. and costs $50.

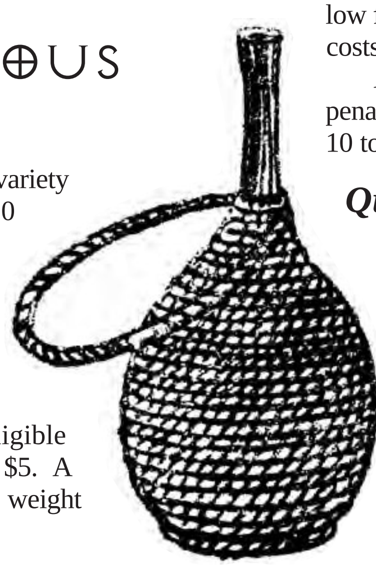
Miscellaneous

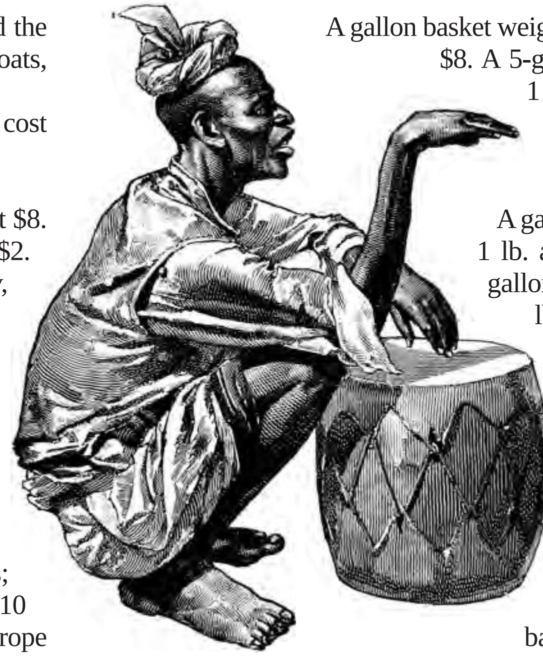
Containers

Containers made from a wide variety of materials are available in TL0 societies. Here are a handful of examples:

A small leather pouch suitable for carrying flint and iron pyrites has negligible weight and costs $10.

A quart waterskin has negligible weight (when empty) and costs $5. A 1-gallon waterskin has negligible weight and costs $10.





A gallon basket weighs 0.5 lbs. and costs $8. A 5-gallon basket weighs 1 lb. and costs $25. A woven backpack weighs 2 lbs. and costs $50.

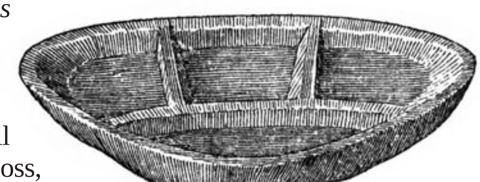
A gallon clay pot weighs 1 lb. and costs $10. A 5-gallon clay pot weighs 2 lbs. and costs $50.

Drum

Apart from its musical uses, a drum can serve as a signaling device, in the "jungle telegraph" or on the battlefield. The beat of a sizable drum can be heard for several miles if there is little background noise (roll vs. Hearing at -1 per mile). Weight: 2 lbs. Cost: $40.

Light Sources

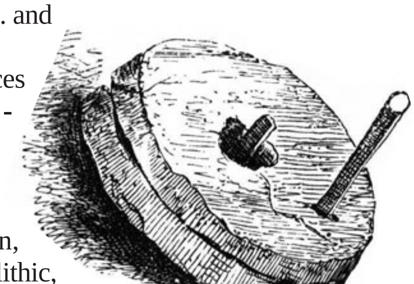
Man used torches to light his way long before he knew how to create fire. A torch burns out after 1 hour. Weight: 1 lb. Cost: $3.



Lamp

Homo sapiens sapiens starts to make lamps, which consist of an open dish of tallow or oil with a strand of moss, rush, or twisted grass for a wick. Lamps burn 3 hours before they must be refilled. Anyone carrying a lamp while moving faster than Move 2 (a brisk walk) must make a DX+4 roll every turn, at -2 per point of Move above 2. On a failure, the lamp blows out at the end of the turn. An empty lamp weighs 0.5 lb. and costs $10; a replacement wick costs $1. Oil or tallow for 4 refills weighs 1 lb. and costs $2.

A torch or lamp reduces penalties for darkness from -10 to -3.

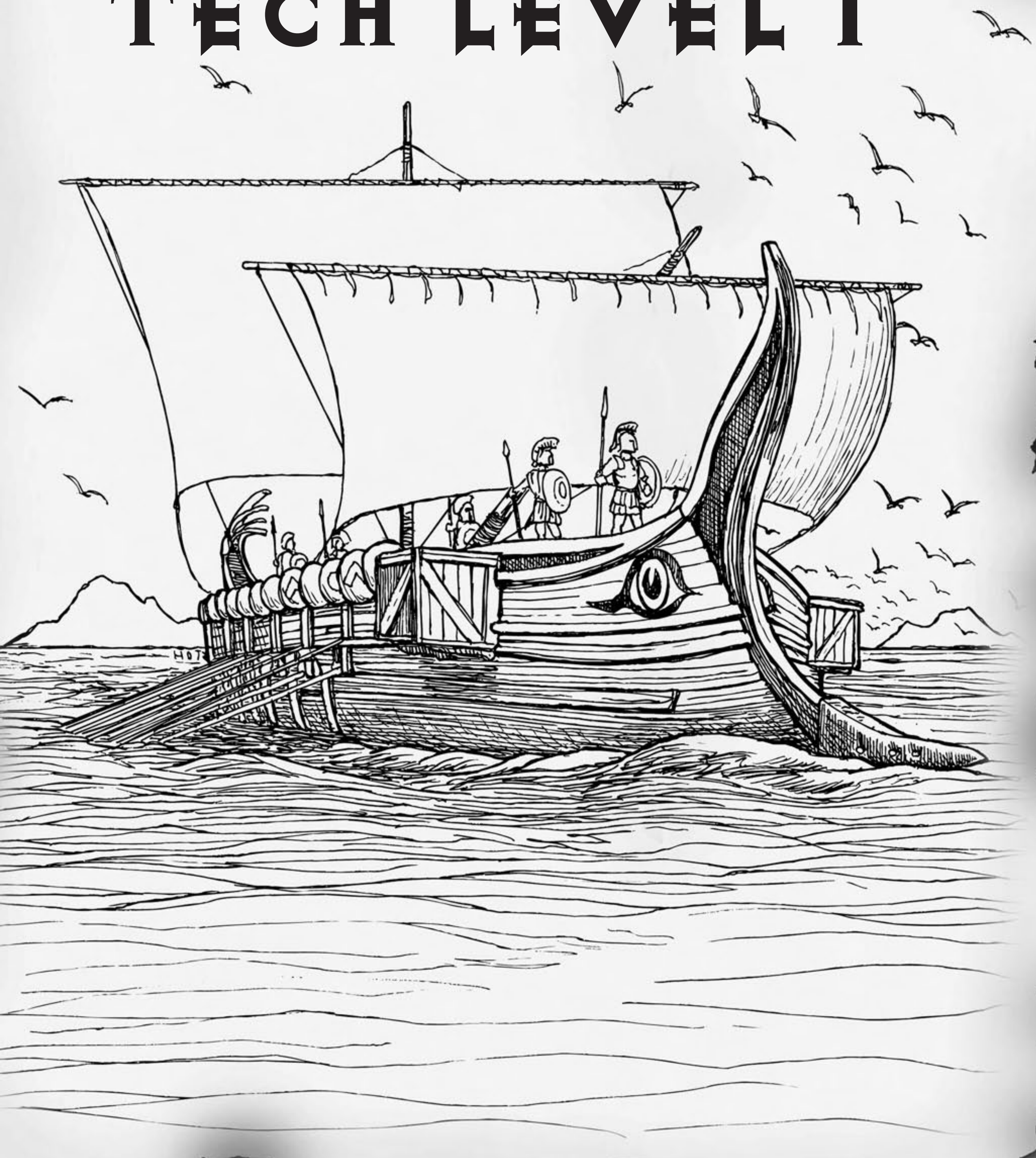


Quern

The saddle quern, developed in the Neolithic, is a pair of stones: a wide, flat stone on which grain is spread and a rounded stone that is rubbed over it to grind the grain. A one-man quern produces 0.5 × ST lbs. of flour per hour; weight 20 lbs., cost $20. A larger two-man quern produces 0.75 × combined ST lbs. of flour per hour; weight 40 lbs., cost $50.

CHAPTER III

THE BRONZE AGE:
TECH LEVEL I



And as men migrated from the east, they found a plain in the land of Shinar and settled there. And they said to one another, "Come, let us make bricks, and burn them thoroughly." And they had bricks for stone, and bitumen for mortar. Then they said, "Come, let us build ourselves a city, and a tower with its top in the heavens . . ."
– Genesis 11:2-4

The Bronze Age is the technological period when metals were first regularly used in tools and weapons. Metal items were generally stronger, more durable versions of their stone predecessors. Other materials were used on a larger scale than before, going from boats to ships and from houses to fortresses. The harnessing of draft animals made a new source of power available; plows and wheeled vehicles became possible.

Yet these technological developments themselves were hardly the only changes taking place among humanity. As man's capabilities increased, so did the complexity of society. Bronze Age man built cities with centralized governments, cultures, and works of art and architecture that still inspire people today. He traded with other cultures to acquire raw materials, or colonized or conquered other territories to secure their future availability. He developed pictographic and written symbols to establish proof of ownership and to record historical events.

In the Eastern and Western Mediterranean, the Levant, Iran and India, Northern and Central Europe, and parts of northern Africa, these changes took place between 4000 and 800 B.C. However, the development of metalworking technology by different civilizations was far from uniform. The Bronze Age in China, for example, did not begin until 1500 B.C. and lasted almost half a millennium after the beginning of the Iron Age in the Indo-European region. Other civilizations such as the Incas and Aztec did not discover bronze until after 1000 A.D., although they developed most other TL1 technology centuries earlier.

This chapter describes the technologies and equipment found in Bronze Age societies, regardless of the time period in which they were developed. While some of these technologies may have been limited to a specific culture, they still provide examples of how far a Bronze Age civilization can progress. Other early civilized societies are considered to be TL1 if they had large-scale agriculture, cities, and writing.

Man and His Environment

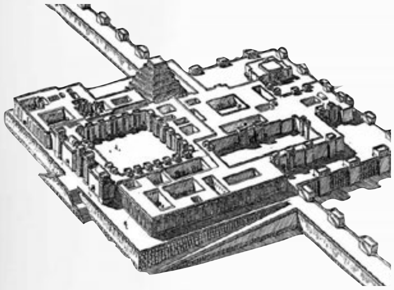
Farming

The Bronze Age marked a shift from small-scale horticulture and shifting cultivation to large-scale agriculture. Two new technologies contributed to this change: the plow and large-scale irrigation.

Life in the Bronze Age

In the Old World, the use of bronze began during the urban revolution. Even in cultures that did not develop bronze or iron, such as the ancient Maya, the first cities achieved other major new technologies, such as writing and irrigation. Urbanization was one of the greatest changes in human life; the very word "civilization" etymologically means the creation of cities.

In this era, and long afterward, the most basic feature of a city was its defenses. Cities were surrounded by walls and moats, to keep out both bandits and other cities' armies. Inside these defenses were marketplaces where local people and foreigners come to trade, palaces for rulers and barracks for their soldiers, and temples to the city's gods. The larger volume of trade let some craftsmen specialize in particular products and other craftsmen produce luxuries for the wealthy, from perfumes and jewelry to weapons. To help keep track of all these transactions, city residents developed aids to memory that eventually became writing, and cities also became repositories of written records.



Most people lived outside the cities; this remained true until late TL5. But even peasant farmers' lives were changed by the presence of cities. They might go there as drafted labor or soldiers or to exchange their crops for other goods. Even if they stayed at home, they paid taxes to the city's ruler, they obeyed his laws, and they might die in his wars.

The resulting new social order gave rise to differences in individual status – the development of class structures that have lasted to the present day. Evidence of these changes has been found as early as 2750 B.C. in both Egypt and Mesopotamia. In both areas merchants and nobles built two-story stone houses with small courtyards, located in or near the center of the community, while common laborers lived in cramped single-story wood houses near the walls.

TL1 without Cities?

These rules treat early civilizations as the typical examples of TL1 societies. But metalworking has also been practiced by many nomadic peoples, from the early Indo-Europeans to 20th-century Afghanis. Are they TL0 and advanced in metallurgy?

For nomadic hunters, this is a reasonable treatment. But animal herding did not develop out of hunting; current evidence suggests that it was an outgrowth of farming and the Bronze Age "secondary products revolution." Thus, herding societies are considered to be an alternative path of historical and technological evolution. Foot nomads such as the Masai are TL1; horse nomads such as the Bedouin or the Mongols are TL2 or TL3. They may be advanced or retarded in metallurgy relative to the TL for their overall way of life.

The Pazyryk Ice Maiden

In 1993, archaeologist Natalya Polosmak discovered a burial site in the high Ukok Plateau in the Altay region of Russia, near the borders of China and Kazakhstan. Altay was home to a semi-nomadic Bronze Age culture known as the Pazyryk from 800 to 100 B.C. The grave had been permeated by water and remained as permafrost until excavated. It contained a young woman, dubbed "Ledi" ("the lady" in Russian), and several artifacts indicating her status as a spiritual leader, healer, and storyteller to her people.

Ledi was probably raised from a young age as the tribe's shaman, possibly a hereditary position. Other Pazyryk graves contain women buried with weapons, indicating training in arms, but Ledi's lack of weapons indicates she was no warrior. The tattoos on her arm have mystical significance. She was buried alone, and with great reverence and wealth, showing she was unmarried and important to her tribe. She would have used herbs to heal injured tribe members, performed rituals such as sacrifices and tattooing, and been the tribe's repository of oral history and legend. Perhaps significantly, Ledi's grave contained no smoking implements or traces of marijuana, both commonly found in other Pazyryk graves, so her shamanic role may have precluded using the drug. Like all members of her culture she was a skilled horse rider. Her cause of death is a mystery – likely illness. She was buried with several sacrificed horses and cuts of fresh horsemeat and mutton for her journey to the afterlife.

Continued on next page . . .

The plow applies animal traction to cultivation. In this period plows were generally made of wood, since bronze cost too much to be turned to such uses. Typically they were drawn by a pair of oxen and guided by a plowman. Early plows did no more than cut a groove through the soil, into which seeds could be cast. Fields are often plowed a second time before planting, at right angles to the first plowing. Plowing increased the acreage that one man could cultivate by a factor of four, allowing the farming of poorer soils with lower yields per acre; as a result, much larger areas were brought under cultivation.

Irrigation supplies water to crops to supplement rainfall. Individual farmers practiced irrigation on a small scale, but eventually entire civilizations built large systems of canals and aqueducts to distribute water to their farms. The early civilizations of China, India, and Mesopotamia all had such systems. Egypt relied mainly on the waters of the Nile, which flooded every year; they built small-scale irrigation works to distribute the flood waters. Mexican agriculture used waterworks for the opposite purpose, constructing raised gardens and canals to drain off excess water.

Nearly all the peasant cultures had monotonous diets based on one or two major food plants: maize or potatoes in the New World, rice in East and South Asia, and wheat over most of Eurasia and in Egypt. From 50% to 80% of a peasant's diet came from one crop, normally a starchy food of some kind. Crop yields per acre were about 400 lbs. for Egyptian wheat, 300 lbs. for northern Chinese wheat, 600 lbs. for southern Chinese rice, and 1,200 lbs. for Mexican maize and Peruvian potatoes; population densities can be estimated by assuming 2 lbs. per person per day (730 lbs. per year). Thus, a southern Chinese family of 5, needing 3,650 lbs. of rice per year, would need 6 acres of fields to support it. (This calculation is simplified by assuming that the entire diet is rice; the results will be reasonably close to the actual sustainable population.)

The main staple crops (maize, rice, wheat, and potatoes) all have roughly comparable water requirements, in the range of 9,000 cf/acre or about 2.5" of water. It takes about 5" of rainfall during the growing season to supply this. Each 10% shortage of water reduces crop yields 25%.

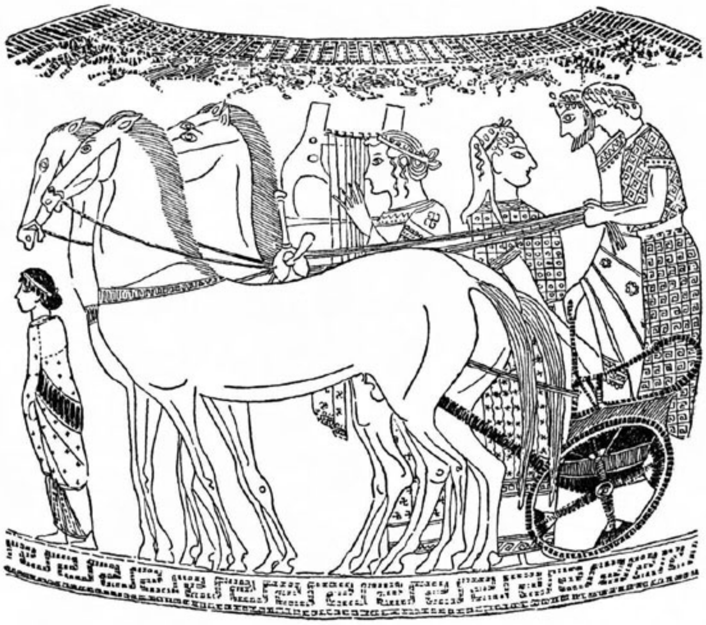
Several tree and vine crops were first domesticated during the Bronze Age, including dates, figs, grapes, and olives. Their fruit added variety to the diet and also was a valuable trade cargo.

Domestication of Animals

The Bronze Age saw a major change in the use of domesticated animals – the "secondary products revolution." Animals were no longer kept only for meat, but also for milk, fiber, and labor. Farmers developed new breeds better adapted to these functions.

Milk was initially added to the human diet in the form of cheese, yogurt, kumiss, and other processed foods. The ability to digest whole milk evolved later, mainly in Northern Europe and Central Asia; even in the 21st century, much of the world's population is lactose intolerant. Sheep and goats preceded cattle, horses, and camels as dairy animals. The ability to continuously obtain food by milking, rather than intermittently by slaughter, made animal husbandry more productive.

Sheep with thick coats of wool emerged in the Chalcolithic and became widespread in the Bronze Age. In many areas, wool largely replaced linen and became a major agricultural product. Sheep's wool can not only be spun and woven but also made directly into felt by pressing the fibers together under moist heat. Felt is useful for tents, blankets, and padding.



Finally, animals were used for traction, pulling sledges, plows, carts, and eventually war chariots (see p. 51). Draft animals included oxen, llamas in Peru, donkeys in Egypt, camels in Russia and Saudi Arabia, horses on the steppes of the Ukraine, and reindeer in the Arctic. Some of these animals were also ridden or used to carry packs. Horses became the favored draft animal on the battlefield. In this period, they remained relatively small, roughly equivalent to ponies as described on p. B144.

As a result of this increased productivity, herds became larger and included more mature females. Full-time herdsmen emerged, traveling on foot in this period. In most regions they were accompanied by dogs; new breeds of herding dogs were developed. A herdsman on foot can tend a few hundred beasts.

The simplest form of herding was based on a farming community and stayed close to it. In the late Bronze Age another form emerged, known as transhumance, in which herds were moved each summer from lowland farm communities to upland pastures. To create such pastures, woodland areas were cleared. Finally, true nomadic herdsmen emerged, with no fixed attachment to any village, though they usually still traded with farmers for some of their food.

Forestry

Bronze Age tools permitted a new style of woodcutting; they stood up under heavy blows from the shoulder that would ruin the edge or break the blade on the best stone tool. As a result, bronze tools allowed increased work output. A forester with a bronze axe could cut down a 1' oak in 20 minutes, rather than 30.

The bronze axe was also easier to maintain, needing only periodic sharpening. This was usually done by hand, with a whetstone. The invention of the wheel led to the invention of the grindstone, but this was too massive for small work teams to carry around in a forest.

Woodcutters provided Bronze Age societies with wood for fuel and building material, and left behind cleared land for cultivation and pasturage. Foresters harvested trees at rates far above the level of sustainable yield.

The Pazyryk Ice Maiden (Continued)

Ledi wore a blouse of yellow silk and a woolen skirt, dyed in horizontal stripes of white and maroon, over felt stockings. Her feet were covered with thigh-high leather riding boots. She had a 3' tall ceremonial headdress of felt, adorned with small wooden carvings of cats, covered in gold leaf. She also possessed two small wooden tables, with detachable legs for easy transportation; a vase-like vessel of carved yak horn; a bronze knife; a polished bronze mirror backed with wood, contained in a red leather pouch; a wooden vessel topped with two carved cats, for making and storing yogurt; a carved wooden stirring stick; a stone bowl for grinding seeds and herbs; and a wooden cup for storing black hair dye. She owned at least one riding horse, with riding tack and decorated felt saddle blankets.

Ledi — 65 points

Age 25; 5'6"; 130 lbs.; a young woman, richly dressed in silken and woolen clothing. Tattooed with stylized animals on the left shoulder and wrist.

ST 10 [0]; **DX** 11 [10]; **IQ** 12 [20]; **HT** 10 [0].

Speed 5.25; Move 5.

Dodge 5.

Advantages: Clerical Investment [5]; Status 1 [5]; Voice [10].

Disadvantages: Disciplines of Faith (Pazyryk Shamanistic Taboos) [-10]; Sense of Duty (Whole Tribe) [-10].

Skills: Animal Handling-11 [2]; Area Knowledge (Altay)-12 [1]; Artist-10 [1]; Bard-14 [2]; Bardic Lore-12 [4]; Beverage-Making-11 [1/2]; Cooking-11 [1/2]; Cyphering-11 [1/2]; Dyeing-11 [1]; Herbalist-12 [4]; Needlecraft-9 [1/2]; Performance/Ritual (Pazyryk)-13 [4]; Riding (Horse, Stirrupless)-13 [8]; Sacrifice-10 [1]; Tattooing-11 [1]; Theology (Pazyryk Beliefs)-10/16 [2]; Weather Sense-12 [2].

Languages: Pazyryk (Native)-12 [0].

References: "Siberian Mummy Unearthed," *National Geographic*, October 1994. PBS Television, *NOVA* Episode No. 2517: "Ice Mummies: Siberian Ice Maiden."

Mining and Smelting

Finding a workable vein of ore was a long and difficult process. Once a producing mine was established, skilled craftsmen set up shop nearby. Mining settlements seldom produced their own food, as metal deposits were often found in hilly or rugged terrain. Nonetheless, miners generally had little trouble trading for food.

Most early mines were primarily of the shaft and tunnel variety, in which softer earth was dug out to provide access to veins of harder ores. The resulting mine configuration often consisted of a series of long, narrow tunnels, up to 60' in length, that were prone to collapse.

The use of metal tools for mining substantially improved the rate of work (see p. B90). Rock can be broken up with a pick at 0.075 × ST cy/hr (double speed for clay; quadruple speed for soil). The resulting loose rock can be shoveled at 0.075 × ST cy/hr (double speed for clay or soil). Fatigue is 1 per hour for shoveling loose material, 2 for breaking up soil, 3 for breaking up clay, 4 for breaking up rock.

Smelting is the extraction of metal from ore by heating. Once the technique was invented – perhaps as early as 5000 B.C. with copper – several improvements made the end product more desirable. The first step was washing and roasting the ore and breaking it into chunks. Once the ore was prepared, it was introduced into an oven. Early smelting ovens were no more than clay-lined depressions with some sort of dome and a hole to expel gases; this led to the invention of the chimney, which made the oven draw more evenly. The ore was introduced through a charging hole at the base and withdrawn from the side as a "bloom," a pool or ball of soft metal that could then be pounded into shape. Smelting copper or bronze requires the skill of Metallurgy. A furnace must be charged with 18 lbs. of charcoal and 16 lbs. of average ore for each 1 lb. of metal it is to produce.

Metals are associated with each other in predictable patterns based on chemical affinities. Lithophiles such as aluminum, magnesium, and calcium react mainly with oxygen, forming oxidized forms or "earths"; since oxygen is so abundant, they are never found as native metals and are unknown until after TL3 ends. Chalcophiles such as lead, mercury, silver, and zinc react mainly with sulfur, which is rarer, and thus are found as native metals, often together. Iron is both a lithophile and a chalcophile and is found in native form only in meteorites, but its ores are extremely common. Siderophiles, such as copper, gold, and nickel, go into solution in iron, but are sometimes found as native metals.

The Cost of Living

How much should things cost in early historical societies? This question can be as complex as the GM wants to make it; economic historians have been researching this subject for over a century and still have many unanswered questions. But here is a simple answer, suitable for a campaign that does not emphasize economics.

A struggling job earns in the neighborhood of $100 a month. In most societies, peasant farmers are usually struggling. Three-fourths of a typical peasant's output, or $75 a month, goes to food for his family. Assume that this is all grain – at least half will be. Then a family of five will consume about 300 lbs. a month of grain, so grain will cost about $0.25 per pound.

At the other end of the scale, silver costs perhaps $1,000 a pound, or 4,000 times as much as grain (see p. B190). The peasant and his family have an annual income equal to 1.2 lbs. of silver. But in most rural communities, money is scarce, and the average farmer may see only one or two silver coins a month.

Irrigation Technology

Manpower dug the irrigation canals in TL1 regions, and muscle power delivered water from these canals onto the fields themselves. The simplest system for raising water used a bucket, held in the hand or suspended from a rope. A more efficient device, the Egyptian *shaduf*, consisted of a long pole pivoted on top of a vertical post, with a rope and bucket at one end and a counterweight at the other. The bucket was lowered into the water by hand; when it was full, the counterweight swung it up to ground level and its contents were deposited onto the cultivated field. Performance statistics for these devices are as follows:

Device	*Volume*	*Height*
Bucket	0.15 × ST	2'
Bucket on Rope	0.25 × ST	3'
Shaduf	0.15 × ST	7.5'

Volume is in cubic feet per minute. An output of 1 cf/minute will irrigate 1 acre over 150 hours, or make up for a 10% shortage of water in 15 hours.

Technologies

Bronze Age societies supported specialized craftsmen in much larger numbers. Their accumulated technical knowledge became greater than any one man could remember. Typically this knowledge was passed on through apprenticeships. The variety of tools and artifacts also increased.

Architecture and Fortifications

Bronze Age construction made use of Neolithic materials, including thatch, wood, mud brick, and unmortared rubble, but on a larger scale than before. In addition, two new materials came into use: *ashlar*, or squared-off stone blocks, and fired bricks. These were used not only for houses but for city walls and other fortifications, for palaces and temples, and for public works such as roads and canals. Such large-scale construction, occasionally undertaken for ritual purposes at TL0, became part of everyday life at TL1.

Stone was the material most widely used in this era. In the relatively cold climates of China and Northern Europe, wood was more often used, both because it was readily available and because it insulated better against heat loss. Mesopotamian civilizations continued to use mud brick, since both wood and stone were expensive imported materials for them; bricks were mixed with straw and dried for several years. Fuel was scarce, preventing them from using fired brick.

In stone and brick structures, the lower structural elements of a wall typically support the elements directly above them, taking advantage of the high compressive strength of such materials. Wooden buildings often have framed designs, in which the weight is mainly supported by posts at corners and at intervals along the walls. Lighter wood or wattle and daub (woven grasses or reeds, covered with mud) may be used in between. Some stone buildings imitate this design with stone pillars. Wood beams or stone lintels run along the tops of the supports and hold up the roof. Posts or pillars can be no more than 30' apart in a wooden building or 8' apart in a stone building. Roofs might be flat or peaked, but the true arch was not yet known. The height of structures was limited to 100' by their tendency to collapse sideways.

Nearly all Bronze Age civilizations fortified their cities – the main exception was Minoan Crete, which relied on its navy for protection and eventually fell to Greek invaders with their own fleet. A city's walls meant security against bandits and armies. The basic principles of fortification were already well understood by the middle of TL1. Walls kept out attackers and gave defenders a superior position from which to stand off a determined assault (see p. B117, *Firing Upward and Downward*). If possible, walls were built taller than 30', the greatest practical height for a ladder, and thick enough to support their own weight and withstand an attack. Towers thrusting out through or over the walls created lines of fire along the length of the walls and provided lookout positions. (Visibility in miles is approximately the square root of height in feet, so a 100' tower on level ground has up to a 10-mile horizon.) Massively fortified gatehouses controlled the few entrances to a city. After the combination of body armor and a shield became common, architects developed gates that forced an intruder to turn left as he entered, presenting his unshielded right side to the interior.

Animal Traction

The ability of draft animals to pull loads depends on two factors: their ST and the form of harness they are using. Efficiency factors are 0.075 for a rope harness or 0.1 for a yoke-and-pole harness. To find maximum weight, sum the ST of the team and multiply by harness efficiency to find effective ST. Modify the weight of the team's load to reflect dragging or pulling on wheels (see pp. 51 and B89) to determine effective weight. Compare effective weight to effective ST on the chart on p. B145 to calculate encumbrance level. For short sprints, the team's Move is the Move of the slowest beast modified downward for encumbrance. For long hauls, assume a daily march at the team's encumbrance level; see p. B187. The distances on p. B187 are for a 10-hour march; if less time is spent on the road, then adjust the given distances proportionally.

For example, two yoked oxen (ST 80) have effective ST 16. A two-wheeled oxcart with a total weight of 2,000 lbs. has an effective weight of 200 lbs., or 12.5 × ST. This is heavy encumbrance, allowing Move 2 or 20 miles travel per day. In practice, oxen are limited to half a day of work, or 10 miles.

Elephants

Elephants were first tamed in the Indus Valley around 4000 B.C.; their use spread to other parts of Asia and later to Africa. The basic abilities of elephants are briefly summarized on p. B142.

Training an elephant starts when it is a baby, and its handler, or "mahout," may be as young as 11 when he begins the assignment. Training consists of both the handler and elephant being taught specific commands by an older, more experienced handler. The elephant learns to listen to its handler, while the handler develops the skills for dealing with (and caring for) his elephant. Training an elephant as a worker or riding mount takes about six months; training it as a war mount takes an additional 12 to 18 months. After training is complete, an elephant will obey its handler, but will accept other riders only when its handler is present.

Elephants are taught to associate a specific command with a specific action. It is not easy to change a set of commands once an elephant has learned them. A typical elephant can memorize 20-25 simple commands; GMs may want to have handlers create a list of known commands to regulate what an elephant can and cannot be made to do.

Brewing

One of the new technologies of the Bronze Age was brewing, or the creation of alcoholic beverages. A wide variety of substances were fermented: dates or grapes, to make wine; barley, to make beer; honey, to make mead; and even milk, to make kumiss. Archaeological relics include drinking vessels made of pottery or metal. Analysis of trace chemicals in the pores of such vessels reveals that they often held deliberate mixtures of different brews, such as mead with beer or wine. Alcohol supplemented or replaced older psychochemicals, such as opium and marijuana, and elaborate rituals grew up concerning its use.

Furnace Heat

Smelting ores and casting metals require intense heat. A rough measure of how difficult it is to work with a metal is its melting point. The metals known to the Bronze and Iron Ages have the following melting points, in °F:

Tin	449
Lead	621
Brass, Bronze	1,650
Silver	1,761
Gold	1,945
Copper	1,981
Steel	2,552
Iron	2,795

Furnaces of the Bronze Age could attain sufficient heat to melt copper and produce bronze. Molten iron was beyond their limits; they could soften native iron, if any could be found, but not smelt the ore or melt the metal.

What Is Bronze?

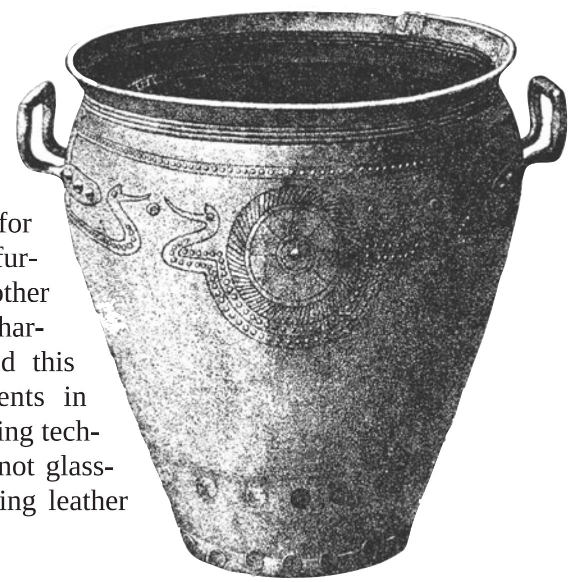
Bronze is usually described as an alloy of copper and tin, averaging 10% tin. In fact, its composition is more variable than that. The proportion of tin can be up to 25%; different proportions give the bronze different properties. Some bronzes also contain up to 5% lead, replacing some of the tin. There are even bronzes made with copper and arsenic; 2-3% arsenic is typical in such alloys. Still, most bronze is made with tin, and the scarcity of tin limits its production. Phoenician traders ventured as far as Britain to acquire tin or tin ore.

Brass is an alloy of copper and zinc, up to 38% zinc in composition. The two are not always clearly distinguished in the ancient world. Brass is not well suited for military applications, however; it is less durable than bronze, though harder.

Walls had to be built and defended with labor available in the city, limiting their maximum size. A population of 250 per acre was typical. To accommodate these numbers, as well as a city's temples, fortifications, storehouses, marketplace, and its ruler's palace, residential construction economized on space. Square or rectangular buildings became typical. The most crowded cities had buildings two to four stories tall filled with shops and apartments. The better-off residents lived in single-story buildings designed like miniature cities, with a single entryway leading into an interior open courtyard around whose perimeter rooms were placed.

The construction of fortifications and monuments required years of effort by hundreds or even thousands of laborers and artisans. While a core of skilled builders worked full time on them, much of the work was done by drafted farmers in the seasons when they could be spared from their crops.

Crafts



The Bronze Age saw increased use of materials altered or transformed from their natural state. Further development of the wood kilns used for pottery led to the construction of furnaces able to melt bronze and other metals for casting. The use of charcoal as a fuel further enhanced this technology. The first experiments in making glass were conducted, using techniques similar to firing pottery, not glassblowing. New methods for tanning leather also came into use.

Bronze

At the outset of the Bronze Age, metal objects of any kind, from weapons to artwork to tools, were a rarity. Metal objects only became common when there were enough smiths and founders to produce finished works and enough miners and panniers to bring the metal out of the ground or from the rivers. Bronze is an alloy of copper and tin, which was only available in a few locations and became a major trade good.

As the methods of smelting and shaping bronze became more widely known, it was used for weapons and containers and for construction – nails for buildings, tools to hew wood, and decoration and ornamentation. It took some time for bronze tools and implements to filter down to the people.

Since the properties of bronze differ from those of iron, the two are defined as different specializations of the Blacksmith skill. Working in tin, lead, and pewter is defined as a third specialization. The three specializations default to each other at -2. Since tin, lead, and pewter are fairly soft, they have no modifier for ST below 13. Working in precious metals requires the Jeweler skill; Blacksmith (any specialization) and Jeweler default to each other at -4. Direct casting of objects from molten metal, as opposed to shaping them with tools, can be done with either Blacksmith or Metallurgy.

Stoneworking

The demand for stone at TL1 supported many different industries, from huge quarries to jewelry shops. Stone blocks were quarried by cutting grooves into the rock face that were filled in with wooden wedges or heated with fire;

water swelled the wedges or chilled the grooves to split the blocks free. Once quarried, they were transported to building sites by river barge (when available) or hauled over land by sledge. Early stonemasons' tools were made of copper, wood, and stone. Blocks of hard stone, up to 2.5 tons in weight, were painstakingly shaped using ball-shaped stone pounders, cut with copper, bronze, or flint saws, and polished with natural abrasives such as sandstone. Softer stones were worked with copper chisels and mallets. Smaller versions of the same tools were used by sculptors, jewelers, and engravers.

Pottery

The potter's wheel increased the productivity of potters, and also enabled them to turn out pots of more consistent shape and thickness. The same technology that was used in smelting furnaces allowed kilns to produce a more even heat, reducing the proportion of pots that crack: 5% for each point by which the Pottery skill roll fails, or a minimum of 50% on a critical failure.

Tanning

For most of the Bronze Age, hides were tanned by boiling and drying. The dried leather was cut up into squares or strips, depending on what the material would be used for. The result was a hard leather that was difficult to cut or sew. Even with these limitations, early leather was used to make shoes, wineskins, and other kinds of sacks. Leather and animal skins were also used for roofing and other building applications. This type of leather was also used for shields, often laid over a harder substance such as wood.

Clothing

Geographical limitations determine the main textiles available to a culture. In Egypt, flax provided linen for clothing; wool was used infrequently and silk and cotton were unknown. As a result, elegant Egyptian textiles in the Bronze Age were finely woven and almost transparent, and starched, folded, or pleated to create interest. By contrast, India, equally hot, had no knowledge of silk, flax, or cotton, and wove cloth solely of wool.

Bronze Age clothing falls into two distinct classes: wrapped and sewn. Examples of wrapped clothing are the loincloth, kilt, or skirt; an example of sewn clothing would be breeches. Wrapping came to its height in the Egyptian New Kingdom, where the pleats in the garment distinguished between ranks. Farther east, wrapping became more voluminous with deeper folds, covering more of the body, until it met the sewn method, with its definite breeches. Loincloths were basic to almost every civilization; kilts or skirts were often worn as additional clothing layers. All cultures had some version of a tunic and cloaks, capes, and mantles. Dress robes or royal clothing were usually more elaborate versions of everyday clothing, with something extra to denote status.

Most garments were held together by girdles rather than belts. Belts imply fasteners attached to the ends of the loops; girdles are tied or, very rarely, pinned together. They can be plain, embroidered, painted, or decorated with jewels, depending on the status or wealth of the wearer.

Fuels

With improved tools, woodcutting becomes a major source of fuel. Freshly cut hardwood is 30% water and has an energy content of 7,000 kilowatt-seconds (kWs) per pound; after drying for a few months it is 15% water, raising the energy content to 8,200 kWs per pound. Coniferous woods start out at 40% water and 7,500 kWs per pound, and end up at 10,000 kWs per pound. In addition to being easier to transport, dried wood burns more easily and with less smoke (see p 15).

However, much of this fuel is converted into a more efficient form, charcoal, by incomplete combustion of wood in pits. Charcoal has almost no moisture content and is virtually smokeless; its energy content averages 13,000 kWs per pound. Charcoal burning is wasteful, reducing 5 lbs. of air-dried wood (energy content 42,000 kWs) to 1 lb. of charcoal (energy content 13,000 kWs). However, charcoal is easier to transport and is the ideal fuel for metalworking.

Not all the fuel in Bronze Age civilizations came from forestry. Dung from herd beasts was an important fuel source; in fact, it is still the major fuel in Indian farming communities. One pound of dried dung has an energy content of 6,000 kWs. This is not as good as wood, but the dung doesn't have to be transported. Dung also has the advantage of burning slowly and evenly, letting a small fire be left untended while the cook does other chores or tends children.

Dried crop residues such as straw, if not fed to livestock, can also serve as fuel. They average 8,000 kWs per pound, a little less than dried hardwood, but take more work to collect and more space to store.

Another useful fuel is peat, vegetative material buried in boggy areas and partially reduced to carbon. It averages 3,000 kWs per pound. Use the rules for digging in soil (p. B90) for digging peat.

Armoury

One of the main applications of metalworking was the creation of improved weapons and armor. Adventurers with the skill of Armoury may want to do this for themselves. The rules that follow can be used for this purpose. They remain valid at TL2 and 3 as well.

Blade weapons make the greatest demands on the armourer's skills, as reflected in their high prices. The creation of a blade weapon requires two rolls against Armoury skill: one to forge the blade and one to quench and temper it. Other hand weapons and missile points require only one roll against Armoury skill.

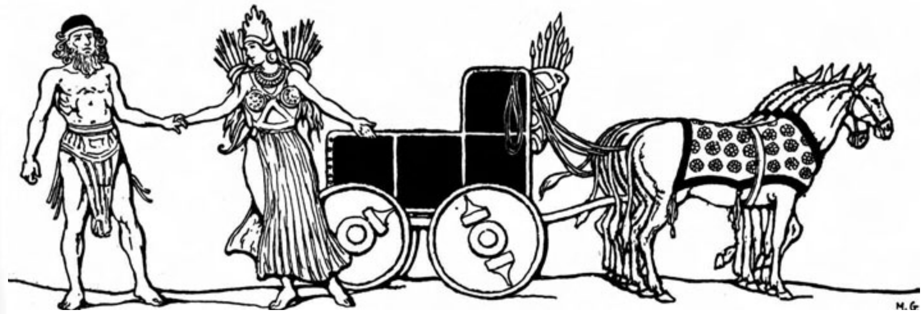
Armoury requires a properly equipped shop, with a forge and quenching trough and at least one assistant. An armourer can work under field conditions, with a simple forge and hand bellows and no assistant, but is at -2 to all skill rolls. Conversely, very good conditions, with specialized tools and at least two assistants with Armoury 15+, give +2 to all skill rolls.

The fastest way to make a weapon is from a prepared blank. Such blanks typically cost $5 per pound of weapon weight. Making a blank from metal ingots doubles the time to make the weapon, but reduces the cost to $1 per pound of weapon weight. The GM may allow a Scrounging roll to come up with metal at no cost, especially on a battlefield or in a conquered city, but such metal is of unpredictable quality and gives -2 to skill, except on a critical success. An armourer with Metallurgy skill may attempt to purchase or produce better quality metal. Each point of success on a Metallurgy roll gives +1 to effective Armoury skill.

The quality of weapon to be made should be specified before any work is done: Cheap, Good, Fine, or Very Fine. (Note that some of these categories do not apply to some types of weapons; see p. B74.) Skill rolls are made at +10 for Cheap weapons and -10 for Fine weapons. An attempt to make a Very Fine weapon is made at least at -20; the GM may rule that an armourer with skill less than 20 cannot even attempt such a weapon.

Bonuses or penalties may be applied to the skill for working slower or faster than normal (see below). Such adjustments may be from -10 to +10.

Continued on next page . . .

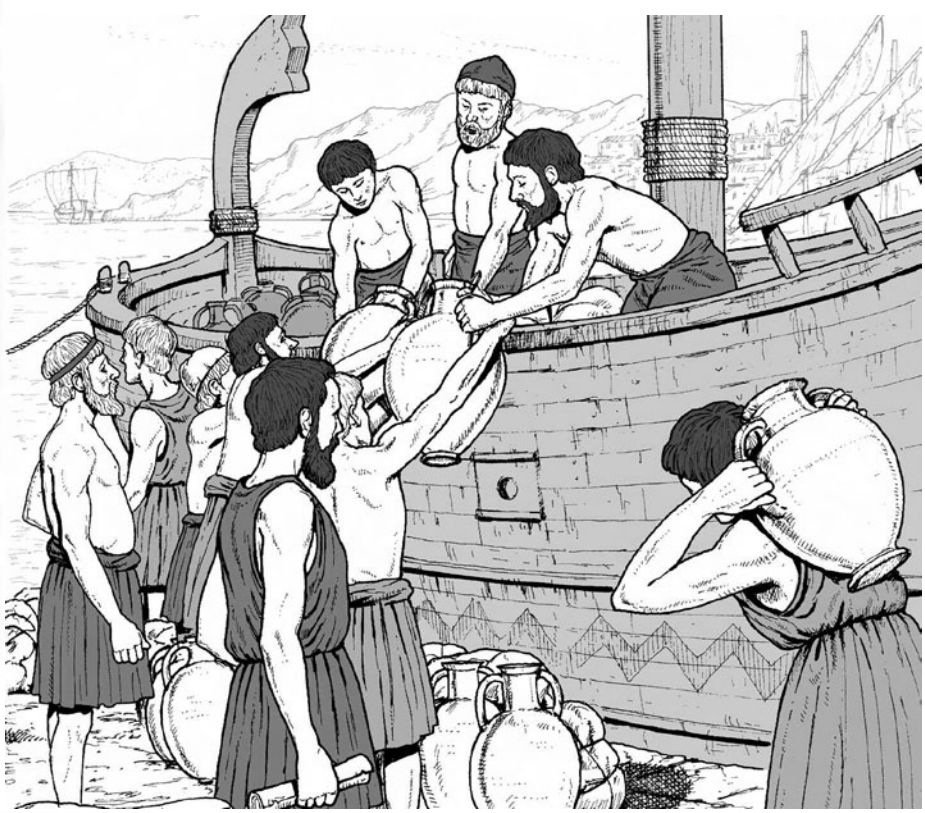


Travel and Transportation

The Bronze Age was a time of major improvements in transportation. Long journeys became possible, and civilizations became aware of each other, leading to diplomatic correspondence, trade, and warfare.

On land, the invention of the wheel led first to the cart and wagon, then to the war chariot. On the water, new construction techniques allowed for large ships that could carry many tons of cargo; late in the Bronze Age, ship designs began to be specialized for warfare (long and narrow) or trade (wide and rounded).

The resources of centralized states facilitated improvements in transportation. Roads began to be built, though at TL1 bad roads are normal (see p. B188); networks of roads connected major cities. Canals provided not only irrigation but also shipping routes connecting one river with another. These projects often had military purposes, but they also brought economic benefits; increased trade helped pay for the military forces that used them. Rulers often organized trade expeditions; for example, Hatshepsut (reigned 1498-1483 B.C.; see pp. EG49-50) sent an Egyptian fleet down the Red Sea to trade with African coastal peoples.



Social Organization

The first civilizations were significantly more complex than the stateless societies that preceded them. They had many specialized occupations, including various craftsmen, rulers, soldiers, priests, and merchants. Most people inherit their parents' occupations, and there is a strong sense of social class. In ***GURPS*** terms, Status is very clearly defined in these societies, covering the full range from +8 (divine ruler) down to -4 (slave laborer). Even fairly small states are too large for anyone to recognize everyone in them on sight; people in public roles learn the skills needed to interact with strangers – and may be very shrewd at sizing them up.

Political Systems

The Bronze Age began with city-states, each consisting of a single walled city and the countryside that supported it. Some TL1 civilizations, such as the Sumerians and the Maya, remained at this level of organization, with many independent cities alternately trading and warring with each other. Other civilizations, including the Egyptians, Babylonians, Assyrians, and Aztecs, were unified into empires encompassing many cities. Normally one powerful city conquered the others in its region.

TL1 political systems were almost all monarchies. The ruler's authority usually derived from religion. He might be considered the steward of the gods, as in Mesopotamia; a descendant of the gods, as in China; or himself a living god among men, as in Egypt and Peru. The strong ties between government and religion made priests important in government. There were occasional power struggles between monarchs and priests, as in Akhenaten's attempt to impose monotheism on Egypt (see pp. WWi14-15).

The development of writing (see pp. 43-44) enabled TL1 governments to keep written records of such matters as tax collection, giving rise to the first bureaucracies; the faceless clerk who is "just doing his job" first appears in TL1 societies.

Law

Many tribal peoples have systems of customary law, but the Bronze Age introduced something new to the world: written law. The Code of Hammurabi is the oldest known example of written law. Carved into a stone pillar, it lists judgments for a series of legal disputes.

Such legal codes vary from culture to culture. However, an important feature of many TL1 legal codes is emphasis on the act rather than on the motives. If one man kills another, the law does not weigh differences between premeditated murder, impulsive murder, death from a blow that was not meant to kill, or sometimes even accidentally caused death; the penalty is the same. On the other hand, killing a nobleman, a peasant, and a slave usually carry different penalties.

Armoury (Continued)

A critical success produces a weapon one level of quality higher than intended. A normal success produces a weapon of the intended quality.

A normal failure by 1-3 points produces a weapon one level of quality less than intended; for Cheap weapons, this indicates that the weapon is useless. A normal failure by 4 or more points always produces a useless weapon. A critical failure can lead to various disasters, at the GM's discretion: 2d injury to a random location, a fire in the shop (losing 1d+4 × 10% of the shop's value), or a flawed weapon that will shatter at the most dramatically appropriate time, ruining the smith's reputation . . . and possibly endangering his life! For a blade, use the worse of the two rolls for forging and quenching to determine blade quality; an armourer can forge a superb sword and then ruin it in the quenching.

Base Time	Weight × 0.75 hours
No blank available	×2
Blade	×1
Other cutting/impaling	×0.9
Crushing	×0.8
Field conditions	×1.5
Advanced equipment	×0.5
Artistic design	×1.2
Skill +1	×1.5
Skill +2-10	×2-10
Skill -2	×0.9
Skill -4	×0.8
Skill -6	×0.7
Skill -8	×0.6
Skill -10	×0.5

Minimum time is 8 hours for a knife or sword, 4 hours for other weapons.

A knife or sword must then be hilted. The base time is 6 hours if supplies are available, 12 hours if not. Modifiers for field conditions, advanced equipment, and artistic design apply. Most other weapons must be hafted; this takes 1 hour for a weapon with reach 1 or less, 2 hours for a longer weapon, with no modifiers to time and no skill roll required. In either case a roll against Armoury is required. An ordinary failure produces a slightly awkward but workable grip; a critical failure produces a hilt or haft that will break when the weapon is used in work or combat.

The base time to make armor depends on the material and the weight, as follows:

Cloth	0.1 hours/pound
Leather	0.5 hours/pound
Scale	1.5 hours/pound
Chain	5 hours/pound
Plate	3 hours/pound

This can then be modified for field conditions, advanced equipment, or artistic design. In addition, if drawn wire of suitable gauge is at hand, the time required to make chain is reduced 50%. No skill roll is required; all armor is considered to be of Good quality.

Trade

An emerging merchant class in Bronze Age society carried goods and ideas through vast geographical areas. The societies of Mesoamerica and Peru are isolated, but most of the other Bronze Age cultures – Egypt, the Minoan/Mycenaean cultures, the Mesopotamian cultures, and Shang China – traded with each other. Even the Harappan society on the Lower Indus may have traded with Mesopotamia by way of the Persian Gulf island of Bahrain. In the Mediterranean, the middle Bronze Age saw the blooming of a trading culture in the Levant, which the Greeks later named Phoenicia. The Phoenicians did not invent trade – the Natufian culture at Jericho may have been trading by sea as long ago as 7000 B.C. – but they certainly pursued it to the fullest.

A characteristic archaeological marker for this period is a change in the distribution of trade goods. In the Stone Age, such goods were most available where they were made and fell off in concentration with distance. But in the Bronze Age, large cities in other regions became secondary centers of concentration, indicating that such goods were being taken directly to the best markets.

Warfare

With the creation of centralized states, the Bronze Age saw the emergence of organized warfare, professional soldiers, and specialized military equipment. Egypt's divine pharaohs and Mesopotamia's priest-kings built monuments commemorating their victories. Armies organized formal ranks and chains of command. To resist these developments, cities were fortified and the first experiments in siegecraft were made.

The characteristic military technology of many TL1 societies was the chariot. It provided a mobile platform from which an archer could fire on the enemy. Despite the cinematic images of chariots driving over footsoldiers or

Transportation Costs

The most expensive form of transportation is carrying goods over land. For short-range haulage of bulk goods, such as farm produce, the oxcart is a typical method of transportation. A pair of oxen can pull a cart (see p. 118) for half a day, covering 10 miles. A cartload of bulk goods is 1,200 lbs. It costs $25 to feed the oxen each way, or $1 per 240 pound-miles in total. River shipping costs roughly one-fifth as much, or $1 per 1,200 pound-miles; ocean shipping costs one-fifth as much as river shipping, or $1 per 6,000 pound-miles. These ratios remain fairly stable until TL5.

These costs have a profound economic impact on cities. Hauling a cartload of grain 60 miles over land roughly doubles its price; thus, food is significantly more expensive in cities. Large cities typically are built on rivers, reducing the transportation costs of food and other essential goods. On the other hand, luxury goods can economically be carried much farther. If a pound of silver is worth $1,000 (see p. B190), then carrying it 240 miles over land adds 0.1% to its cost.

Guarding the Walls

The effectiveness of a city's defenses depends on how well they are manned. Typical urban population density is 250 inhabitants per acre, of whom 50 are men of fighting age. The perimeter of a one-acre site is approximately 800', which means that each man has to defend 16', a very unfavorable ratio, as adjacent men are too far apart to support each other.

If the area increases, the population increases proportionately, but the perimeter increases in proportion to the square root of the area. A site of 7 acres, for example, would have 350 men and a perimeter of 2,117', or just over 6' per man, making it at least marginally defensible. Jericho, the earliest known fortified site, occupied 10 acres.

In special circumstances, these ratios can change. A site with natural defenses on one side, such as a cliff face, has less perimeter to defend. And a military base whose inhabitants are all fighting men can be much smaller. A 0.3-acre site with 75 men has a perimeter of 438', just under 6' per man.

cutting them down with scythed wheels, this kind of shock attack was seldom used in the Bronze Age. Near Eastern chariot forces expanded from fewer than 100 chariots in the mid-17th century B.C. to several thousand by the mid-13th century B.C. India and China also had aristocratic warriors riding in chariots. Entire divisions of government built the chariots, tended the horses, and kept records. Among the first civilizations, only the TL1 societies of North and South America lacked chariots, having no horses to draw them.

The first fleets were built during this period, as well. The earliest warships, from 2500 B.C. on, were troop carriers. Egypt and Crete both built them, and the Cretans ruled a naval empire between 2000 and 1450 B.C. Egypt fought a major sea battle in 1190 B.C. against a fleet of raiders known as the Sea Peoples. Naval engagements involved exchanges of arrow fire and boarding actions.

Early Sumerian city-states controlled about 1,800 square miles and supported royal bodyguards of about 600, with up to 5,000 men at full mobilization. The Battle of Kadesh in 1304 B.C. pitted 20,000 Egyptians against 17,000 Hittites; the total Egyptian army was several times this large, perhaps 100,000 men. Bronze Age military operations had a maximum effective reach of 500 miles.

Advances in Learning

Throughout the Bronze Age, schooling was a privilege of the rich, limited to nobles destined for careers as scribes or bureaucrats. In large part, this restriction was based on the complexity of the scripts of that time period. These scripts required years of intensive study, mostly copying out long compositions about good manners and morals and loyalty to the state. Massive collections of written records supplemented oral tradition as a store of knowledge.

Writing and Literacy

The first scripts came into use during the Bronze Age. Actual writing was preceded by tally marks (see p. 19) and by pictograms; these served as aids to memory, but did not record specific words. The skill of Picture-Writing can be used to keep pictographic records.

In true writing, there is a way to represent any word in a language, even purely abstract words such as “and,” “of,” or even “substantiality.” Writing systems use three main strategies to achieve this: logographic (or ideographic), in which each written symbol represents a word; syllabic, in which each symbol represents a syllable; and alphabetic, in which each symbol represents a phoneme. Logographic systems commonly have a few thousand signs and may require not merely Literacy but a special skill, such as Chinese Ideograms, to master them all.

Syllabaries tend to have 100-200 signs (languages that develop syllabaries usually allow only a few patterns for syllables, such as one consonant followed by one vowel), and alphabets seldom have more than 50; using these requires only Literacy.

Siegecraft

Ancient military theorists distinguished five methods of capturing an enemy city: going over the walls, going through them, going under them, betrayal from within the walls, and blockade. The evidence on whether Bronze Age armies ever tunneled under city walls is unclear, but all the other methods are known to have been used. Breaking through walls relied on rams or picks; going over them was done with ladders or ramps.

Slavery

Slavery is probably older than the Bronze Age or the building of cities. A number of recent TL0 societies, especially chiefdoms, have practiced slavery. Typically a slave was a captive taken in a raid on another chiefdom and kept alive to gain the benefit of his labor.

However, slavery became much more common at TL1. The increased military capabilities of ancient rulers enabled them to make war on each other and on TL0 societies around their countries, resulting in the capture of prisoners. Women – and later, men – became the property of the ruler, who sent them to work on his lands or gave them to temples to serve the priests. The leaders of raiders such as the Sea Peoples or the Mycenaean Greeks might also take captives as slaves.

The emergence of market economies in early cities provided another source of slaves. A man who fell into debt might sell himself to pay his creditor, or might be enslaved to his creditor by court order. Parents could also sell their children, and might choose to do so in a year of famine rather than see them starve.

In most ancient societies, slaves had some measure of personal security, at least through informal arrangements and sometimes under the law. They could be punished, often harshly, for not working, but it might not be legal to kill them outright. Even if it was, a slave represented a large investment that became a loss if he was killed. Masters were generally required to feed their slaves. Slaves could be set free, either as a boon or for a price; the legal code of ancient Israel stated that all slaves were to be offered freedom after seven years. Slaves in cities often were paid for good service, to encourage hard work, and they might even be able to save their pay and buy their own freedom. A slave’s life was harsh, but becoming a slave was not quite unthinkable.

Tombs

The treasures buried within famous pyramid tomb complexes of Egypt are discussed in detail in ***GURPS Egypt*** (pp. 27, 75-76). However, the Egyptians were not unique in constructing elaborate resting places for the dead. Both the Minoan and Mycenaean cultures also built extensive necropolises beneath the earth. Set aside from towns and other settlements, these graves were located on "hallowed ground," protected by tradition (and by dire warnings against sacrilegious thieves). The area established for a grave community was marked by a double circuit wall of limestone, and each set of interments was placed in a round beehive-shaped building called a *tholos* (plural *tholoi*). The graves were not identified with links to particular personalities, but rather marked with hunting or military scenes or symbolic decorations. In some cases, the shaft-grave was dynastic in nature, and would be reopened for the next generation of deceased relatives, each of whom would be buried with the goods, weapons, and armor they treasured most in life.

Record-Keeping

Written records used three distinct types of media. Some records were actually carved or engraved into hard materials such as stone or wood. In Mesopotamia, a stylus was used to press lines ("cuneiform") into soft clay, which was then left to harden or even baked into hardness. In a variant on this technique, a clay tablet could be kept moist for reuse, or a wax tablet could be used instead. Finally, the scribe could use inks and other pigments to trace letters onto flat walls or onto special flexible media.

The earliest example of these flexible media was papyrus, made from the papyrus plant, cultivated in the Nile Delta from the time of the Old Kingdom (2500 B.C. and before). Papyrus was used in Egypt to make cloth, sails, mats, rafts, cords, and above all, material for scrolls. The creation of papyrus sheets was a combination of agricultural and weaving skills.

The layers of the plant stem were carefully removed and laid side by side on a flat frame. Each layer was laid atop the previous one at right angles, and the layers were dampened and pressed into a single sheet. When dried in the sun, the papyrus sap helped hold the sheet together. If well-made, the sheet was bright white and free of defects or discoloration. Papyrus-making developed into a high art in Egypt, and the technology to cultivate the plant and produce sheets spread throughout the Mediterranean.

Many early scripts – including Egyptian hieroglyphics, Sumerian cuneiform, and Mayan – combined these principles in a complex way. Most of their signs were logograms, standing for a word. But some of these signs acquired secondary meanings, representing sounds. In some cases this followed a rebus principle – as when a sketch of an eye stands for the English syllable "I" – giving rise to a syllabary. In others the word sign came to stand for the first phoneme of the word, effectively producing an alphabet. Full mastery of such systems is quite complex; a special skill may be required. Note that Picture-Writing cannot represent this kind of skill, even in a script such as Mayan with pictorial elements.

As a result of the emergence of writing, professional scribes came into being. They served in government posts, inscribed sacred texts on temple walls, or recorded private contracts in the marketplace. The majority of written records concerned very practical matters such as taxes or business deals, but the first written literature dates to this era as well, and includes hymns, epics, and collections of proverbs.

Mathematics

Along with writing, Bronze Age cultures developed systems for recording numbers and measurements. These were intended mainly for practical purposes such as accounting and did not need to encompass an unlimited range of numbers. The simplest systems, using tally marks, went back to the Stone Age (see p. 19).

Systems with distinct numerical signs evolved when fixed numbers of tally marks were grouped in a standard way – for example, marking four vertical bars and then a slash across them for the fifth. The Roman numerals, with I for one, V for five, X for 10, and with repeated Is or Xs for other numbers, suggest such an origin (though of course Rome was an Iron Age society).

Nonpositional systems for writing numbers make arithmetic hard to follow; they are more useful to record the results of calculations than to perform them. For any addition or subtraction involving multi-digit numbers, apply a -1 modifier to Cyphering skill per additional digit; for multiplication, double the modifier. The use of an abacus (see p. 56) avoids these difficulties. Note that positional systems, including zero, were developed by both the Mesopotamians (base 60) and the Maya (base 20); these cultures can be considered advanced in mathematics.

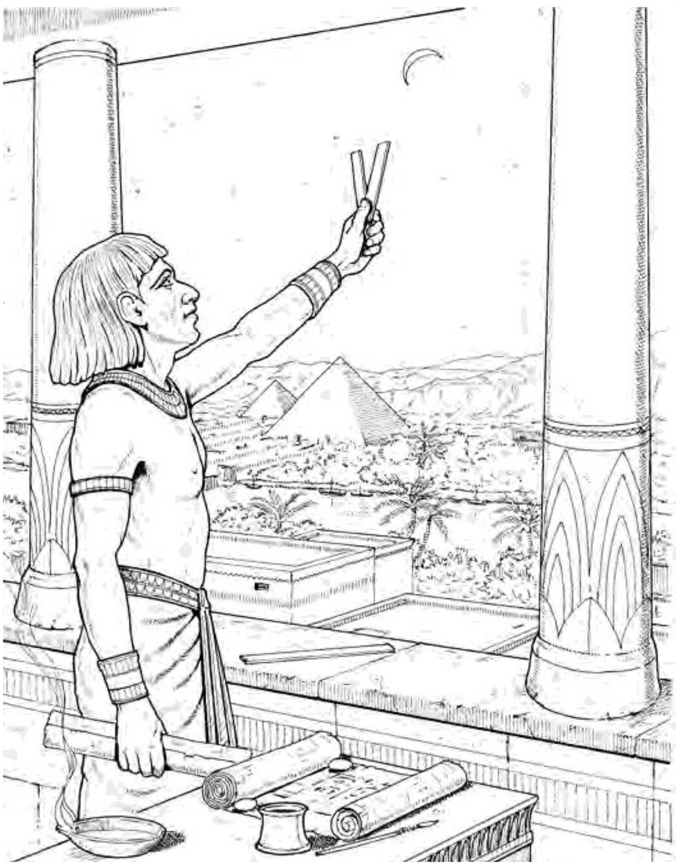
With the development of units of measurement, continuous quantities such as length, area, volume, or weight could be divided up into standard units and recorded as numbers. The early units typically were based on the human body, which was always available as a measuring device. For example, common units of length were the length of the thumb's last joint (the inch), the width of the hand, the length of the foot, the length of the forearm (the cubit, about 18"), and the length of a long pace (the yard). Measurement provided a basis for buying and selling, for keeping inventories, and for planning various sorts of work, all the way up to the building of pyramids and similar monuments.

The measurement of land areas led to the development of geometry. In this period, geometry was mainly a collection of useful formulas that were not necessarily exact. For example, many cultures estimated pi (π), the ratio of a circle's circumference to its diameter, as 22/7. This is approximately 3.142857, slightly larger than the actual 3.1415927. Formulas for the areas of circles, squares, and triangles have obvious practical uses.

A number of cultures developed methods for solving algebraic equations. They did not use symbolic notation; nor did they have general solutions for large classes of equations. Instead, a text listed a series of problems and gave methods for solving each. Fairly complex problems could be solved by these methods; the Babylonians, for example, had formulas for quadratic and cubic equations, expressed in words rather than symbols. The skill that best represents these abilities is Cyphering rather than Mathematics.

Astronomy and Navigation

Bronze Age cultures had a greater awareness of time than their Stone Age ancestors. Mathematicians in many nations tracked the paths of heavenly bodies, particularly the planets, sun, and moon. This gave rise to the notions of months (a complete lunar cycle) and years (a complete cycle of the four seasons, as reflected in the sun's passage through the constellations of the zodiac).



Every Bronze Age culture had some means of reckoning these time units. Numerology entered heavily into these calculations; most calendars had 12 months, adding five extra ("intercalary") days to make the lunar and solar cycles roughly coincide.

While days, months, and years were reasonably well understood during TL1, nothing more sophisticated than a sundial existed to measure smaller time increments. The sun (or moon) regulated lengths of time during a day (or night), but the notion of "o'clock" was completely absent. This affected everything: appointments, elapsed time, and so forth. No one dreamed of arranging to meet someone else at five minutes after some hour.

The skill of Navigation emerged at TLs 1 and 2, as mariners learned to use celestial bodies and the ocean currents to set their courses. However, Navigation is extremely difficult without instruments. Apply a -4 modifier to all Navigation rolls to determine position. Maintaining a given heading – for example, "sail due northwest" – is much easier than knowing exact position; allow a +4 modifier to Navigation, canceling out the penalty for not having instruments. Regardless of your instruments or the task at hand, Navigation/TL1 is always at -3 if you do not know the currents and -5 if you cannot see the stars.

Media of Exchange

When standardized units of weight emerged, they were quickly applied to the precious metals, gold and silver. These metals had long served as a store of value, because they had a high value for a small weight and because they lasted almost indefinitely. Almost anyone would take them in trade for almost any other good – so people were more willing to accept them, which further increased their worth. But once they could be weighed, they also became a unit of account. It became possible to measure not just an object's length or weight, but its value. The scale became the symbol of both the merchant and the judge.

Medications

Where TL0 herbal treatments used the raw or dried herb, TL1 physicians had several other ways of preparing an herb for human consumption:

Infusion: This is the commonest and cheapest method of extracting the medicinal components of herbs. Hot water is used to extract the volatile components of the dried or green leaves, stems, and flowers. Preparation takes 10 minutes after the water is boiled. Infusions may use single herbs or a blend, and are drunk hot or cold. An infusion's potency lasts one week.

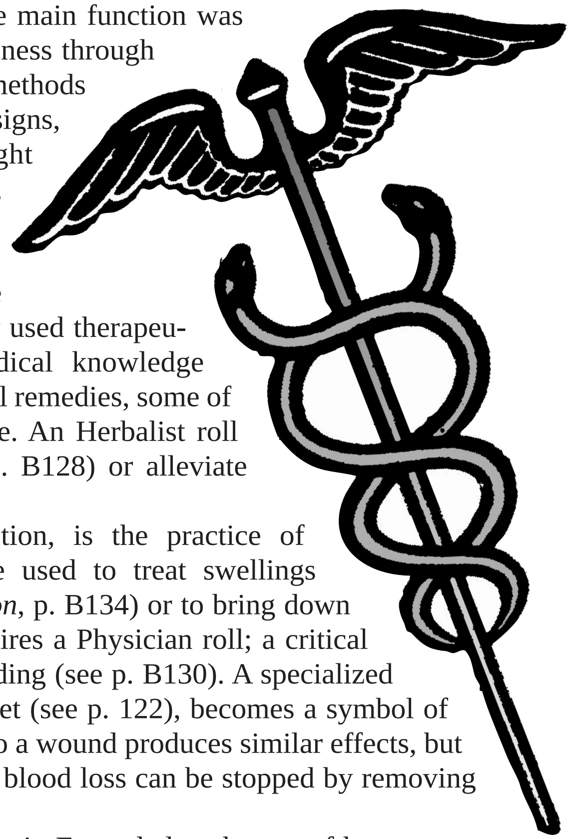
Extract/Decoction: Roots, barks, and fruits are thicker and less permeable and do not release their active principles by simple infusion. It is necessary to simmer these parts in boiling water. A lid is used to avoid losing volatile constituents. The material should be cut or broken into small pieces. When the liquid is ready, the solid pieces are removed. Decoctions can be taken hot or cold. Time to prepare is one hour. Potency lasts one week.

Compress: A cloth is soaked in an infusion or decoction and applied to an afflicted area. A compress must be used immediately for the patient to receive the benefits.

Poultice: Crushed fresh or dried herbs are mixed with a hot, soft, adhesive substance (such as moist flour or a mixture of bread and milk) and applied directly to the skin. A poultice must be used as soon as it is prepared.

Syrup: Most infused or decocted herbs are not palatable, especially for children. To disguise their taste, infusions and decoctions can be mixed with honey or sugar. The soothing action of the solvents is beneficial for treating coughs and sore throats. A syrup remains potent for one week.

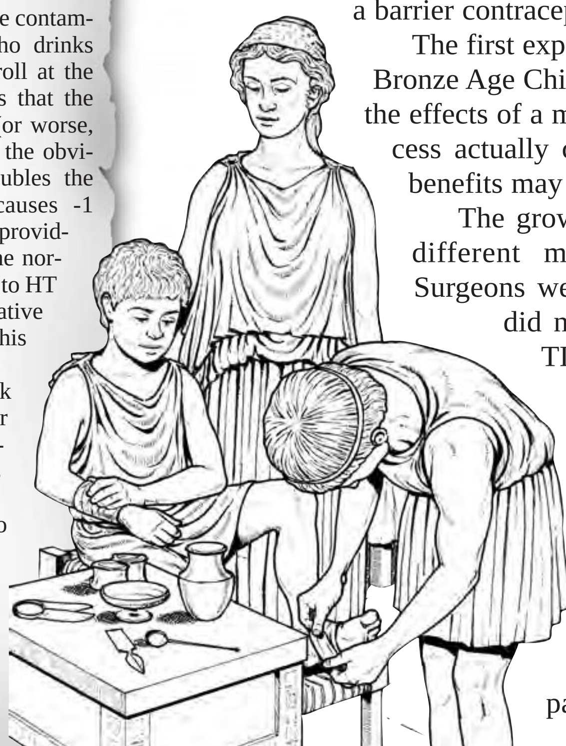
Medicine



In most Bronze Age cultures, the practitioners of medicine were priests, whose main function was to predict the course of an illness through divination. Some of these methods relied on naturally occurring signs, and a priest-physician might have some skill in Diagnosis, having observed the symptoms of a number of illnesses. Praying to the gods on the patient's behalf was a widely used therapeutic measure. However, medical knowledge also included the use of herbal remedies, some of which were actually effective. An Herbalist roll can restore hit points (see p. B128) or alleviate some diseases.

Phlebotomy, or venesection, is the practice of bleeding patients. It can be used to treat swellings caused by injury (see *Infection*, p. B134) or to bring down a high fever. Either feat requires a Physician roll; a critical failure causes excessive bleeding (see p. B130). A specialized tool for phlebotomy, the lancet (see p. 122), becomes a symbol of medicine. Applying leeches to a wound produces similar effects, but with less pain, and excessive blood loss can be stopped by removing the leeches.

The domestication of bees in Egypt led to the use of honey, sometimes mixed with salt, to treat wounds. This has an antibiotic effect; a successful Herbalist roll gives +1 to resist or recover from infection. A more exotic use of honey, mixed with acacia leaves or dried crocodile dung, is as a barrier contraceptive.



The first experiments with acupuncture were made in Bronze Age China. A successful Physician roll alleviates the effects of a migraine (see p. CI82), and a critical success actually cures it; at the GM's discretion similar benefits may be gained for other forms of pain.

The growth of organized warfare gave rise to a different medical profession: military surgery. Surgeons were not usually trained in medicine and did not have the skill of Physician. Instead, TL1-3 surgeons can take First Aid as a prerequisite for Surgery, reflecting their training as field medics. Battlefield surgery included cauterization of wounds and even amputation. Regular physicians also often had some skill in Surgery, but for different procedures aimed at relieving chronic illnesses. In either form of surgery the patient still endured serious pain (see p. 22).

Public Health

The rise of urban civilization led to a decrease in overall health. Diseases in small populations tend to "run their course," infecting everyone susceptible and then dying off. Larger populations can sustain a constant percentage of infected people; cities created large, dense populations that acted as disease reservoirs. Close contact with domestic animals, especially pigs, added another reservoir. Cities were mostly built on rivers, an environment where diseases thrived. In addition, long-distance trade or warfare enabled diseases to spread to other cities, effectively making the population which sustained a disease several times larger.

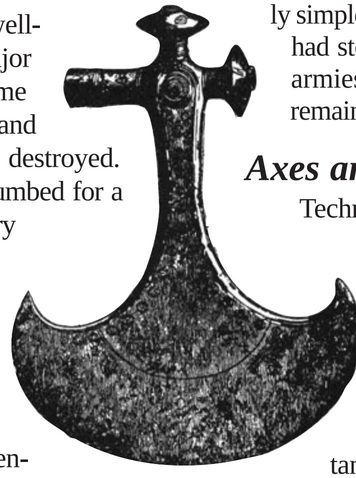
Another source of ill health was the ability of urban rulers to exploit the peasants surrounding their cities. Peasants were often undernourished, which was reflected in height differences between peasants and nobles in many societies. Even apart from occasional famines, one can reasonably assume that, for much of the year, the average peasant has missed a recent meal or two and is suffering from Fatigue as a result. Anyone at Struggling or lower wealth is at -1 to resist disease due to chronic poor nutrition.

Contaminated water also becomes a problem at TL1. In any large city, rivers and other groundwater sources become contaminated with sewage. Anyone who drinks tainted water must make a HT roll at the end of the day. Failure indicates that the victim is stricken with diarrhea (or worse, on a critical failure). Apart from the obvious problems involved, this doubles the daily water requirement and causes -1 Fatigue (-3 if extra water is not provided). A person who recovers by the normal process (see p. B133) is at +4 to HT to resist further attacks. Adults native to a city will automatically have this bonus.

City dwellers often do not drink much water, preferring beer or wine. Water is still used in cooking, but the high temperatures involved kill many bacteria. Such measures give an additional +2 to HT.

Weapons and Warfare

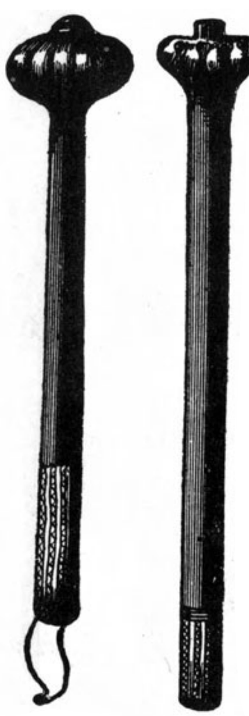
The Bronze Age was an era of well-documented conflict. Every major culture was beset by war at some point during this time period, and some (such as the Minoans and Hittites) were destroyed. Other civilizations, such as the Egyptians, succumbed for a time to foreign invaders, whose advanced military technologies were then assimilated into the conquered society. Resource-rich regions such as the Levant became prizes to fight over, and standing armies, composed of professional soldiers supplemented by foreign mercenaries, became the rule rather than the exception.



Technological progress resulted in the invention of important new weapons, including the battleaxe and the composite bow. As man's destructive capabilities expanded, his preoccupation with developing both personal (shields, helmets, and armor) and large-scale (city walls and fortresses) defenses also grew. But the invention that most altered the practice of war during the Bronze Age was the chariot. For about 500 years, these horse-drawn wheeled vehicles ruled supreme on the battlefield. Rulers assembled large and expensive chariot forces that faced off against each other, reducing other troops to auxiliary roles.

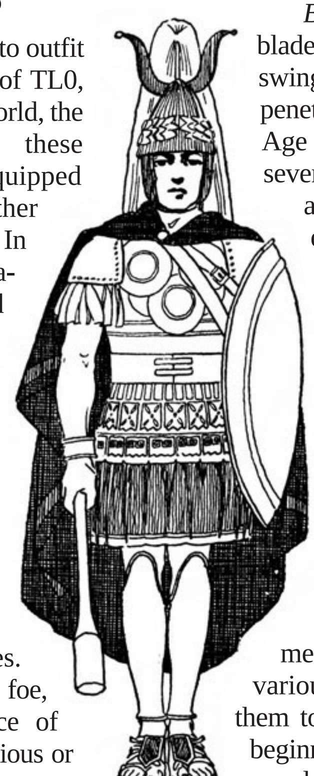
Hand Weapons

During the Bronze Age, soldiers continued to outfit themselves with the traditional hand weapons of TL0, such as the axe and spear. In most parts of the world, the TL1 versions of these weapons were equipped with metallic rather than stone heads. In addition, an innovative hand-to-hand weapon appeared that could only be produced through metalworking: the sword.



Mace

The mace was a potent weapon in the hands of the earliest Bronze Age armies. Swung downward at a foe, it had a good chance of knocking him unconscious or even cracking his skull. Maces in this period were normally simple round balls without spikes or flanges; many still had stone heads. After the development of the helmet, armies turned to other weapons, though maces remained in ceremonial use long afterward.

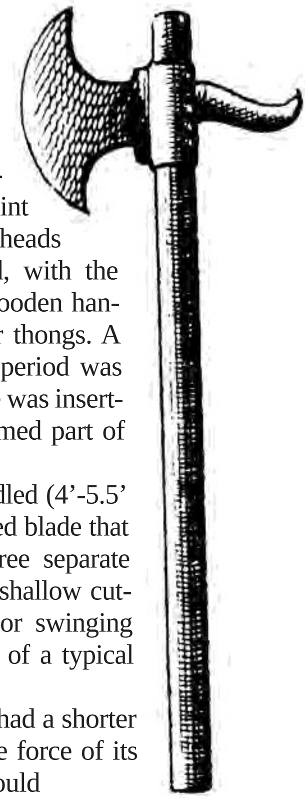


Greek Foot Soldier with Mace

Axes and Polearms

Techniques for casting bronze enabled TL1 armourers to fashion axe-heads in shapes and lengths than were unattainable by Stone Age flint knappers. Early axe-heads were commonly tanged, with the tang inserted into a split wooden handle that was bound with leather thongs. A sturdier design developed later in the period was the socketed axe, whose wooden handle was inserted into a tubular metal socket that formed part of the axe-head.

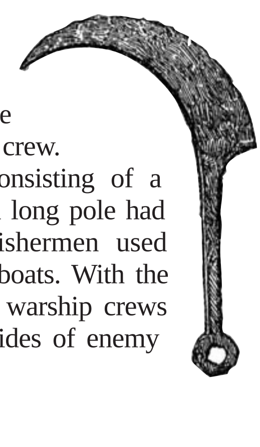
Epsilon Axe. This unique long-handled (4'-5.5' long) Egyptian axe had a crescent-shaped blade that was attached to the axe handle in three separate places. This blade provides a wide but shallow cutting surface best suited for a slicing or swinging attack, rather than the downward slash of a typical battleaxe.



Egyptian Battleaxe

Battleaxe. The true battleaxe had a shorter blade, designed to concentrate the force of its swing on a narrow edge that could penetrate helmets or armor. Bronze Age armourers developed blades of several shapes; these are all classified as battleaxes, though the more effectively shaped ones can be considered Fine weapons.

Ko. The Bronze Age Chinese produced very long axe-like weapons (averaging 10') with two or three triangular blades thrusting out at right angles to the shaft, spaced about a foot apart. Such weapons were used by charioteers to repel attack at close quarters, but could also strike upward at a chariot's crew.

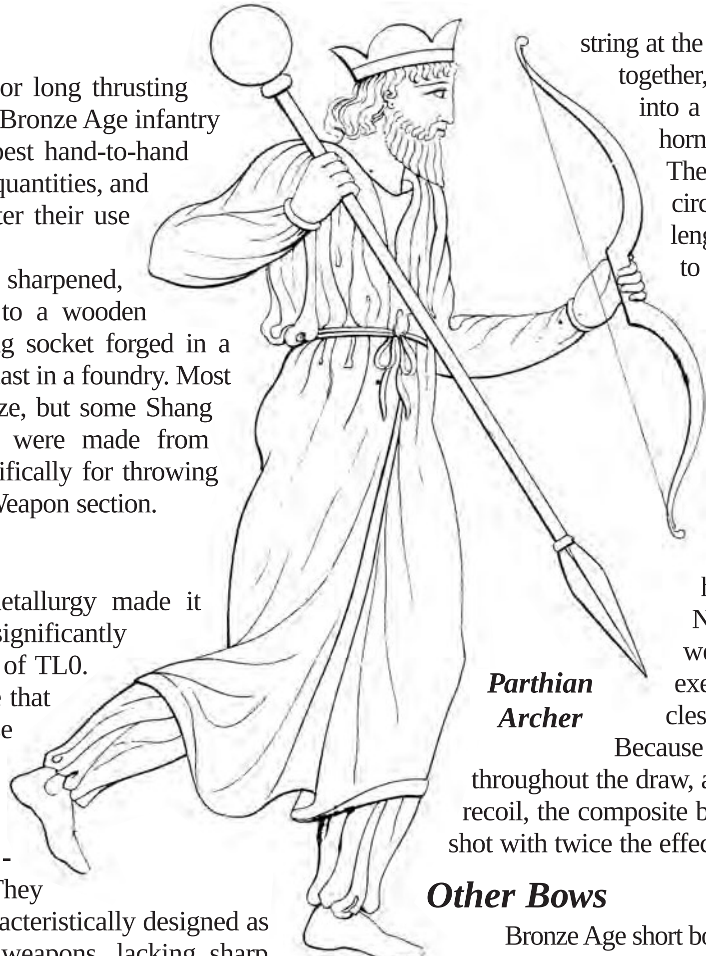


Hook. Weapons consisting of a metal hook mounted on a long pole had various shipboard uses. Fishermen used them to lever large fish into boats. With the beginning of naval warfare, warship crews used them to grapple the sides of enemy vessels.

Spears

Warriors carrying short or long thrusting spears were the mainstays of Bronze Age infantry units. Spears were the cheapest hand-to-hand weapons to produce in mass quantities, and the training required to master their use was relatively modest.

A spear consists of a sharpened, pointed spearhead, attached to a wooden handle with either a split-ring socket forged in a smithy or a solid-ring socket cast in a foundry. Most spearheads are made of bronze, but some Shang dynasty (China) spearheads were made from jadeite. Spears designed specifically for throwing are described in the Ranged Weapon section.



Parthian Archer

Knives and Swords

The development of metallurgy made it possible to create blades significantly longer than the stone knives of TL0. However, the length of blade that could be made with bronze was still limited. Most blade weapons in this period were no longer than short-swords. They were characteristically designed as thrusting weapons, lacking sharp edges. The first edged sword was an unusually designed weapon from Egypt.

Chinese Sword

Khopesh: The *khopesh*, or sickle-sword, is the weapon referred to in Old Testament passages about "smiting with the edge of the sword." It is approximately the length of a broadsword; however, its working surface is a semicircular section about two-thirds of the way down the length of the weapon, sharpened on the outer edge. It has no point.

Ranged Weapons

The most significant TL1 development in ranged weapons is the composite bow. However, high cost and long production time limit its availability. The common warrior relies on the short bow, the sling, and the spear. Indeed, new types of weapons such as the javelin are specifically designed for throwing.

Composite Bow

The first composite bows appeared around the beginning of the second millennium B.C., and the knowledge of their construction spread quickly across the civilized world. The composite bow is made of three distinct materials. The core of the bow consists of five pieces of plain or laminated wood – a central grip, two arms, and two tips with nocks for a bowstring at the ends. Once these pieces are glued together, the timber skeleton is steamed into a curve, and strips of compressible horn are glued to the belly of the bow. The bow is then bent into a complete circle with the tips tied together, and lengths of tendon or sinew are glued to the back of the bow. To make a composite bow takes 40 hours of work, spread out over a 3-6 month period. Long waits are required before the bowyer can apply the different layers of material, since he must wait for the glue that holds each layer to dry.

Composite bows reach from head to waist when strung. Novice archers learning the weapon have to perform rigorous exercises to develop their arm muscles, due to its much greater pull. Because the central grip remains rigid throughout the draw, and the release produces minimal recoil, the composite bow generates a smooth, accurate shot with twice the effective range of the short bow.

Other Bows

Bronze Age short bows and regular bows are essentially identical to their TL0 versions. However, by using metal-tipped arrows as ammunition instead of arrows with flint or bone heads, the effective range of the bow increases (see p. 113).

Massed Fire

Even when they still use TL0 missile weapons, such as the short bow and sling, the organized armies of TL1 use them in a new way: massed fire. To represent this tactic, treat every 20 archers as a single attacker firing a 20-round burst. To hit, roll against average skill, modified for the target's Range, Speed, and Size, and for tactical considerations. Range is measured from the midpoint of the archers' formation to the midpoint of the enemy formation. Speed is the average speed of the target formation. Size is based on the size of the target formation. Modifiers for altitude, cover, darkness, footing, etc. apply normally. The margin of success determines the number of hits on the enemy formation:

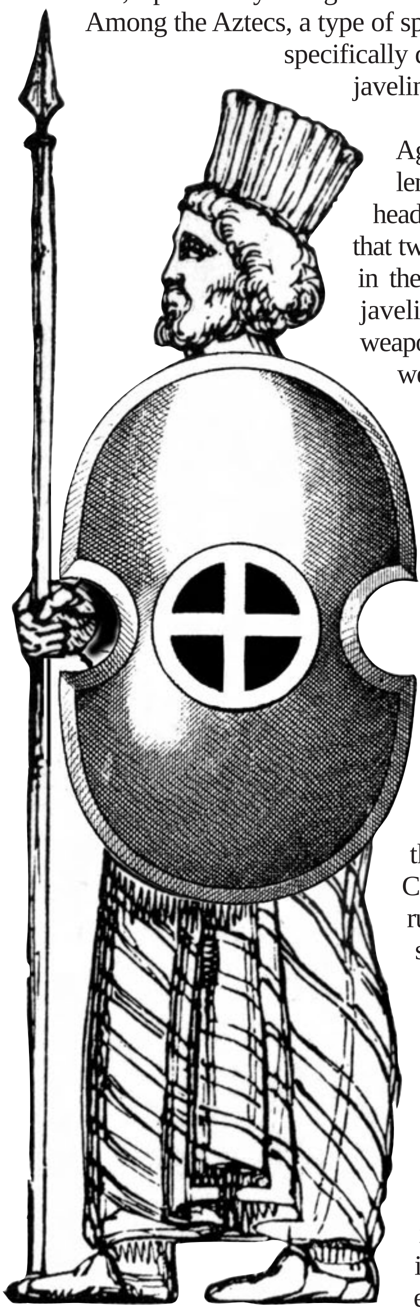
Roll Made By	Number of Hits
-3	0
-2	1
-1	5
0-1	10
2-4	15
5+	20

This assumes that the target formation is tight, similar to a pike square or phalanx. Halve the number of hits if the target formation is loose (e.g., foot archers or mounted knights); divide the number of hits by 4 if the target formation formation is very loose (e.g., horse archers or skirmishers). If it matters who is hit – for instance, if there are PCs or major NPCs in the target formation – determine this using random die rolls.

Spear

Most Bronze Age spears are not balanced for throwing, although they may be thrown anyway in the heat of battle. During the late Bronze Age, however, a new weapon proliferates, specifically designed to be thrown: the javelin. Among the Aztecs, a type of spear thrower, the *atlatl*, is specifically designed for use with the javelin.

Javelin: The Bronze Age javelin is 3.5' to 4' in length, with a 3-5" elliptical head. It is slender enough so that two javelins can be gripped in the palm of one hand. The javelin began as a hunting weapon. Later, it became the weapon of choice among "chariot runners," small squads of footsoldiers who are expected to keep up with and support a chariot crew. Javelins are more practical for a runner than a bow, for they can be thrown on the move and allow the soldier to carry a shield for protection. A soldier can carry only a few javelins, usually no more than half a dozen. Consequently, a chariot runner may carry a shortsword or other small hand weapon for backup.



Persian Soldier

Shields

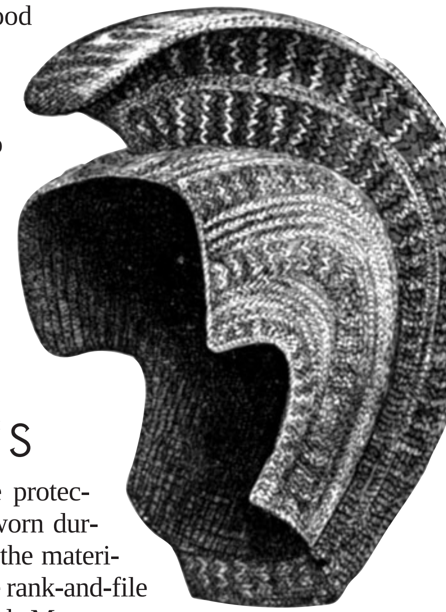
Shields were used long before the Bronze Age, but organized warfare made them vitally important, especially for infantrymen who had to engage the other side. Early soldiers, especially in Egypt, wore no armor, but carried extremely large shields that covered them from head to foot (see p. 117). This design does not provide PD and cannot be used to block; rather, it acts as a movable source of cover (see pp. B118-119).

With the development of the helmet, and then of body armor, this kind of massive protection became unnecessary. A variety of large shields, typically rectangular, came into use, first in Sumer and centuries later in Egypt.

The Hittites developed an innovative design that mitigated some of the problems of the large shield: the figure-eight shield, whose body curved in at the level of the grip. Figure-eight shields are treated as large shields for most purposes, but cost 10% more and weigh 10% less. They subtract only 1 from effective weapon skill; Parry skill is figured from weapon skill as modified. If hit location rules are used, the penalty to hit the shield arm is -3, and the penalty to hit the shield hand is -6.

With the development of torso armor and full body armor, round shields come into use. These could be either small or medium. Their lightness made them useful to footsoldiers, especially chariot runners who could not afford heavy burdens.

A variant on this design, the *chimalli*, was used by the Maya and later by the Aztecs. This was a small shield made of wood and covered with deerhide (treat as a wood shield). Some chimalli have a fringe of feathers extending down from the shield to screen the upper thighs; on a roll of 1-3 on 1d, this gives +1 PD to hit locations 12-14. The feather fringe weighs 1 lb. and costs $100.



Polynesian Helmet

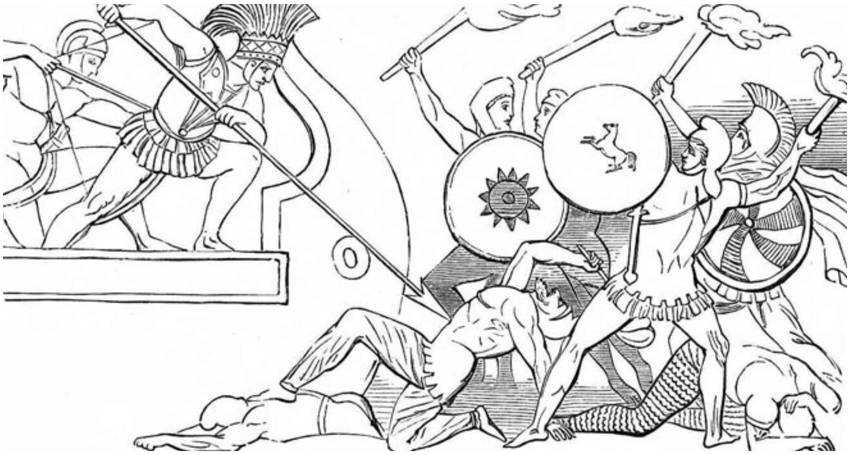
Helmets

Helmets were the protection most frequently worn during TL1. Leather was the material most available to the rank-and-file fighter. In Crete and Mycenaean Greece, helms were often made from hundreds of pieces of boar tusk, sewn onto a base of leather thongs.

The Sumerians were the first to experiment with metal helms. The first designs were pot-helms, covering only the top of the head. Early pot-helms were made of copper backed by leather and conformed to the shape of the head. Later pot-helms were made of bronze and shaped to turn a blow, giving better PD. More elaborate helmets provide partial protection for the face in the form of neck flaps, cheek pieces, or visors (see p. 114). Full helms did not exist at this tech level. Visored helmets give -1 to Vision rolls, but also make it harder to target the wearer's eyes (p. B203).

Armor

Full sets of armor were rare during the Bronze Age. Most TL1 armor covered only the torso. Infantrymen were lightly armored at best. Old Kingdom Egyptian soldiers and barbarian skirmishers such as the mercenary Shardana are often depicted fighting unarmored, or even naked. More commonly, they wore leather garments. The Chinese developed a technique for hardening leather plates with lacquer and stitching them together with silk. Other cultures, such as the Aztecs, used quilted armor: two layers of cloth packed with cotton or other padding – rock salt was sometimes used.



The ancient Sumerians first experimented with metal armor in the form of a leather cloak studded with bronze disks. This garment was awkward, as the arms could not be freed to wield a weapon without uncovering the front of the wearer's body. It was eventually replaced with scale armor, made up of metal plates sewn onto leather or cloth, and lamellar armor, in which similar plates overlapped slightly. Scale armor reached its fullest application in the *sariam,* a scale robe that covered the warrior from shoulder to mid-calf or ankle.

Heavier armor made up of overlapping bronze plates was also used. The most advanced design was the bronze panoply, which protected the neck, the body, and the upper arms and legs. Separate leg protection, in the form of shin guards or greaves, began to appear in a number of Mediterranean cultures late in TL1. Bronze Age greaves were very thin (only 1/12" thick), but they offered the first real protection for the portion of the leg extending below a large shield. Heavily armored warriors still wore bronze through much of TL2.

Siege Weapons

City walls and fortifications often make it impossible to conquer a country without long, expensive sieges. Armies went over city walls with ladders (see p. 56) or earthen ramps; they broke through them with rams, picks, or drills.

Rams at TL1 are simply large logs carried by gangs of men. They deliver dice of damage equal to 1/4 of the total ST of the men using them, and can strike one blow per 60 seconds.

Picks and drills are bronze tools used to remove stone and mortar from fortress walls. Each such tool takes 120/ST minutes to inflict 1 point of damage, first on the DR of the wall and then on its hit points. When all the hit points are destroyed, an area of 1 sf has been penetrated and can be removed.

Wheeled Vehicles

The first wheels appeared in the region north of Mesopotamia, which was plentifully supplied with large trees. The original wheels were solid wooden disks, each cut from a single large tree. A technique for piecing together several planks to form a solid wheel allowed the use of smaller trees. However, their weight and rigidity still made them inefficient; divide effective weight by 5 for two-wheeled carts or by 10 for four-wheeled wagons (see p. B89).

The invention of the spoked wheel in China and Mesopotamia during the second millennium B.C. made wheeled vehicles much more efficient (divide effective weight by 10 for two-wheeled carts or by 20 for four-wheeled wagons). Spoked wheels made the construction of the chariot possible.

Early wheeled vehicles had wheels and axles made from one solid piece of wood. Wooden forks on the underbody were lowered over each axle, and if necessary, the entire vehicle could be lifted off the axles. Since the wheels on the two sides could not rotate at different speeds, turning was difficult: any turn requires a Teamster roll at -2, with additional modifiers if the turn is sharper than the turning radius (see Appendix, p. 118). Later designs have wheels turning freely on a permanently attached axle. For this design, a Teamster roll is required only for a turn sharper than the turning radius.

The civilizations of the New World never developed wheeled vehicles. In the case of the Maya and Aztecs, this may have been because they lacked draft animals to pull them.

Chariots

It is believed that the chariot was first designed as a hunting vehicle, a vantage point for a bowman seeking game or to put down a predator such as a wolf. Toward the middle of the second millennium B.C., the nomads who used these vehicles discovered that the infantry who defended nearby lands could not stand against chariot tactics. Circling 100-200 yards from enemy foot soldiers, a single chariot crew could dispatch up to six foes per minute while running a minimal risk of being successfully counterattacked.

Some early chariots may have been pulled by wild asses (use the donkey statistics from p. B144). For best performance, however, a team of horses is required. Bronze age horses are fairly small (use the pony statistics from p. B144). Horses used for this purpose must be extensively trained in order not to have penalties to maneuver rolls, but are not classified as war-trained (as they do not attack). A horse trained for chariot duty commands three times the normal price.

Chariots were designed for operation on level, even terrain and in fair weather. Since both sides in a civilized middle to late Bronze Age battle typically had chariots among their forces, it was common for a defender to select a battleground suitable for chariot use and for an attacker to meet him upon that appointed spot. Indeed, there are recorded instances in which defenders actually plowed or otherwise prepared a battlefield to be more accommodating to the chariotry on both sides. Nonetheless, any battleground will have areas of rough terrain within its boundaries, and infantrymen and damaged chariots will seek out these havens once the battle begins. Chariots entering such areas suffer penalties from -2 to -5 when attempting to execute challenging maneuvers, depending on the severity of the terrain, and the driver must make Teamster rolls each turn even when traveling in a straight line. Chariot units will likely be completely unable to enter areas of broken, hilly, or mountainous terrain.

Driving a chariot uses the Teamster skill (see p. B47). In battle, chariots are driven fast, giving them a comparatively large turning radius; avoiding obstacles or reaching foes may call for tight turns that are made at penalties to Teamster skill (see p. 118). These penalties may be offset by the following maneuver:

Sharp Turn (Hard) Defaults to Teamster -4
Prerequisite: Teamster; cannot exceed Teamster skill level

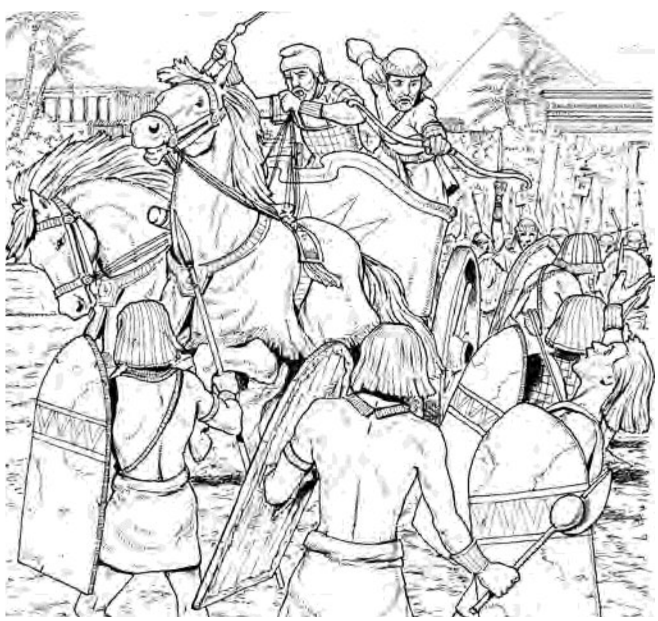
This maneuver reduces the penalties for turning sharply. One does not roll against the Sharp Turn maneuver to use it; instead, each level of Sharp Turn gives the attacker a bonus that can be used to offset penalties for turning sharply. The bonus is +1 if Sharp Turn is known at Teamster -3, +2 if it is known at Teamster -2, +3 if it is known at Teamster -1, and +4 if it is known at Teamster. No further improvement is possible. The bonuses cannot result in the turning roll being made at a higher level than Teamster skill.

Using a missile weapon from a chariot is at -4 to skill for the driver, -2 for a passenger, with other modifiers as on p. B136. This penalty can be offset by a maneuver comparable to Horse Archery:

Chariot Warrior (Hard) Defaults to any missile weapon skill -4
Prerequisite: Any missile weapon skill; must specialize; cannot exceed missile weapon skill.

This maneuver reduces the penalties for using a missile weapon from a chariot. Each level of Chariot Warrior gives the attacker a bonus that can be used to offset penalties for being in a chariot. The bonus is +1 if Chariot Warrior is known at -3 to missile weapon skill, +2 if it is known at -2, +3 if it is known at -1, and +4 if it is known at the value of the prerequisite skill. No further improvement is possible. The bonuses cannot result in the missile attack roll being made at a higher level than the missile weapon skill.

A warrior can also attempt to fight from a chariot in melee combat, where he may actually be able to use its speed to his advantage in the attack. To utilize this tactic, the warrior must be armed with a weapon of sufficient length to reach beyond the chariot and strike the selected opponent. The warrior makes his attack using the appropriate weapon maneuver, at -1 for every four full hexes by which the chariot's current Move exceeds 4. If the attack hits, it does +1 damage for current Move 1-5, +2 damage for current Move 6-10, or +3 damage for Move 11+. If the blow does 10 or more points of base damage to the victim (before adjustments for armor, damage multipliers, etc.), there is a chance that the weapon used will become stuck in the foe. Roll vs. ST to recover the weapon; if unsuccessful, roll vs. DX to let go of the weapon. If both rolls fail, the warrior is pulled off the speeding chariot, taking falling damage (see p. B47).



Chariot crewmen can block and parry normally but have too little room to dodge.

Mounting or dismounting a stationary chariot usually takes 1 second, with no roll required. A chariot rider seeking to jump off a stationary chariot and enter combat in the same round must make a DX or Jumping roll. A failure aborts any attack and reduces all active defense rolls by -1, and a critical failure causes him to fall prone in the initial exit hex. A chariot rider may attempt to dismount his chariot while it is still moving. Roll against Jumping, at -1 for each two hexes of the chariot's Move, and a further -2 if the warrior is attempting to enter combat in the same turn. On a success, he lands upright and running, with half of his normal movement rate remaining to move and attack. If he fails, he suffers falling damage.

The front and side panels of the chariot provide partial cover (-2 to all attacks). A melee weapon of length 2 or more is required to attack a chariot crewman without risk; any attacker striking with a length 1 melee weapon faces a trampling attack at half damage (see p. B113).

Attacks against the chariot's horses receive a +1 size adjustment. Animals protected by barding gain the benefits of PD and DR; they have no active defense, since mounts harnessed as a team cannot dodge. If a horse is wounded, see p. B137.

Attacks against the chariot itself receive a +1 size adjustment; the chariot's PD and DR may be applied. In addition to general damage, attackers may attempt aimed shots against perceived weak points of the vehicle, such as the wheels and the yoke-pole; both are attacked at -3 (+1 for overall size, -4 for location).

The Appendix provides statistics for several styles of chariot and similar war vehicles. The battle car has four wheels and is effectively a wagon; the platform car has two wheels and standing room for a single man; and the straddle car has two wheels and is ridden like a bicycle. The stats assume that these three chariots are pulled by asses, which were domesticated before horses in Sumer. The light chariot typifies those used in Egypt, after their introduction by the Hyksos, and also in India and Greece. The heavy chariot was used by the Hittites, who favored an entirely different style of chariot warfare, riding against enemy infantry or chariots and striking at them with long spears. It has two passengers, a warrior with a two-handed spear and a shieldbearer to protect him. The Chinese used a similar model, but harnessed it to four horses rather than two, raising its top speed to Move 7 (50 miles/day). Its standard crew was a driver, a bowman, and a halberdier. They also used standard light two-horse chariots.

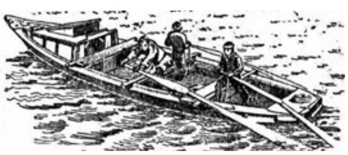
Ships

The Bronze Age saw major innovations in the technology of watercraft: planked construction, which allowed the construction of larger watercraft than before, and the use of sails and oars for propulsion. The first ships were built in ancient Egypt for use along the Nile, and were used later for travel by sea.

Construction

Bronze Age woodworking involved a new technique: splitting logs into planks and beams which could be joined into larger structures. Wooden boats were no longer limited to the size of a single tree, as canoes had been. Like the hide boats of the Stone Age, plank boats could have different shapes, allowing them to attain large sizes without sacrificing stability in the water. The result was a new industry: shipbuilding.

The first use of planks was to extend the sides of dugout canoes; a log could be expanded sideways, giving it a wider beam, and then planks used to give it higher sides. This technique first appeared in late TL0, as a number of tribal cultures used it; it remained in use in the construction of traditional Japanese fishing boats until relatively recently. From this design it was a short step to having a plank on the bottom and two planks on the sides. The Chinese and Southeast Asian *sampan* was originally built this way, as reflected by its name, which means "three boards." (Sampans have a distinctive design feature: internal watertight partitions, sometimes thought to be imitations of the structure of bamboo, make them harder to sink.)



From this starting point, it was possible to add more planks along the sides, producing a wider and higher boat or ship. Planks were joined edge to edge for a tight seam, caulked with pitch or other substances. The main structural strength of the ship came from the joints between planks. Larger ships used frames, typically a series of ribs, for greater strength.

A variety of methods were used to fasten planks together. Many early craft used the same technique for plank boats as for hide boats and bark canoes: sewing. The builders would drill holes in the planks and run rope through them to pull the planks together. Another widespread technique, used in some Egyptian ships and most Greek ships, was mortise-and-tenon joining. Facing slots were cut into the edges of planks, flat wooden tongues were driven into one row of slots, and then the other plank's slots were driven onto the protruding ends of the tongues. For greater reliability, small pegs driven through each plank held the tongues in place.

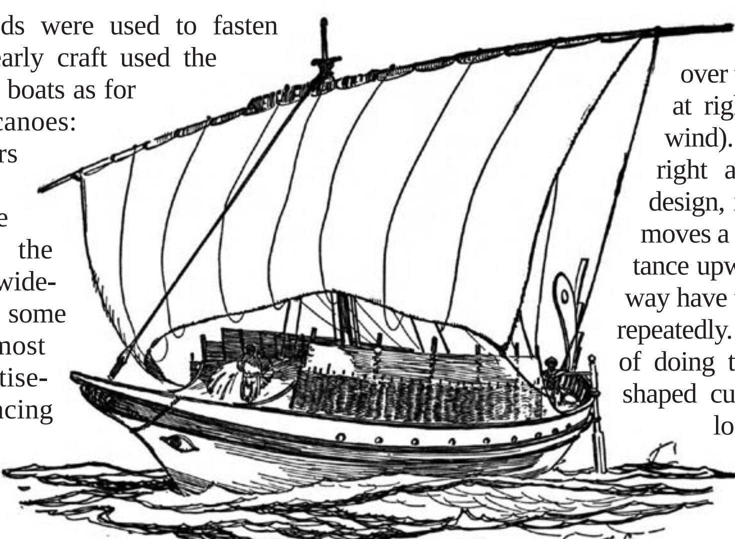
The Egyptian shipbuilding tradition developed somewhat differently, starting out from reed rafts and raft boats. Early TL1 Egyptian raft boats sometimes had wooden platforms for greater strength or better footing. The need to carry heavier cargoes along the Nile, including massive stone obelisks, led to the development of planked barges and boats with mortise-and-tenon joining. Originally these craft were all keelless and flat-bottomed. However, contact with other nautical cultures and experience in building seagoing ships led the Egyptians to adopt keeled designs. River craft were built of acacia, a wood that only came in short pieces. The Greek historian Herodotus compared using acacia to bricklaying. Seagoing ships were built of cedar imported from Lebanon.

By the end of the Bronze Age, ships were built to serve specialized purposes. Warships were typically long and narrow for better speed. Cargo ships were wider, to increase the tonnage they could carry. Hatshepsut used huge but narrow barges to carry entire obelisks down the Nile, each one pulled by oarsmen in 30 boats.

Propulsion

Three major forms of propulsion came into use at TL1: sails, oars, and towropes. All three seem to have been used first in Egypt.

Sails generate force in two different ways. The wind pushes against the flat surface of the sail, providing thrust, and blows over the surface, generating lift (a force at right angles to the direction of the wind). A sailing vessel can thus move at right angles to the wind. With good design, it can even sail upwind, though it moves a long way sideways for a short distance upwind. Ships beating upwind in this way have to reverse their sideways direction repeatedly. There are several different ways of doing this: tacking, which traces an S-shaped curve; wearing, in which the ship loops back on its course; and shunting, in which the sails are reversed and the ship sails in reverse.



Sailing ships at TL1 were square-rigged; the sail was a single broad sheet of cloth, paper, or even leaves, hung at right angles to the ship's fore and aft axis. Square-rigged ships could make 80% of full speed with the wind at the stern, 100% with the wind slightly to one side of the stern, 50% with the wind coming from the side, or 10% if beating upwind. Polynesian sailing canoes were an exception; they had complex asymmetrical sails that could make 90% of full speed with the wind coming from the side or 30% if beating upwind. Square-rigged ships beat upwind by wearing; Polynesian craft, symmetrical fore and aft, relied on shunting.

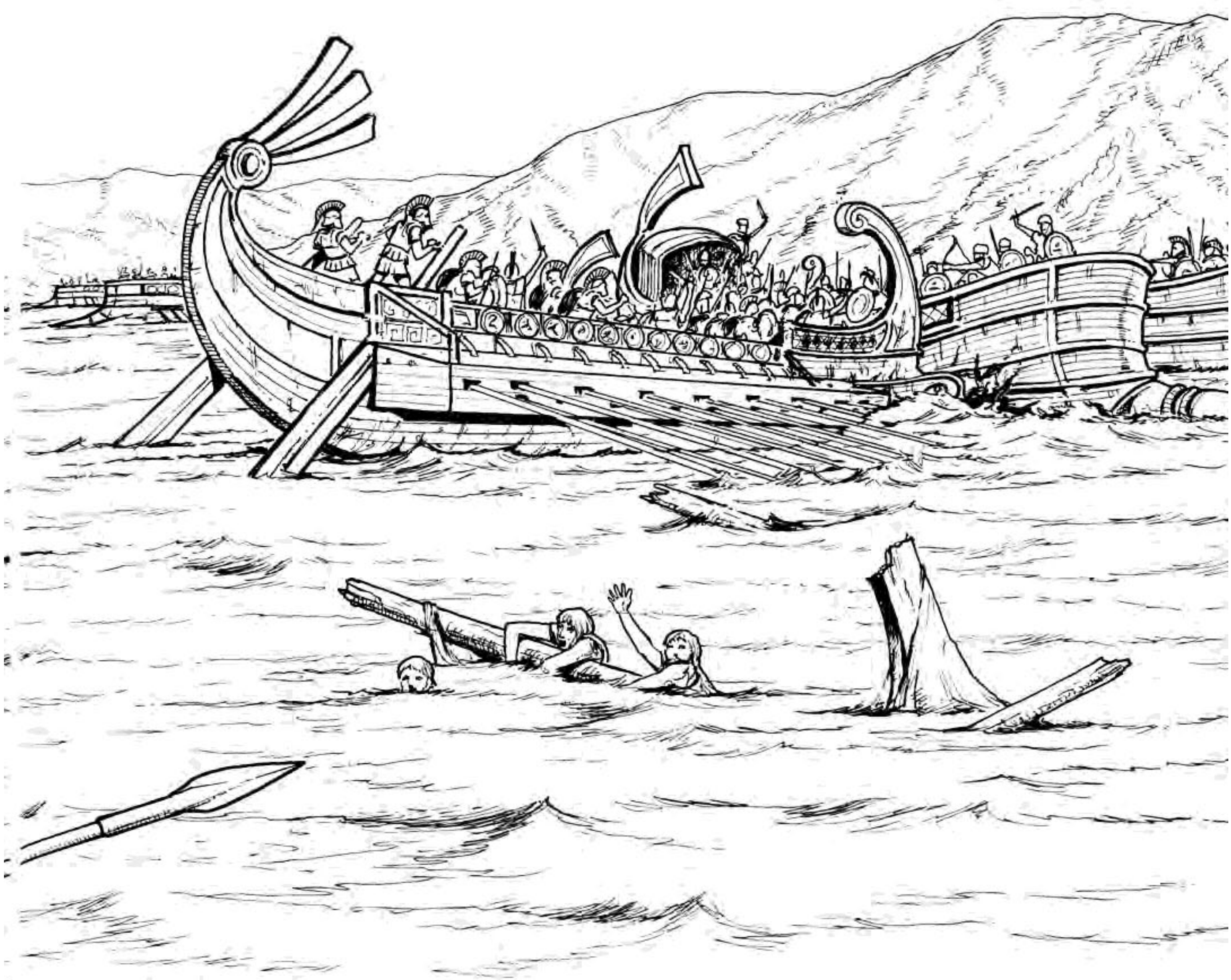
Beating upwind requires a keel or equivalent structure, so that the craft has greater resistance to moving sideways than to moving lengthwise. Canoes, especially double canoes and outrigger canoes, can be treated as keeled craft. Ancient Egyptian craft were originally flat-bottomed; as a result, they could only sail before the wind, not beat upwind. This worked out conveniently, since the major winds blew up the Nile; a boat could ride the current downriver and then sail upriver. Once the Egyptians developed seagoing craft, they began using keeled designs. Much later, Chinese ships (see p. 100) combined flat bottoms with deep rudders that provided the same benefits as a keel.

Early Egyptian craft had another peculiarity: being keelless and lacking a strong frame, they could not support a central mast. Instead, they had distinctive wishbone masts, clamped to both sides of the ship. Seagoing ships abandoned this design in favor of a mast fastened to the keel.

The lack of a rigid structure meant that early Egyptian ships could not be propelled efficiently by oars. Instead, men stood along their sides and paddled them. The oar was developed around 2500 B.C. Allowing the use of the full musculature of the body, not just the arm muscles, the oar at least doubled the effective force a man could supply. It required some form of oarlock, an anchoring point at the side of the ship, to use as a fulcrum. Except in small boats, oarsmen wielded a single oar at one side of the craft.

Steering

The steering capabilities of TL1 vessels underwent two distinct improvements during the course of the Bronze Age. Early Bronze Age ships were typically steered with a pair of stern-mounted sweep oars. By the middle of the age, these were replaced with rudders that added greater turning flexibility. Finally, near the end of TL1, tillers were added to each rudder, enabling them to be turned more quickly and easily.



Tools and Equipment

Agricultural Tools

In general, the tools of Bronze Age agriculture were made of the same materials as those of earlier ages; bronze was too scarce and expensive to be used for such purposes. The major innovation was the use of animal traction, which permitted cultivation on a larger scale than before.

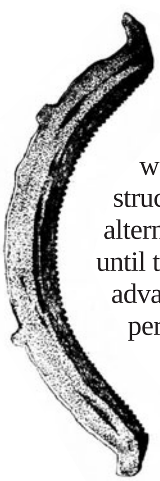
Plow

The single most important agricultural implement was the plow, pulled by oxen or other draft animals. Plows were made of hard wood and designed to cut a shallow groove in the soil. Weight: 20-100 lbs. Cost: $10-$100. Pulling a light plow was equivalent to dragging a 240-lb. load (see *Animal Traction*, p. 37).

Sickle

The only significant Bronze Age contribution to the sickle was the curved handle, developed in Egypt, making the cutting motion more natural. Weight: 5 lbs. Cost: $15.

Craft Tools



Saw

Saws were found in the Minoan, Mesopotamian, and Egyptian cultures. Egyptian woodworkers used saws of various sizes to do construction and finish carpentry. The notion of bending alternate saw teeth left and right was not developed until the end of the Bronze Age. This was the next great advance for the saw, as it created a kerf, or saw slot, permitting easier cutting. Weight: 5 lbs. Cost: $10.

Mallet and Chisel

A variety of specialized hammer types were created in Bronze Age cultures, including mallets, setting mauls, and sledges. In general, the hammer is the simplest tool; almost any object can be used as a hammer. However, when combined with the chisel, the hammer becomes an instrument for artists. Weight: 5-30 lbs. (for heavy sledges). Cost: $20-$50.

Chisels in Mesoamerica were originally made of obsidian and were used to work soft stone. In Egypt and Mesopotamia, copper and bronze chisels were used to shape stone pillars and statuary and to make wooden joints and panels. Early chisels are more than a cubit long, but with the advent of harder alloys, they could be shorter, permitting more accurate use. Weight: 1-3 lbs. Cost: $10-$30.

Axe/Adze

Axes and adzes were extensively used in the Bronze Age, with cast bronze heads replacing stone ones (see p. 29). Weight: 5-20 lbs. Cost: $50-$70.

Bow Drill

The classic drill of the Bronze Age was the bow drill. The earliest version of this tool was a thong wrapped around a sharpened bit. By pulling the thong back and forth, the bit can dig through very hard stone. This tool eventually evolved into the pump drill, which uses a crosspiece, further multiplying the force driving the bit into its hole. A specialized form of the drill, used in Egypt, employed a sharpened hollow cylinder. Combined with coarse sand, this form cut long, wide holes. Weight: 1-2 lbs. Cost: $20.

File

This tool is used to sharpen blades for axes, saws, and knives. Files were used in Egypt, where they were made of hardened bronze. Weight: 1-2 lbs. Cost: $40.

Plane

Planes are another Egyptian invention, used for wood finishing. They were originally made of abrasive stones covered with fine sand. Weight: 2-3 lbs. Cost: $70.

Spokeshave

A knife-edge with handles at both ends of the blade, used with a drawing motion to shave a surface. Spokeshaves were commonly used to trim spear shafts. Weight: 5 lbs. Cost: $20.

Tongs

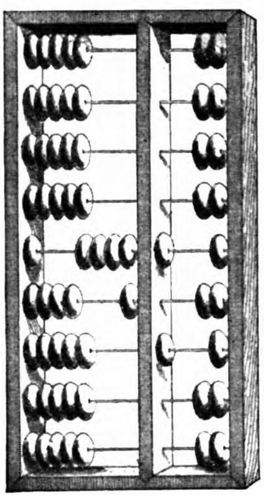
Tongs are bronze loops used to handle molten metal or glass. The Egyptian form was hinged to increase gripping power; later forms resembled pairs of tweezers, with a spring-back mechanism that made them even more powerful. Weight: 2-5 lbs. Cost: $20-$50.

Survival Gear

Cloak

The availability of woven cloth, especially wool, makes it possible to create an outer garment for protection against rain, wind, and cold. A cloak weighs 5 lbs. and costs $50. Note that the Cloak skill (pp. CI132-133) is not known in the Bronze Age; anyone using a cloak in combat does so at the default.

Miscellaneous



Abacus

An abacus is a frame holding pebbles or beads, often strung on wires. It is used to perform the same calculations as Cyphering, but with Abacus skill (see p. CI153). Its use avoids the penalties for nonpositional notation (see p. 44), as positional relations are built into it. Weights and costs vary; for a small model useful for up to six places, assume weight 2 lbs. and cost $50. An improvised abacus may be made with pebbles on any flat surface, costing nothing, but is used at -2 due to the risk of counters getting misplaced. If no abacus is available, calculations are performed at -5 to skill.

Balance

Used by merchants and administrators to weigh precious metals and other goods, the balance is a pair of metal pans of equal weight, suspended from the ends of a wooden beam that is pivoted in the middle. Its use requires a set of standard weights, generally cast from lead. Many cities have officials appointed to verify that merchants' weights are accurate. A small balance, suitable for weighing precious metals, gems, dyes, spices, and other valuable commodities, weighs 1 lb. and costs $25; a set of weights good for up to 2 lbs. total weighs 2 lbs. and costs $10.

Ladder

In addition to their peacetime uses, ladders could be used to scale the walls of enemy fortresses or cities in a siege. A sturdy 36' model, the largest that is practical, might weigh 55 lbs. and cost $90; tilted at the optimal 30° angle, it can scale a 30' wall.

Merkhet

A slitted palm-leaf used by Egyptian sailors to make astronomical observations by observing the pattern of stars moving across a plumb line. Extremely fragile, it is usually carried in a slender hardwood case. It reduces the penalty for lacking navigational equipment to -3, if the stars are visible. Weight: negligible. Cost: $10.

Papyrus

Papyrus can be obtained in single sheets, which weigh less than an ounce and cost $1. Outside Egypt, the price for papyrus may be 3-5 times higher.

Timed Candle

A tallow or beeswax candle designed to burn for a specified number of hours (ranging from 2 to 12). Weight: 1 lb. Cost: $5.

Trumpet

The first trumpets were made from ram horns. Later these were imitated by metalworkers, who created brass trumpets. The combination of their loudness and relatively shrill tone makes their sound carry as far as that of drums, and their ability to sound several different notes lets them signal a variety of battle maneuvers. Weight: 2 lbs. Cost: $100.

Wax Tablet

The wax tablet is the preferred note-taking medium for TL1-2 scribes, as its surface can be smoothed and reused. Weight: 2-10 lbs. Cost: $10-$50.

CHAPTER IV

THE IRON AGE: TECH LEVEL 2

"Gold is for the mistress – silver for the maid –
Copper for the craftsman cunning at his trade."
"Good!" said the Baron, sitting in his hall,
"But Iron – Cold Iron – is master of them all."
– Rudyard Kipling, ***Cold Iron***

During the first part of TL2, iron-making technology spread from its birthplace in Anatolia outward to all the Old World civilizations. Some areas of the world, including Japan and sub-Saharan Africa, passed directly from stone to iron, though their other technologies might have been TL1 or even TL0.

Iron and bronze coexisted for a time, but iron displaced bronze in the production of most practical goods. The superior hardness of iron was less important than its abundance. Copper and tin were scarce, making bronze the prerogative of the rich and powerful, and restricting its use to weapons and ornamental objects. But iron ore is plentifully distributed throughout the world. Iron was common enough to be used in plowshares and craftsmen's tools.

Warships and merchant vessels traveled farther by sea, while the horse and camel became popular mounts on land. The Roman Empire placed a significant percentage of the world's population under one rule. Even more significant in the long term, however, was the creation of two trade routes that carried goods and technological innovations between distant lands – the Silk Road from Antioch to China and the Arab sea trade between Alexandria and India.

Life in the Iron Age

The Iron Age was an era of improved transportation – both on land, with the breeding of larger horses, and at sea, with improved ship design. People in cities had access to goods imported from distant lands. In the Mediterranean, ships were used not merely for exotic luxuries, but for necessities such as grain, olive oil, and wine. An enormous fleet carrying grain from Egypt enabled Rome to exceed a million inhabitants. River and canal shipping in China allowed comparable growth.

Life in big cities acquired a quality all its own. City dwellers were much less self-sufficient than country dwellers; they might have gardens or keep animals, but much of their food, clothing, and fuel was bought in the marketplace. They did far more buying and selling and handled far more money. Stereotypes about the slow countryman and the sneaky city man appeared in the literature of the time.

Cities were filled with all sort of information and misinformation. People talked with each other so often that a rumor could spread within days. There was an eager audience for news; the Athenians, for example, were said to be always eager to see and talk of new things.

In Greece and, later, in the Roman Empire, providing such things became a major function of government. The Greeks held athletic contests, including the quadrennial Olympic Games, and many cities had theaters where plays were performed. The Romans had both theater and public games, including chariot races (see p. 74), but also used their arenas for gladiatorial combat, simulated hunts, and public executions. Men newly elected to public office were expected to sponsor such events.

Indirect Heating

The Romans developed an efficient heating system called the *hypocaust*. Houses were built with false floors made of tile. The space under the tile carried heated air from an external furnace, so that the room was heated without being filled with smoke. Similar heating systems were invented independently in China.

Man and His Environment

As civilization advanced man began to further his mastery over the land around him.

Farming

Iron Age farmers used improved tools that allowed cultivation of heavier soils and the use of more difficult terrain such as forest and steppe. Examples include the moldboard plow, the harrow, and iron plowshares. Labor-saving devices for harvesting and processing crops were also developed. These were not adopted everywhere; the light soils of the Mediterranean lands ruled by the Romans were suited only to the lighter scratch plow, and heavy iron plows did not reach Northern Europe until later.

An innovation of the Iron Age was crop rotation, in which fields were left fallow in alternate seasons to replenish their mineral content. This concept was actively practiced in both China and the Mediterranean region. Mediterranean agriculture largely changed from barley and spring wheat to winter wheat that could withstand colder weather.

Access to water remained a concern for farmers, and rulers still emphasized irrigation. See the sidebar on irrigation technology (p. 36).

The rotary grist mill turned milling into a profitable profession. Mills used human, animal, or water power to turn a grindstone. The capacity of a mill in pounds of grain per hour equals the ST of its power source.

Domestication of Animals

Horsebreeders at TL2 developed larger horses that could carry heavier loads. A ST 40 cavalry horse can carry a man (150 lbs.) with enough gear to count as medium encumbrance (60 lbs.), plus riding gear (up to 30 lbs.), and still itself be only lightly encumbered. The racehorse, saddle horse, and cavalry horse (p. B144) became available. However, horses were expensive, and owning one was the mark of the upper classes. Ordinary people, including infantrymen, traveled by boat or walked.

Riding horses made animal herding more efficient. Two mounted shepherds could control a flock of 2,000 sheep. This led to the emergence of mounted nomadic peoples, such as the Scythians, Huns, and Bedouin. Societies that combine pastoralism with riding can be considered to be TL2.

Forestry

Iron axes increased the productivity of forestry. A forester with an iron axe can cut down a 1' oak in 15 minutes. This was significant when vast woodcutting projects were undertaken by foundries producing iron or bronze, armies building siege engines, or seaports building fleets of naval vessels. Over much of the Mediterranean and Near East, deforestation became a problem. Human industrial activities were large enough to have a measurable environmental impact.

Mining and Smelting

The technology of mining improved significantly in the Iron Age. The widespread availability of iron increased the number of metal tools, allowing miners to work faster (see p. 36). Mines went deeper into the earth in pursuit of ores as easily accessible deposits were worked out.

One obstacle to excavation was flooding when a mineshaft passed into porous rock below the water table. This was overcome in Roman times by the development of water-raising engines, from the Archimedean screw to the water wheel (see *Irrigation*, pp. 61-62). In some large mines, multiple stages of pumps might raise water to a substantial height; the Rio Tinto copper mines had a chain of eight pairs of one-man wheels, raising water a total of 96'.

The two common types of iron ore, magnetite and hematite, both weigh approximately 8,500 lbs. per cy. Typically, about 5% of the material removed from the ground was actually ore. The raw ore was crushed into powder and then washed with water so that the heavier metal-bearing fragments could settle to the bottom of the slurry and be separated out. At TL2, roughly two-thirds of the iron ore was recovered. The resulting fine reddish powder was dried and then charged into a smelting furnace powered by charcoal and bellows-driven hot air. The processed iron was withdrawn from the smelter in the form of a pool or ball of soft, red-hot metal, known as a bloom, which was beaten with hammers to force out the remaining impurities. At TL2, between two-thirds and three-fourths of the iron in the initial charge was contained in the final ingot . . . only 200 lbs. of iron from a cubic yard of ore.

Miles Herculaneus

The Roman town of Herculaneum was buried by pyroclastic flows of hot ash and rocks from the eruption of Mt. Vesuvius in 79 A.D. Many houses have been preserved, but most of the residents escaped the town before it was buried. An exception is a skeleton found in 1982 on what was the marina of the seaside town. The man, known only as "the Soldier," is the only known Roman soldier whose remains have survived to the present.

Analysis of his bones shows that his thighs had strong muscles for riding horses without stirrups – he was in the cavalry. He also showed heavy muscle development suited to wielding sword and shield, and throwing javelins. The Soldier had clearly seen combat, since he was missing three of his front teeth and had scars from a deep flesh wound on his left thigh. He was tall and strong, but his missing teeth and very large nose would have made him unhandsome. It is likely that he was spending time in Herculaneum at his home, on leave from duty. If he grew up there he probably would have acquired some fishing skills and, like most Romans, would have been literate. When the volcano erupted, he grabbed his vital possessions and portable wealth and fled to the docks, where he died among other people waiting for boats to rescue them.

Found with the Soldier were his iron sword (a *spatha*) and its scabbard, attached to a leather belt finely decorated with metal. A similar belt held a scabbard for a dagger. He wore a leather backpack, containing carpenter's tools – Roman legionaries were expected to practice a useful craft. A wooden handle held an iron head that acted as both a hammer and an adze. Two iron chisels and a hook for pulling down branches completed his kit. He carried three gold and several silver coins. His house in the town would have been furnished with marble basins, bowls, and tables, since marble was cheap and plentiful. A small wooden shrine would house marble figurines of the Soldier's chosen gods, probably with Hercules prominent among them. Beds and lounges were made of wood, with mattress and upholstery stuffed with combed wool. Spoons and serving dishes were of silver or bronze, while knives were iron. The house would have a lead water tank, filled by an aqueduct system which served most of the houses, and a latrine connected to a central sewer. The walls would be decorated with murals and frescoes depicting Roman life or the gods.

Continued on next page . . .

Miles Herculaneus (Continued)

The Soldier **110 points**

Age 37; 5'9"; 170 lbs.; a middle-aged man, strong and healthy.

ST 12 [20]; **DX** 11 [10]; **IQ** 10 [0]; **HT** 11 [10].

Speed 5.5; Move 5.

Dodge 5; Parry 6 (sword); Block 6.

Advantages: Combat Reflexes [15]; Comfortable [10]; Fit [5]; Military Rank 2 (Decurion) [10]; Rapid Healing [5]; Status 1 [0] (free from military rank).

Disadvantages: Code of Honor (Roman) [-10]; Duty (Roman Legion) [-10]; Sense of Duty (Friends and Family) [-5]; Unattractive [-5].

Skills: Area Knowledge (Herculaneum)-11 [2]; Boating-9 [1/2]; Boxing-11 [2]; Carpentry-12 [4]; Cyphering-9 [1/2]; First Aid-10 [1]; Fishing-10 [1]; Knife-12 [2]; Leadership-9 [1]; Riding (Horse)-13 [8]; Shield-13 [4]; Shortsword [4]; Spear-12 [4]; Spear Throwing-14 [8]; Strategy-11 [6]; Tactics-11 [6].

Languages: Ancient German-8 [1/2]; Greek-8 [1/2]; Latin (Native)-10 [0].

Further Reading: Joseph Jay Diess, *Herculaneum – Italy's Buried Treasure*, revised and updated edition, Harper & Row, New York, 1985. *National Geographic*, May 1984.

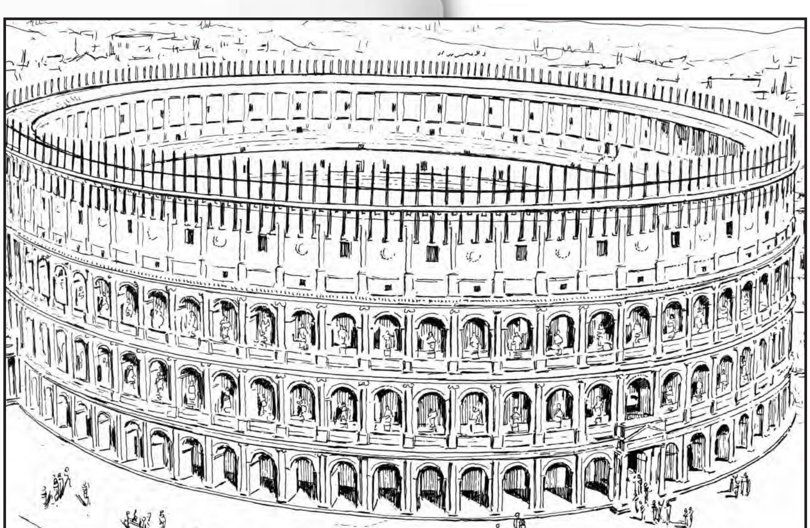
Technologies

The Iron Age brought new materials into use, including concrete, glass, and iron. Societies developed sophisticated mechanisms, from the water wheels that irrigated many fields to the Chinese crossbows and Roman catapults that increased the range of missile fire. This was the first era when some inventors became famous enough that their names are still widely known (for example, Archimedes, described on pp. WWii14-15).

Architecture and Fortifications

Construction techniques in the Roman Empire benefitted from the invention of concrete, a mixture of lime slurry, volcanic ash, and small stones. Poured into wooden forms, the mixture hardened rapidly; formulations were even available that would harden underwater. Concrete buildings were typically faced with stone, both for aesthetic reasons and because stone was more resistant to damage.

Structurally, Greek architecture continued to rely on post and lintel techniques, though the posts were converted into ornately decorated columns in several styles. The Romans and the Chinese developed the arch, a semicircle of building stones in which the downward weight of the keystone was transmitted sideways to the two stones beneath it and on down to the foundations of the arch. Series of arches could act as the foundations for bridges, allowing water to flow through. The barrel vault, basically a long half cylinder in which each section acts as an arch, provided a new form of roof. A further development of the arch was the dome, a hemisphere in which the keystone's weight is transmitted to all sides. A dome can be stable with thickness as small as 2.1% of its diameter. Domes made it possible to roof over very large areas; the Pantheon, built by the Roman emperor Hadrian (reigned 117-138 A.D.), covers more than 15,000 sf.



Early domes required continuous supports along their entire circumference. An alternative design known as the groin vault, consisting of two barrel vaults crossing at right angles, solved this problem by placing the outward thrust of the vaults solely on the four corners of a square.

Chinese architecture favored wood-framed structures with rammed-earth foundations, overhanging roofs supported by a system of brackets, and a strut-style skeletal frame. The interplay of these design elements produced building features peculiar to the East, including non-weight-bearing walls and curving structural lines.

The basic principles of fortification remained unchanged from the Bronze Age, but they were applied on a larger scale. Romans built Hadrian's Wall across the width of Great Britain to hold off attacks from the north. China's Great Wall, built in 214 B.C. by Ch'in Shih Huang Ti (see pp. WWi26-27), united several existing defenses into a wall 1,500 miles long.

Crafts

Improvements in metal-working led a variety of advances in the creation of raw materials and finished goods.

Ironworking

Iron-tipped tools expanded man's ability to control his environment. Forged iron takes an edge better and keeps it longer than bronze or copper. In Greece, iron tools increased from 3% of artifacts to 54% between the 12th and 10th centuries B.C.

The output of a foundry can take three forms, depending on carbon content. Most iron produced during the Iron Age was soft wrought iron, containing only a few hundredths of a percent of carbon. Cast iron, which is brittle, contains 1.7% to 4% carbon. True steel ranges from 0.1% to 2% carbon and averages 0.8%. Wrought iron could be hammered into tools or weapons, while cast iron could be poured into reusable clay molds.

Prior to 1200 A.D., only wrought iron could be produced in any quantity. Special techniques could produce small quantities of steel or cast iron. Processes used to produce steel included annealing and tempering (heating iron for several hours, then quenching with water), cementation (roasting iron and charcoal), and forge welding (heating two pieces of iron with different carbon content simultaneously and hammering them together).

Much of the iron ore used in China had a high phosphorus content, which lowered the melting point of the iron. This enabled Chinese ironworkers to produce cast iron in much larger amounts than elsewhere.

Glass

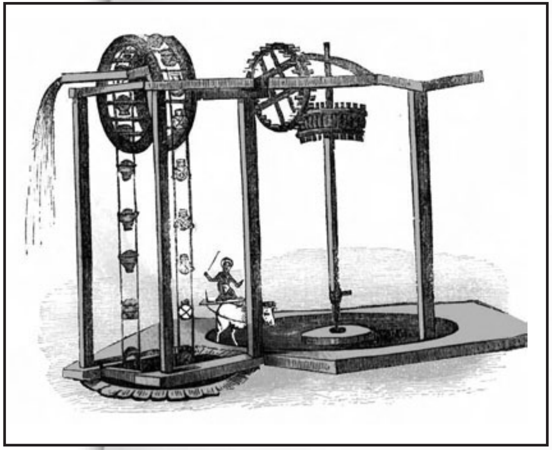
Glass is made by heating sand until it melts and fuses into a solid mass at 2,900°F. Adding an alkaline flux, such as lime or ash, lowers the melting point as far as 2,350°F, a temperature that could be achieved in ancient furnaces.

The earliest known use of glass was in Mesopotamia in the 17th century B.C., but it may have been known a millennium earlier in Egypt. Bronze Age glassmaking produced only small quantities of glass, suitable for beads or small vessels. The mature form of the technology developed in the Phoenician city of Sidon by 100 B.C., where large quantities were produced. Glassblowing may have been invented here. The skill developed to high levels under the Roman Empire, especially in the Egyptian city of Alexandria. Its major use was to make bottles and drinking vessels, which were often square in cross-section.

TL2 glass was usually colored, a result of the inclusion of metal oxide impurities. The Romans discovered the technique of adding manganese oxide to remove this color. The first leaded glass mirrors were developed in the late Roman Empire.

Cloth

Outside of metalworking, textile production was the largest industry of Rome, China, and Persia for most of the Iron Age. Raw materials included silk, wool, cotton, hemp, and flax. Different steps were required to turn each material into cloth; Weaving skill (p. CI137) includes knowledge of the raw materials from the local area. Wool was the most time-consuming to prepare, as almost half the weight of a fleece was dirt and grease. Even after woolen cloth was woven, it went to a fuller and was washed again. This eliminated any remaining grease or dirt and also thickened and tightened the cloth.



Irrigation

The Iron Age saw the invention of a variety of devices for raising water to a higher level more efficiently:

The *Archimedean screw* or *cochlea* had a large screw turning in a cylindrical shaft, so that its motion carried water upward. Whether this was actually invented by Archimedes (287-212 B.C.) is not certain, but it was credited to him in the Roman Empire, where it was widely used.

The *water ladder* or *long gu che* ("dragon backbone machine") was a closed loop of flexible material stretched between two pulleys, with boards fastened across its outer surface at a slant. As the top surface moved upward, the boards carried water along. Power came from men turning four pedals arranged around a shaft while leaning on a pole for balance. This was mainly used in China.

The *noria* or *water wheel* was a large wheel with buckets along its outer rim. As men or oxen turned the central shaft, the buckets lifted water to the top and dumped it out. In effect, this was an overshot water wheel (see p. 63) running backward; instead of extracting power from falling water, it used power to raise water. This device may have helped to inspire the invention of the water wheel as a power source. Norias were used in the Roman Empire and the Near East and also in China and Southeast Asia.

The *saqiya* also used a turning shaft, but rather than attach the buckets to the outside of a wheel, it attached them to a rope looped around the shaft. It was much cheaper to build for the same height. Saqiyas were used in the same areas as norias.

Continued on next page . . .

Irrigation (Continued)

The *rope and bucket* or *charsa* used a team of two or four oxen walking down an inclined plane to pull a rope that raised a bucket or waterskin. It was mainly used in India. The noria and saqiya were also often powered by oxen (ST 80 per ox).

Finally, the Romans invented a pump using two pistons on a rocker arm, which moved up and down in cylinders with one-way valves. This was not used for irrigation but found other uses, including being mounted on vehicles with large water tanks for use by Rome's fire watch. Apparently it generated a fair level of pressure; the author who described it mentioned precautions against the nozzle being blown off by the force of the water.

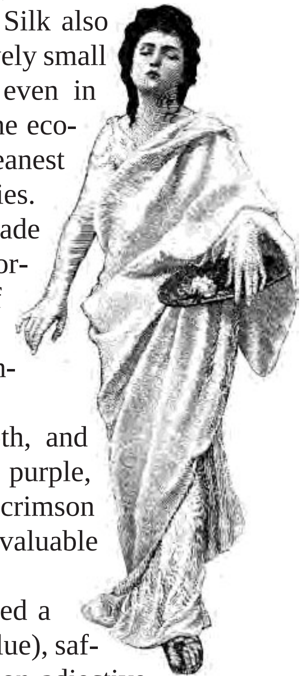
Device	*Volume*	*Height*
Archimedean screw	0.45 × ST	2'
Water ladder	0.25 × ST	2'
Noria	0.03 × ST	30'
Saqiya	0.03 × ST	18'
Rope and bucket	0.03 × ST	30'
Piston pump	0.08 × ST	–

Volume is in cubic feet per minute. An output of 1 cf/minute will irrigate 1 acre in 15 hours, or make up for a 10% shortage of water in 1.5 hours. Reduced height can be traded off for increased output; for example, a 10' noria, one-third the standard height, could output 0.09 cf per minute per point of ST applied.

Fire Engines

A water sprayer used by the Roman fire department might have the following specifications: Components, water tank (16 cf), pump, and nozzle; output, 1.6 cf/minute; range, 20'; power, 2 men; weight, 350 lbs.; cost, $1,750. A full tank would hold 16 cf (1,000 lbs.). A cart holding such a sprayer could be pulled by two oxen, or half a dozen men could carry the pump and tank separately, with the tank empty, and then fill the tank with a bucket brigade.

Hemp and flax had fewer impurities than wool, but were coarse materials that were more difficult to weave. Silk also had few impurities, but weavers produced comparatively small quantities (see sidebar, p. 64). It was expensive, even in China, and a highly prized trade good that formed the economic backbone of the Silk Road. Cotton was the cleanest of the common fibers, with only 10% dirt or impurities.



Throughout most of the world, cloth was still made on upright vertical looms, though prototypes of the horizontal loom appeared in China in the latter part of the age. Once the cloth was woven, dyes were used to color it. These dyes fell into two categories, substantive and adjective.

Substantive dyes bonded directly with the cloth, and were rare and highly prized. One such dye is Tyrian purple, derived from the murex shell; another is carmine, a crimson shade produced from the cochineal insect. Both were valuable long-distance trade goods.

Adjective dyes were plant-based dyes that needed a mordant to fix them to the fabric. Woad and indigo (blue), saffron (orange-yellow), and madder (red) were common adjective dyes. Such plants can be located in the wild with a Dyeing skill roll (p. CI136) for use in local textile industries; however, the dyes typically have little trade value. The most common Iron Age mordant was alum, which came from Anatolia and from the Sahara via Egypt and was a trade item elsewhere.

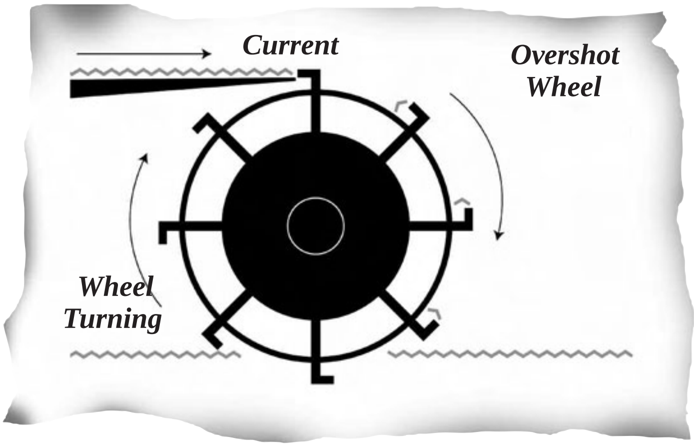
Leather

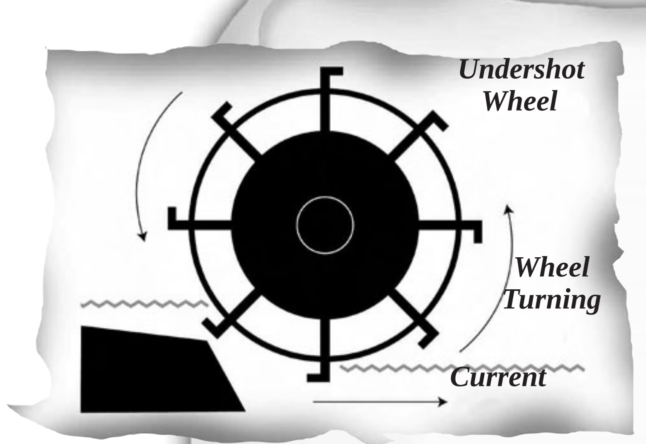
Iron Age man had a variety of methods for tanning hides. Brain and urine tanning were still used (see p. 18), but were joined by oil tanning, vegetable tanning, and alum tawing.

Oil tanning was used in Iron Age Africa, Central Asia, and Japan. The technique is simple but labor-intensive. Butter, animal fat, palm oil, safflower oil, or fish oil is repeatedly rubbed into the hide. The finished result can be beaten on rocks or with hammers to make it more pliant, or smoked, oxidizing the oils to make the hide firmer and more resistant.

In vegetable tanning, pelts are placed in a pit or vat with alternating layers of plant matter, then covered by water and left to cure for 6-12 months. Alternatively, the pelt can be formed into a bag filled with a more concentrated mixture of the same materials and hung from a pole for 3-7 days as the tannin diffuses through the pelt. Vegetable-tanned skins can be hardened for shields or armor by baking them in an oven or the hot sun or coating them with hot beeswax.

Alum "tawing" or mineral tanning was known in China, Assyria, and Phoenicia. This process consists of soaking skins in alum and salt dissolved in water. Variations use alum with mud, gallnuts, or sumac leaf. Tawing produces a thick rough whitish leather that is moderately flexible and absorbs a variety of dyes. The finished hides must be waterproofed with tallow or egg yolk; otherwise, contact with water washes out the alum to make rawhide.





Travel and Transportation

The range of travel became many times greater in the Iron Age. One major reason for this was increased investment in roads by rulers. During the Iron Age, the empires of Persia, Rome, and China built extensive road networks to provide permanent lines of communication and improve the speed with which armies could be mobilized; these are considered average roads (see p. B188). Persia's Royal Road extended 1,600 miles from end to end, while China contained an estimated 4,250 miles of Imperial highway by 200 B.C., and almost 20,000 miles by 200 A.D. Roads constructed during the reign of Ch'in Shih Huang Ti (221-210 B.C.) were nine lanes (45') wide, with a center lane reserved for Imperial vehicles. Yet both these systems were dwarfed by the system constructed by the Roman Empire. Over the course of six centuries, the Roman Empire built over 50,000 miles of roads, with pavement 16' wide and 3' deep. The labor cost was about 24,000 man-days per mile to build a road (about $96,000) and about 8,000 man-days of maintenance per century to maintain it (about $32,000 per century).

Roads outside these areas remained primitive, ranging from cleared but unpaved roads to crude, narrow wagon tracks. Such roads are classified as *bad roads* in dry conditions, and *very bad roads* during periods of rain, when they quickly turn to mud (see p. B188).

The Chinese Empire built many canals, partly because shipping by canal was safer – and more easily taxed – than shipping by sea. Much of their trade traveled by water.

Social Organization

Iron Age societies were less religious and more militaristic than Bronze Age societies. Many of the best-remembered rulers were bold military adventurers whose armies swept across other nations, incorporating them into huge empires. Assyrians such as Ashurnasirpal and Sargon (pp. WWii8-9), Persians such as Cyrus (pp. WWi18-19), Alexander of Macedon (pp. WWi24-25), Chandragupta Maurya of India, Ch'in Shih Huang Ti of China (pp. WWi26-27), and Julius Caesar of Rome (pp. WWi28-29) and his heir Augustus Caesar all had ambitions that exceeded the scale of any Bronze Age ruler's dreams. Vast numbers of men fought in their armies, and the literature of the time, from Homer's *Iliad* to the Old Testament to the *Mahabharata* of India, is filled with battles.

Water Mills

The water mill did not come into common use at TL2, perhaps because slave labor was available for grinding grain. However, the basic design was known. Any water wheel built at TL2 should be considered a prototype.

Water wheels have three main forms: undershot, in which the water hits the wheel near the bottom, turning it in the direction of stream flow; overshot, in which the water hits at the top of the wheel and propels it forward, forcing the bottom of the wheel to turn against the stream (very rare at TL2); and vertical, in which the water hits one side of a horizontal wheel and turns it on a vertical shaft. The cost and the power output of any wheel depend on its diameter. The maximum diameter for a wheel in normal practice is 16'.

Type	*Cost*	*Effective ST*
Overshot	$7.50	11.25
Undershot	$7.50	2.25
Vertical	$10.00	3.75

Cost is dollars per foot of wheel diameter; effective ST is per foot of wheel diameter. An overshot wheel needs a fall of water through the full height of the wheel, either naturally occurring or produced by a watercourse. A typical watercourse is at least 100' long per 1' of wheel diameter. Constructing a watercourse doubles the cost of a wheel.

One ingenious application of the water wheel used it to operate a saqiya, raising water to the level of the central shaft (half the wheel's diameter). This was only used with undershot wheels; an overshot wheel could only operate if the water was already at the height of its top, making the exercise pointless, and the increased efficiency of a vertical wheel did not compensate for the cost of the complex gearing. An undershot wheel with diameter 12' would have effective ST 27; raising water to a height of 6' would give it capacity 0.09 × ST, or 2.43 cf/minute, enough to irrigate 1 acre in 6.17 hours.

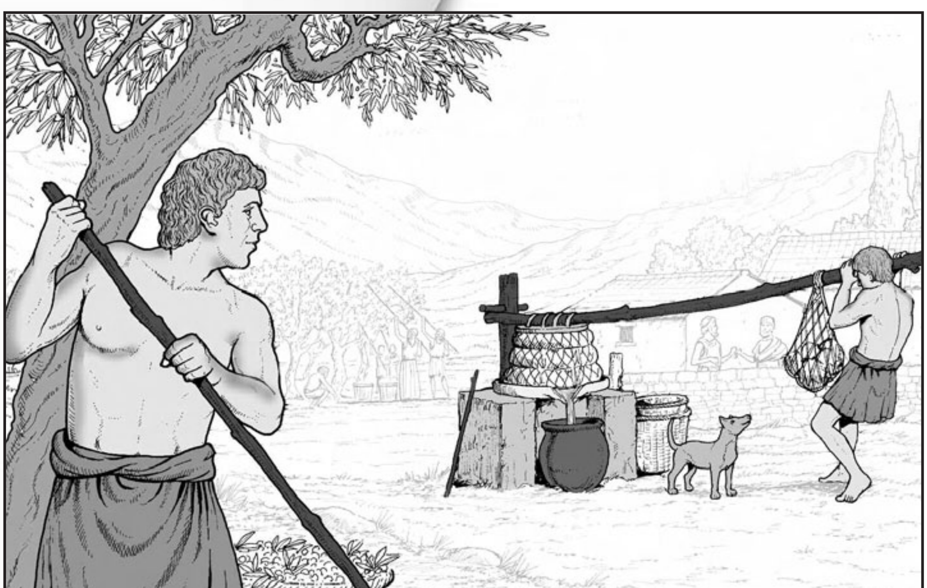
Paradoxically, these brutal wars often led to times of peace. The smaller kingdoms, forced into great empires, could no longer make war on each other, and the empires were too large for more than border clashes. Chandragupta Maurya's grandson Ashoka is still remembered for converting to Buddhism and renouncing war. Many other religions of the era also aspired to an end to war.

Political Systems

Nearly all Iron Age nations were governed by single rulers, whether these were hereditary monarchs or tyrants who held power by military force. Because much of a government's success was based upon the military, diplomatic, and administrative abilities of its monarch and his small group of advisors, the fortunes of a kingdom often rose or fell because of the decisions of those in charge. Nations that prospered and expanded under one king often had difficulty maintaining that prosperity when his heir or handpicked successor came to power.

The two exceptions to the prevailing monarchic structure were the experiments in popularly based government that took place in classical Greece and Rome – the democracy of Athens and the republic of Rome. These forms of government are more fully described in ***GURPS Greece*** (pp. 11-15, 50) and ***GURPS Imperial Rome,*** *Second Edition* (pp. 46-51).

In reality, how much voice a citizen actually had in government depended on his wealth and status within society. Even the most representative Iron Age governments did more to help the wealthy than the populace at large. They built roads, irrigation projects, docks, and shipyards for the benefit of the rich.



Law

A major influence on the development of law was the emergence of multiethnic empires, from Assyria at the start of the Iron Age to Rome at its end. Acceptance of their rule could not be based on a common language or religion. The militaristic Assyrians attempted to break down the loyalties of subjects by resettling them far from their original homes; the Persians followed a more moderate strategy of preserving local customs and religions, making their rulers the protectors of subject peoples – Cyrus the Great is commemorated in the Bible for restoring the Temple in Jerusalem. Both these nations needed one system of laws for all their regional governors and administrators to follow, independent of local customs.

The short-lived Macedonian Empire and the much more enduring Roman Empire followed their example. Roman jurisconsults (legal scholars called in to advise magistrates) developed the idea of the *jus gentium* or "law of nations," the common content in the laws of different peoples, including such ideas as property, contract, and inheritance. Roman law made life and eco-

Oleiculture

Olive growing was a cornerstone of Mediterranean agriculture. Olives are important as a source of both food and oil, used for cooking, cleaning, and lamp oil. Olive trees take 15 years to produce a first crop, and even when mature yield a good harvest only once every two years. Once fully grown, however, they can flourish for centuries.

The increasing demand for wine and olive oil led to the development of the press, which consisted of a beam pivoted at one end. The operator pushed and pulled at the free end of the beam, lowering it to crush the grapes or olives into pulp. The liquid was then sifted from the seeds and crushed fruit and stored in ceramic jars.

Sericulture

The cultivation of silkworms remained a Chinese monopoly throughout the Iron Age. In sericulture, timing and temperature have to be carefully monitored. From the moment the worms hatch until they build their cocoons a month later, they must be fed every few hours, day and night. The women who patiently provide this attention later boil and unravel the fine thread of the cocoons, each of which produces a continuous strand of silk several thousand feet long. It takes 6.4 lbs. of cocoons to produce enough fiber for a single 2.25' × 40' cloth, weighing 0.4 lbs., which represents a year's work for a weaver and 3-4 support workers.

nomic matters more predictable, because they were less subject to the random whims of local rulers. Law was one of Rome's most important tools in creating the largest political system that had yet existed.

A harsher concept of law was imposed on China by Ch'in Shih Huang Ti, who first unified China under a single government. The nations of China had much smaller differences in language, custom, and religion than European or Near Eastern peoples. But Ch'in Shih Huang Ti placed equal importance on doing away with local customs in favor of explicit rules, which he enforced with a systematic harshness comparable to that of the Assyrians. Perhaps as a result, his dynasty lasted only a few years after his death of its founder. But many of his changes in administration, language, and weights and measures lasted much longer, including China's civil service system and examinations.

Trade and Money

During the Iron Age, coinage came into common use in most civilized areas. In about the fifth century B.C., the Greeks introduced bronze and silver coins stamped with a guaranteed weight and purity. Coins were produced from a variety of metals, including gold, silver, bronze, copper, and iron, and on occasion from nonmetallic materials. The value of the coin was closely tied to the value of its material.

Trade routes grew longer during the Iron Age, in some cases stretching for thousands of miles. Some routes employed both land and water transportation at different points. Although improving transportation facilitated this growth, the most important reason for expanding trade was the growing demand for luxury items.

The longest overland travel routes were the famous caravan routes collectively known as the Silk Road, which connected China's capital, Changan, with the peoples of the West. Over 4,000 miles in total length, the Silk Road consisted of three distinct routes: a north route connecting China with the Black Sea, a central route to Persia and the Mediterranean, and a southern route to Afghanistan, Iran, and India. Each road was little more than a web of rough tracks that extended across the northern and southern edges of the Gobi Desert, passing from one isolated oasis to the next. Trade along this route was lucrative, including not only silk but horses, skins and furs, jewelry, ivory, pearls, tortoise shells, lacquer, and spices. But it was also an extremely hazardous journey through regions of hostile climate and heavy bandit presence that even regular Chinese military activity could only partly control. Caravans traveling this route had to maintain their own defense forces, cutting into profits.

Two significant new waterborne trade routes were established during the Iron Age. The merchant fleets of the Phoenicians, and later the Carthaginians, extended their trade routes west to the Iberian Peninsula and beyond, seeking access to metal ores. By 1 A.D., sea routes also connected Hanoi and Canton with India, and India with Alexandria in Egypt, with stops at port cities in Persia and East Africa. From there, goods could go to Byzantium by land, or they could take sea routes to Rome and Genoa. Travel along this route had to be carefully coordinated to take advantage of the summer monsoons and the seasonal changes in regional winds.

The Workshops of Dionysius

In 399 B.C., the tyrant of Syracuse, Dionysius I, announced that he would pay high wages to weapons makers who came to his city. Armourers from all over the Mediterranean set up workshops in every available space. Each workshop was supervised by a friend of Dionysius. Undoubtedly most of the armourers simply made weapons of existing types, but they developed at least one major invention, the *gastraphetes*, an early version of the crossbow and probably the first artillery weapon ever made (see p. 72). Ancient historians credited Syracuse with introducing artillery and describe the production of many different types of bolts and missiles, probably so that their effectiveness could be tested. When Dionysius fought the Carthaginians at Motya in 397 B.C., his use of artillery seems to have been a complete surprise to them.

Syracuse preserved its tradition of advanced military technology for some time; in 217 B.C., the later tyrant Hieron II persuaded Archimedes to help stand off the Romans with his engineering skills (see pp. WWii14-15).

Cranes

Starting from simple pulleys for such purposes as raising buckets from wells, Greek and Roman engineers went on to develop cranes with multiply banked pulleys for heavy lifting. Reportedly Archimedes used them to raise heavy weights over the walls of Syracuse to drop on Roman ships and even to raise the prows of ships out of the water. Cranes were also used in the theater to lower an actor onto the stage, simulating the descent of a god – the literal *deus ex machina*.

Small cranes are powered by men hauling on ropes. Larger cranes are powered by treadmills or other muscle engines. A crane multiplies the effective strength of the men powering it by a factor depending on how many pulleys it has:

1 pulley	×0.9
3 pulleys	×2.4
5 pulleys	×3.6
7 pulleys	×4.5

In practice, ancient engineers stopped at three or occasionally five pulleys.

The cost of a crane is $350 per ton of maximum load supported plus $50 per pulley. The normal basic load is 12 lbs. per point of ST. The speed is 1 foot per second divided by the number of pulleys. Thus, a crane powered by three average men on a treadmill, total ST 30, with five pulleys would be able to lift 360 × 3.6 lbs., or 1,296 lbs., at 1' per 5 seconds. Its cost would be $600 × 0.65 or $390.

Postal Service

Early forms of postal services existed in Iron Age Rome, Persia, and China. Using networks of horse and camel riders, mail could be successfully carried over huge distances if the need arose.

The postal system of the Persian Empire was the most extensive, stretching from the Aegean coast of Turkey to India. Linked to the operations of the royal messenger service, the system consisted of a series of relay stations located along the 1,600-mile-long Royal Road. Riders bearing mail in satchels found fresh horses waiting at each post and passed on their burdens to the next man. Messengers rode day and night, up to 180 miles in 24 hours. This system continued to operate after the Persian Empire was conquered by Alexander the Great, in the Sassanid Empire of the late Iron Age.

Writing Materials

Papyrus (see p. 44) remained the most common writing medium available to TL2 man. In India, writing was recorded on palm fronds, which did not survive well due to climate and insects. Various Western cultures utilized parchment, made from the skins of sheep and goats, or vellum, a fine parchment made from the skins of calves or kids.

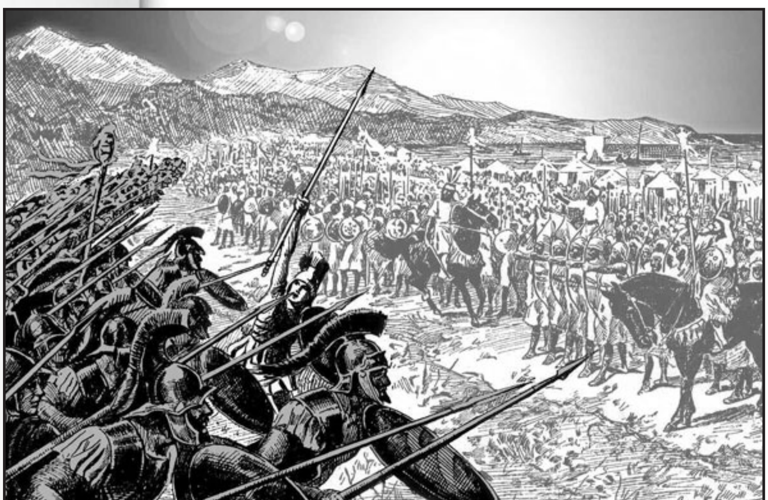
Larger documents were produced as scrolls, made by gluing multiple sheets edge to edge and wrapping the finished product around a wooden dowel. Most scrolls consisted of 20 sheets, forming a cylinder 6" in diameter and 15-20' long when unrolled that held 10,000 to 20,000 words. Papyrus scrolls were awkward to read and handle and easy to drop and damage.

In about the first century A.D., a new storage medium known as the codex appeared. It consisted of sheets of papyrus or parchment glued or sewn together on one side to form a primitive book. This technology originated in the Mediterranean and spread eastward, gradually replacing the scroll.

Around the same time period, China was making its own breakthrough, inventing paper. The new medium consisted of a thin felt of plant fibers shaken to an even layer on a sieve, then pressed against a wall to dry. The resulting product, far sturdier than its predecessors, remained unknown outside of the Far East until the Middle Ages.

Warfare

As the Iron Age began, the mobility of fighting forces increased on both land and sea. The breeding of larger horses, able to carry a warrior and his equipment at a high speed (see p. 57), produced the first cavalry forces. The stable civilizations of the Bronze Age were shaken, and in some cases overthrown, by raiders on horseback or in ships, such as the Sea Peoples who attacked Egypt and the Mycenaean Greeks who overthrew Crete. New empires, or revived older empires, learned to use these new types of forces to consolidate their rule. Assyrian armies used both cavalry and chariots to support footsoldiers; the Persians relied more on cavalry.



A further revolution occurred with the development of heavy infantry, fighting in close formation where they could protect each other from cavalry. For two to three centuries, the Greek *phalanx*, a disciplined armored infantry unit fighting in close formation (often compared to a hedgehog), was seen as the ultimate military weapon, after a much larger Persian army failed to defeat it at Marathon. Its basic characteristics were copied by other armies throughout Europe and Northern Africa. Over time, however, conflicts against more mobile troops revealed weaknesses in the phalanx. Later armies added missile troops and cavalry units to create a more versatile and balanced force. The conquering armies of the Macedonians and Romans and the expansionist dynasties of China were all of this latter type. As larger breeds of horses were created and riding equipment improved, cavalry forces began to evolve from lightly armored units suitable only for reconnaissance and skirmishing to more heavily armored units that could be used as both missile and shock troops.

The Iron Age was also the source of many developments in the field of siegecraft, including an array of mechanical devices designed to throw stones, bolts, or other ammunition at the enemy. In the Mediterranean, the principles of siegecraft developed on land were used at sea against enemy ships. Several centuries of naval warfare were dominated by ramming tactics, and a special ship with banked oars, the trireme, was designed to carry them out. Under the Romans, ships carried catapults and similar engines to clear defenders from enemy ships' decks before boarding actions.

Iron Age armies and fleets were larger than ever before. The Assyrian army had 150,000-200,000 men, and the Persian armies that invaded Greece had up to 360,000. Rome's legions, at the end of the Iron Age, numbered 350,000. On the sea, the Battle of Salamis in 480 B.C. saw 800 Persian ships defeated by 300 Greek vessels.

This larger scale of operations made logistics vital. Xenophon's 10,000 Greek soldiers could march from Mesopotamia to the Black Sea, living off the land, but the armies of the Assyrian, Persian, Macedonian, and Roman empires needed elaborate supplies. Alexander the Great achieved superior mobility by requiring his soldiers to carry 60-70 lbs. of equipment and supplies, and the Romans followed his example. The legionaries recruited by Marius in the late Roman Republic called themselves "Marius' mules" for the loads they had to bear.

Advances in Learning

With the rise of sound-based alphabets in the Iron Age, people could, for the first time, become literate without massive time investment. As a result, several TL2 cultures provided basic education to a much wider percentage of their population. Literacy rates in the Roman Republic are believed to have been substantially higher than at any other time in Italy's history prior to the 20th century.

In Greece and Rome, higher education remained the prerogative of the wealthy. Subjects included geometry, natural and political sciences, law, and elocution and rhetoric (corresponding to elements of the Bard skill). Han Dynasty China supported two institutions of higher learning, the Imperial University for Imperial clan descendants and the National Academy for talented commoners. Graduates of either could take oral exams to enter the bureaucracy.

Areas that were exposed to the customs of Greece, Rome, and China sometimes incorporated some of these educational initiatives into their own cultures. Nonetheless, youths in other lands were much more likely to acquire their education through mentoring or apprenticeship.

Writing and Literacy

Alphabetic scripts first developed in the Bronze Age; by the late Bronze Age, 1525-1200 B.C., they were in fairly wide use in the Near East. The early alphabetic scripts were mostly used for Semitic languages and followed the pattern, still common in such languages, of writing only the consonants. This was still the pattern for the Phoenician script, which emerged during the Iron Age and was spread across the Mediterranean by Phoenician traders.

The Greek alphabet derived from the Phoenician, but in Greek, changing the vowels in a word can completely change its meaning. They found it necessary to have separate letters for vowels. The same was done in the Etruscan and Roman alphabets, derived from the Greek in the seventh or sixth centuries B.C.

Marking Time

Man's ability to measure the increments of time in a TL2 day was limited. Sunrise, sunset, and high noon were experienced equally by all, but most other times were subject to interpretation. Sundials accurately displayed the hour, but functioned only in daylight and when the weather was clear. Hourglasses and timed candles (light sources manufactured to burn out in a stated length of time, ranging from 2 to 12 hours) measured the passage of time from a starting point, but did not indicate the time at that starting point.

Late in the age, the first 24-hour timing devices were invented. These water clocks, or *clepsydra*, worked by pouring a measured amount of water through a hole. The flow of water moved counters along the face of the clock that indicated the passage of time. Later Chinese clocks operated by means of a small power source like a miniature water wheel. Some Chinese clocks indicated not only the time of day, but also the phases of the moon and movement of other heavenly bodies.

Locks

To protect their belongings against thieves, Iron Age city dwellers developed a variety of locks. The earlier forms go back to the late Bronze Age, but the mature form of the technology is TL2.

Pin-Tumbler Lock. Created in ancient Egypt, this was a large wooden bolt with holes in the top, into which matching pins dropped from above. A key shaped somewhat like a toothbrush, with pins protruding from its top, was inserted into a hole and used to push the lock pins back up, after which the bolt could be moved. Versions with wooden pins are TL1; the oldest known example was found in the ruins of the palace of Khorsabad, in Mesopotamia, and dated to 2000 B.C. Versions with metal pins are TL2.

Rotary Lock. The ancient Greeks used a very simple lock in which a sickle-shaped iron key was inserted into a keyhole. The point of the key caught a bolt, and when the key was turned, it drew the bolt back. This early TL2 device can be opened with any key of this type, or with a Lockpicking roll at +3.

Warded Rotary Lock. A more secure version of the rotary lock was developed in Rome, in which pieces of iron projected into the interior of the lock, blocking the path in which the key had to be turned. A key with cutouts matching the projections was needed to open the bolt. The Romans typically made keys of bronze and locks of iron. Unfortunately, warded locks are relatively easy to pick; treat this as +1 to Lockpicking skill.

Continued on next page . . .

Locks (Continued)

Barb-Spring Lock: Both the Romans and the Chinese developed this precursor to the padlock. An iron bolt was slid into the lock from one side, and springs on its end spread a set of barbs that held it in place. An L-shaped key was slid in from the other side to compress the spring and let the bolt be withdrawn.

Gadgets and Automata

TL2 societies has enough skilled craftsmen, and enough practical knowledge of mechanical effects and materials, to produce some very ingenious "trick" devices. These generally served as rich men's toys and amusements, entertainments displayed to the public by showmen and conjurers, or fake religious miracles. Automata – animated models of men or animals – were always popular.

Stories from Classical Greece mention model birds that could actually fly (or at least appear to) and temple doors that were "miraculously" opened by hidden hydraulics. In the first century A.D., Hero of Alexandria, famed as the inventor of an early (and not very practical) steam engine, was also credited with surveying instruments, coin-operated machines, a fire engine, and a water organ.

The ancient Chinese, too, had stories of clever devices, especially automata. Some, such as the south-pointing carriage, on which a figure was linked to the axle and wheels so that it always pointed in the same direction (see p. CH40), are at least theoretically possible, if not necessarily practical. Others, such as the flying powder tube, a gunpowder rocket that would return to its launcher after dropping a bomb on an enemy (see p. CH46), were clearly mythical.

If such devices appear in games, they will require relevant Craft, Mechanic, or Engineer skills at 15+ to construct, although in some cases, it is mainly a matter of understanding the conjuring trick; the actual manufacture may be quite simple. The Gadgeteer advantage (p. CI25) may also be required. Note especially that, until the invention of the high-quality watchspring at TL4, the power available to self-contained miniature devices is severely limited.

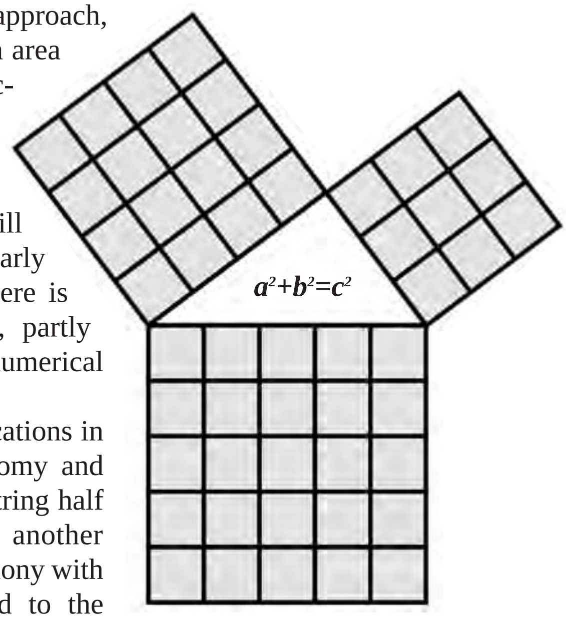
The grammarians of India developed many different scripts, starting with the Brahmi script used for the inscriptions of the emperor Ashoka in the third century B.C. Its origins are uncertain, but it may have been influenced by Near Eastern alphabets. The Devanagari script, developed by Indian grammarians, gave an extremely precise record of how words were pronounced.

In the same period, Chinese writing was developed on an entirely different principle: the use of a separate character for each word. The earliest dictionary, compiled in the first century A.D. by Xu Shen, listed 9,353 characters. Nearly all texts could be read by someone who knew 2,000-2,500 characters, but learning these was a formidable task.

Mathematics

The Iron Age saw a new approach to mathematics: the application of systematic abstract reasoning to mathematical questions. This was pursued most enthusiastically by the Greeks, from Pythagoras (pp. WWii12-13) to Archimedes (pp. WWii14-15), but Indian mathematicians also explored such questions. Euclid of Alexandria's textbook, the *Elements*, placed its emphasis on proving all conclusions logically from a few clearly stated basic assumptions. It became the model for Western mathematical education and systematic reasoning in general for the next 2,000 years.

In ancient Greek mathematics, sophisticated calculation typically involved the use of geometrical models. Archimedes exemplified this approach, using geometry to estimate an area or volume by adding up successively smaller parts. This approach is ancestral to TL4 integral calculus.



In ***GURPS*** terms, the skill of Mathematics becomes clearly separate from Cyphering. There is little progress in Cyphering, partly because of the limitations of numerical notation. (See pp. 44-45.)

Mathematics found applications in other areas, including astronomy and music. The discovery that a string half or one-third the length of another string produced a note in harmony with the original string's note led to the arithmetic of fractions being called "harmonics" or "music." In astronomy, geometric relationships were used to estimate the size and distance of the sun and moon, and astronomers debated whether planets orbited the earth or the sun.

Navigation

The Greek geographer Skylax was the first to produce a coastline description, called the *Periplus*, in the 6th century B.C.; a more complete description of the eastern Mediterranean was published two centuries later. Similar codices of nautical instructions, known as *rahmani*, were published by Arab seafarers in the later Iron Age. Such guides typically eliminate Navigation penalties for sailing in an unknown area, though not all authors are totally reliable.

Medicine

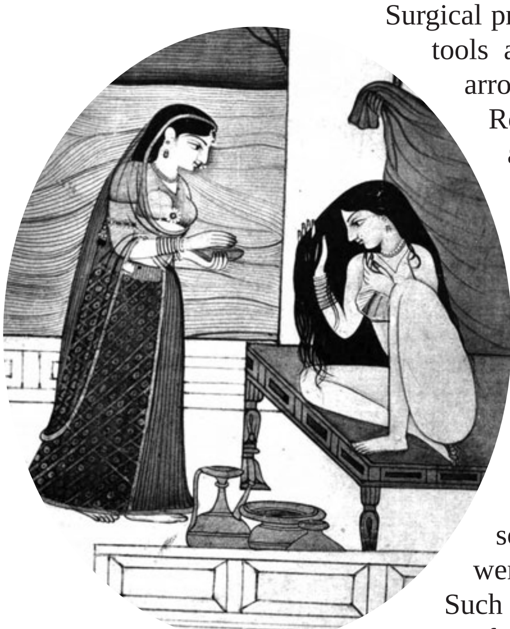
In the Iron Age, religious theories of disease were still widely accepted. But a second, naturalistic approach grew up in several areas. Greek practitioners of humoral medicine, Indian *ayurvedic* physicians, and Chinese Taoists all conceived of health as a balance of various elements that made up the human body, and illness as a disturbance of that balance. Therapy attempted to restore that balance.

In Greek humoral medicine, for example, two pairs of opposites, wet vs. dry and hot vs. cold, were linked to the bodily fluids black bile, phlegm, blood, and yellow bile, called the "humors." Each humor was linked to one of the classical elements: earth, water, air, and fire. An excess of a particular humor was associated both with certain illnesses and with certain personality traits. For example, some liver ailments were described as caused by too much yellow bile, and so were irritability and restlessness, described as the choleric temperament. Treatment tried to make the patient colder and moister through diet and drugs.

Expanding on this idea, the ancient Greeks believed that the physical environment had a strong influence on health. They attempted, for example, to make sure their cities had sources of pure water. The improved sanitation that resulted helped mitigate the public health problems of the urban revolution (see p. 46). The Roman Empire spread such ideas over much of the Mediterranean and Near East.

One Greek medical technique was immersion therapy, based on prolonged bathing. The diuretic effects of immersion can be beneficial for conditions such as toxemia during late pregnancy. Immersion can also help flush water-soluble poisons out of the system (+1 to HT rolls).

These ideas influenced the Roman legions, which examined recruits for general health and tried to maintain that health through diet, exercise, and sanitation. The army trained wound dressers and surgeons. Surgical practice was fairly sophisticated, using such tools as a special spoon for extracting barbed arrowheads without inflicting further injury. Roman soldiers outlived civilians by an average of five years.



The most skillful surgeons of the era, though, came from India. Their skills included several forms of plastic surgery, notably the rebuilding of lost noses.

Late antiquity witness the birth of the private hospital in Egypt. A number of these facilities, founded by private individuals and independent of any church, appeared during the 4th century A. D. Hospitals become the first organized source of long-term care for the sick and were natural gathering places for physicians. Such institutions may offer experimental versions of TL3 treatments.

Chinese Medicine

GURPS represents the Chinese version of TL2 medical theory and practice as Chi Treatment (p. CI138) and Yin/Yang Healing (p. CI145). However, these are classified as esoteric skills, suggesting that they are mystically or supernaturally based. In a realistic campaign, Chinese methods fall under the skill of Herbalist, i.e., TL0-3 Physician (see p. CI150), in the same way that Greek humoral medicine falls there rather than being assigned to a special skill of Hermetic Medicine. Such techniques as acupuncture (p. 46) may be effective for certain purposes whether or not the theory of chi is true.

Iron Age Medicines

Herbalist rolls can be enhanced if the caregiver employs a published compendium of medical knowledge, or *materia medica*. The best known example, composed by the Roman physician Dioscurides in the first century A.D., and republished in the sixth century, described some 600 plants and their possible medical uses. The usefulness of such a compendium depends on the accuracy of its illustrations; many books were recopied so many times that their drawings became hopelessly distorted. As a result, the skill modifier for a particular *materia medica* can be from +3 to -2.

New methods for administering medicinal substances were developed at TL2:

Infused Oils. Pure vegetable oils such as olive oil have the property of dissolving the fat-soluble active principles of herbs. This process is slow but results in an oil-based solution that can be used to make creams and ointments. Hot oil infusion is recommended for the hard parts of the plants, while cold infusion is more suitable for flowers and leaves. Infused oils will keep for years if stored properly.

Ointments. To make an ointment, herbs are simmered in waxes or fats containing no water. After the simmered herbs are separated by squeezing and cooling, the result is a solid mixture of wax or fat with the medicinal constituents of the plant. Petroleum jelly, soft paraffin wax, and beeswax are some common bases. Ointments form an oily barrier on the surface of injuries and carry the active principles to the affected area. Ointments keep for a year or two.

Creams. Creams are mixtures of oils or fats with water. To prevent the oil and water from separating, an emulsifying agent is added. Creams are permeable, letting the skin breathe and sweat. Their water content and an additional hydrophobic agent such as glycerine promote the hydration and cooling of the skin. Creams keep for somewhat less time than ointments.

Weapons and Warfare

The Iron Age saw a number of major innovations in weapons and equipment. The use of iron for weapons, and later for armor, made soldiers more effective in combat. The first artillery weapons were developed for besieging cities and were also carried on ships.

Hand Weapons

In TL2 settings, hand weapons gain increased importance, as infantry combat plays a greater part in warfare. The Greek phalanx and the Roman legion were made up of foot soldiers whose primary mission was to close with the enemy. Carefully planned infantry tactics built the Roman Empire and maintained its borders for centuries.

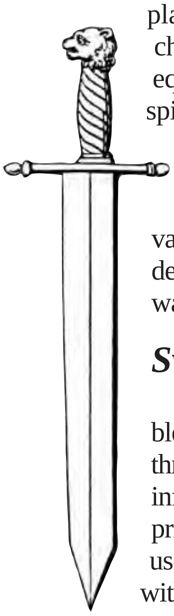
Spears

The spear was the most important hand weapon of the early and middle Iron Age. Assyrian infantrymen were divided into spearmen, archers, and slingers; Persian infantrymen also carried spears. The Greek phalanx, an array of men in close formation protected by each other's shields, developed into a force that could stand off Persian cavalry. The Macedonians developed a much longer two-handed spear, the *sarissa*, which can be classified as a pike.

Both Greek and Macedonian cavalrymen also used spears: the Greek *kamax* and the Macedonian *xyston*. All were normally used two-handed. They are considered to be spears rather than lances, as they are designed primarily for stabbing downward rather than for couching (but see p. 78).

A peculiarity of Greek and Macedonian spears was the butt spike (see p. 110). Footsoldiers' spears were designed to be planted in the ground to meet a charge. Cavalrymen carried similarly equipped spears and might use the spike in an attack if the spearhead broke off.

Romans at war with Celtic adversaries faced an unpleasant variant on the spear: the belly spear, designed with a spiral head and backward-pointing barbs (see p. 110).



Swords

With the greater strength of iron, it became possible to create straight blades that could cut as well as thrust. The sword did not immediately become a major infantry weapon; but in the later Iron Age, it was the primary hand weapon of the Celts and was heavily used by the Romans and Chinese. The Spanish *falcata*, with a blade that could both cut and thrust, can be treated as a shortsword, as can the Roman *gladius*. The *spatha*, a thrusting broadsword originally designed for cavalry use, replaced the gladius in the second to third century A.D.

Roman tacticians preferred to close with the enemy, using their shields for protection. The gladius could strike effectively at close range, thrusting past the enemy's defenses.

The Celts had a unique sword-fighting style, whirling their double-edged blades over their heads and from side to side as they approached, then striking at the enemy with a downward cut. Celtic blades tended to be longer than other Iron Age swords, but were blunt-ended, doing crushing damage if used to thrust; they are effectively broadswords without thrusting points.

Axes and Maces

Most Iron Age soldiers did not use axes and maces as weapons. One exception was the *francisca*, a hatchet with a curved blade used by Frankish warriors. It was primarily designed for throwing but could be used as a hand weapon.

Other Hand Weapons

The lasso appeared in Central Asia during the Iron Age, employed by both nomadic warriors and settled communities. Iranian nomads and Huns used the lasso not only for hunting, but to pursue and capture defeated foes.

Ranged Weapons

Spears

Throwing spears and javelins were carried by auxiliaries in most of the world's armies during this period. Examples include the 3.5'-5' javelins carried by Celtic warriors and Greek *peltasts*, the 4' *verutum* carried by Roman *velites*, and the 5' Indian *sakti*, made of bamboo with a barbed three-point metal tip. All these weapons can be equated to javelins.

Greek use of the javelin was enhanced by a special technique:

Thong Throwing (Average) *Defaults to Spear Throwing-2* *Prerequisite: Spear Throwing; cannot exceed prerequisite skill level*

A leather thong is wrapped around the shaft of a javelin, unwinding as it is thrown and imparting a spin that stabilizes its flight. For effects, see the Appendix (p. 112).

The Carthaginian *saunion* was effectively a javelin made of iron with a barbed head (see p. 110).

The Roman *pilum* consisted of a barbed iron shank fastened to a wooden shaft. The weighted head of the pilum was designed to bend on impact to prevent its being thrown back. If a pilum inflicts half the damage needed to penetrate a shield (see p. B120 or p. 117), it becomes embedded. Each pilum embedded in a shield reduces the user's effective Block by 3 and his overall DX by 2. Removing a pilum takes three seconds and a ST roll. Alternatively, the shield can be discarded.

Roman legionaries in the late empire carried up to five *plumbata*, dartlike weapons designed to be thrown by hand. Treat these as darts.

Bows

Self bow designs dominated Africa, Southeast Asia, and India. Composite bows were used by virtually all European cultures, the Central Asian steppe peoples, and the Koreans and Japanese. As at TL1, they were generally constructed of layers of wood, horn, and sinew. In Arabia, however, composite bows were made of multiple layers of wood, because suitable horn was not available.

Composite bows produced in Japan, Korea, and India were lacquered to provide protection against the humid climate (add 5% to cost). Unlacquered bows used in such climates quickly lose resiliency, effectively making them cheap weapons.

New TL2 developments in bow and arrow technology include the horse bow, a composite bow designed for mounted combat, smaller than a regular composite bow, with 2/3 of the weapon's length above the grip. Horse bows can be used for dismounted combat at no penalty. Firing a regular bow while mounted adds -2 to the penalties for mounted ranged combat rolls (p. B137). The familiarity rules (p. B43) apply to horse bows vs. bows for footsoldiers.

Crossbows

The first crossbows appeared in China around the fifth century B.C. They were revolutionary weapons, as powerful as composite bows and much less expensive. The TL2 Chinese crossbow is a complex mechanical device in which three levers must be properly aligned before the weapon can be fired; this adds 3 seconds to the time between shots. A typical crossbow has high enough ST to need to be cocked with a stirrup (treat as equivalent to using a goat's foot, p. B114).

Chinese armorers also developed the *chukonu*, or repeating crossbow, which had a magazine of 10 bolts, allowing the user to fire it without readying or placing the bolts. For optimal rate of fire (1/2), the user should select a chukonu whose ST does not exceed his own.

Artillery and Siege Weapons

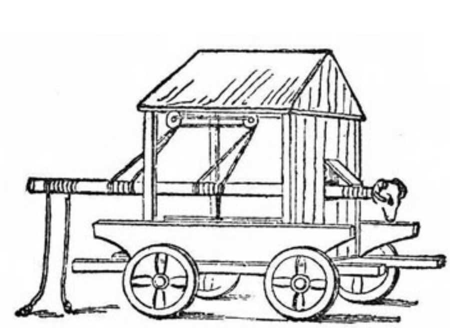
Iron Age developments in technology and greater resources allow the construction of improved siege engines to counter fortifications.

Rams, Picks, and Drills

Iron Age battering rams were often far more elaborate than hand-carried logs. The standard TL2 ram has an iron-sheathed head and is either mounted on rollers or attached by chains or ropes to the roof of a wheeled frame. The roof is braced with heavy timbers and covered with wicker, hides, and straw soaked with vinegar for protection from fire. It provides cover for those beneath it until breached or set aflame. One Assyrian model, housed in a six-wheeled vehicle and powered by 10 men, is listed in the Appendix (p. 118).

Rams deliver dice of damage equal to a fraction of the total ST of the men using them:

Ram Type	*Head*	*ST Multiplier*	*RoF*
Hand-Held	Iron	1/2	1/60
Sling Ram	Iron	2/3	1/45



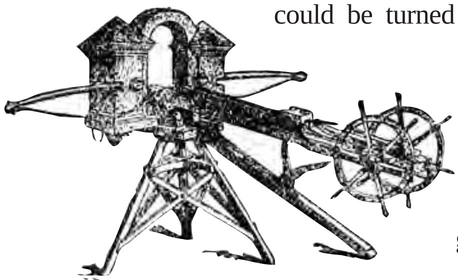
Picks and drills are now made of iron and take 100/ST minutes to inflict 1 point of damage.

Another variant on this technique, which is favored by the Assyrians, uses a large spearlike blade mounted on a long wooden beam to attack a city wall from a safer distance. It takes at least two men to wield this device, which needs 200/ST minutes to inflict one point of damage, but the users are not directly under the parapets, a dangerous location if the walls are manned.

Artillery

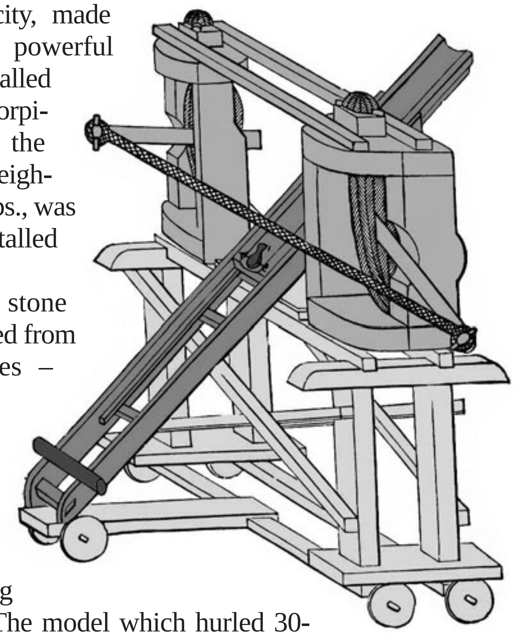
The first artillery weapons in Europe were devised in Syracuse in 399 B.C. (see sidebar, p. 65). The original weapons were powered by the elasticity of a bow. Within half a century, torsion springs had been devised that were more compact and could store more total energy. The non-torsion forms were abandoned for centuries.

The first known example of artillery, the *gastraphetes*, was a one-man portable dart thrower with a curved crosspiece that was braced against the stomach to cock the string. The operator pushed a slider out the front of the gastraphetes, caught the string on a claw at its back, and then leaned into a wall to force the string back. The ST rating of a gastraphetes can only exceed that of its user by 4. This limit was circumvented by the addition of a crank that could be turned to draw back the bowstring.



Roman Ballista

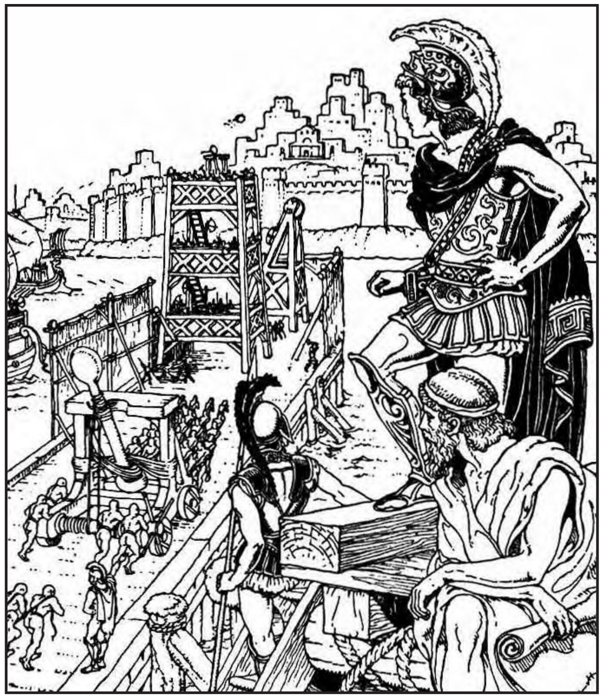
The shift to torsion springs, made from animal sinew, from horsehair (not as good), or in emergencies from hair donated by the women of a city, made possible more powerful bolt throwers, called catapults or scorpions. One of the larger sizes, weighing about 110 lbs., was commonly installed on warships.



Roman Torsion Catapult

The first stone throwers evolved from the gastraphetes – the greater power of torsion springs allowed the production of large devices hurling heavy stones. The model which hurled 30-lb. stones was considered most efficient overall, but a larger one, using 60-lb. stones, was necessary for any attempt to break through a city's defenses. Warships sometimes carried a small weapon which hurled 15-lb. stones.

Around the second century A.D., the Romans developed a one-armed torsion-powered device that used a lobbing motion to hurl stones in a vertical plane. Called an *onager* (after a type of wild ass known for its dangerous kick), it had to be fired from a solid platform.



The names of mechanical artillery devices are often confusing, as their meanings changed in the course of history. Originally, both bolt throwers and stone throwers were called by the Greek name *katapeltes*. The Romans kept the name catapult for bolt throwers, but borrowed the Greek word *ballista* for stone throwers. Relatively small catapults were also called scorpions. However, by the fourth century A.D., the bow was revived as an energy storage device in bolt throwing engines, which became known as ballistae (or *arcuballistae*, the source of the medieval word "arbalest"). The name catapult then came to be used for stone throwers. Since this usage evolved during very late TL2 or early TL3, the older names are used for TL2 engines.

Torsion-powered artillery is susceptible to malfunction in wet weather, as skeins go slack and springs soften. In the later Roman Empire, experiments were made with other forms of energy storage, including bronze springs and pistons and cylinders that stored energy in compressed air. All these devices proved impractical due to the limitations of metallurgy and machining.

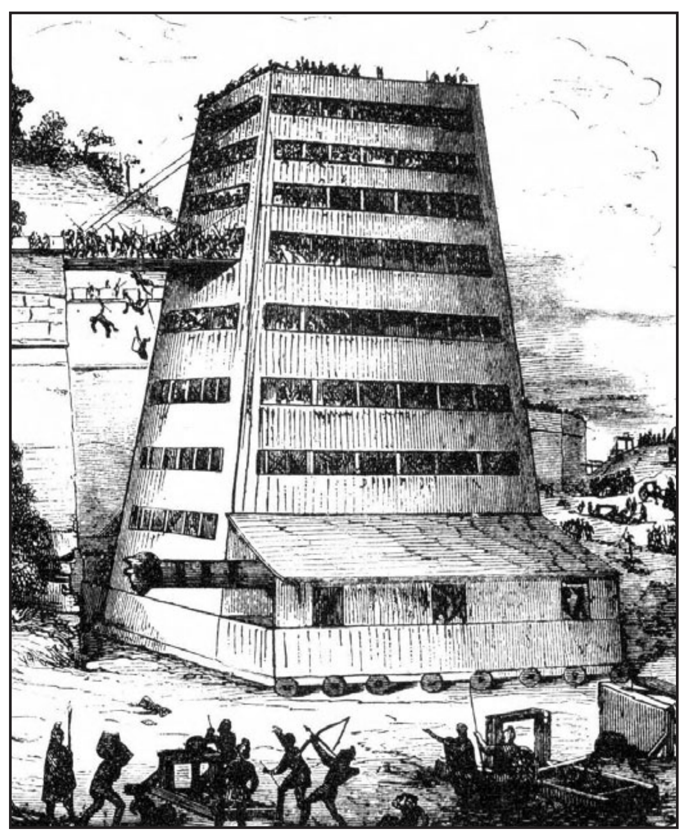
Siege Towers

Although wooden or leather-and-cord scaling ladders remain in use throughout the Iron Age, a number of technological enhancements were developed to make such assaults more effective. Foremost was the siege tower itself, built in a variety of sizes; see the Appendix for a common Persian model carrying one ballista throwing 15-lb. stones and four 110-lb. scorpions. Other developments included:

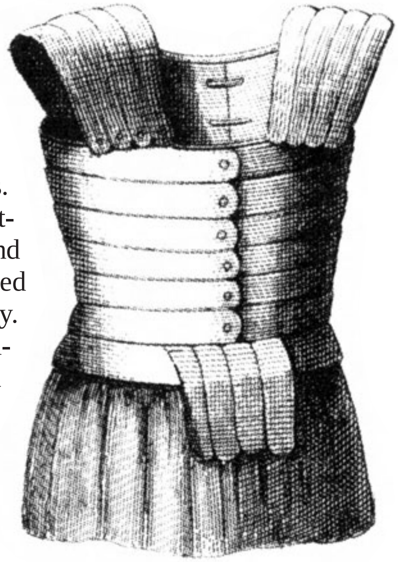
Korax. A flying bridge attached to the belfry of a siege tower. As the tower rolled up to an enemy wall, the korax could be lowered across the gap between the two structures, providing a more secure and defensible point of access. The korax was usually wide enough to allow two warriors to move abreast. Its statistics may be estimated as 37.5 lbs. and $10 per foot of length; treat it as DR 3, with 2 HP per foot of length.

Sambuca. This "siege ladder" was a mechanical contraption with reinforced sides and a roof. A 10-man assault party entered a compartment at the front. Up to 2.5 tons of counterweights were then loaded into the rear, tipping the front end up to the height of the enemy battlements. The sambuca was too heavy to be pushed aside and could be built long enough to traverse ditches or moats. However, the assault party within was vulnerable to counterattack as it advanced.

Helepolis: The ultimate example of this craft was the helepolis ("city-destroyer") built for Demetrius Poliorcetes for his siege of Rhodes in 305 B.C. That tower was built on a grille of timberwork 72' square and had a total height of 140'. The bottom level covered 4,225 sf and the topmost level 900 sf. The nine floors of the helepolis contained 16 catapults and four ballistas, each of which had its own port with shutters that opened and closed mechan-ically. Occupants moved between floors via two internal staircases. The front and sides were covered with iron plates, while the artillery ports were padded with leather and wool. The 150-ton tower had eight iron wheels 15' in diameter and room for 1,200 men to push at a time, moving it forward at about 2' per hour. During the siege, the helepolis drove the defenders of Rhodes off the battlements, as its heavy catapults stripped the crenelations off the city walls. Nonetheless, it was ultimately forced to withdraw when the Rhodians mired it in a swamp of sewage, dislodged some of its protective iron plating, and shot flaming arrows at it.



Armor

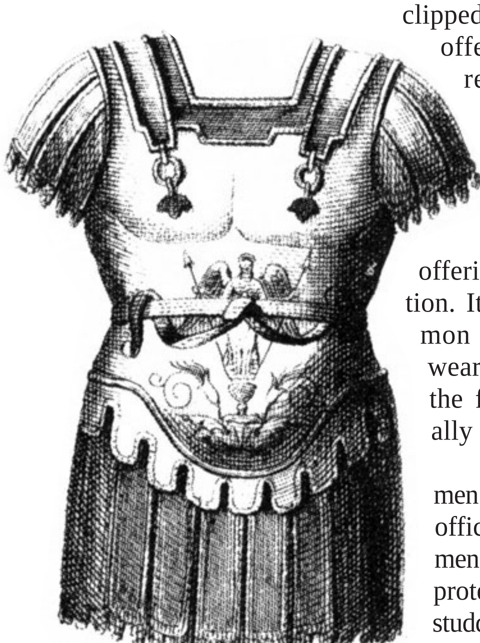


During the Iron Age, the most common body armor was still worn over the chest, abdomen, and vital areas. Most torso armor protected the wearer front and rear, but some provided frontal protection only. Partial leg coverings, primarily hinged or strap-on metal greaves, fell in and out of favor. Armor for shoulders, arms, and thighs was rare.

Metal armor was sometimes still made of bronze, sometimes of iron. Scale and lamellar armor were readily converted over to iron. Iron was not easily cast into large flat surfaces, and cast iron was brittle, so bronze remained the material of choice for breastplates and cuirasses. On the other hand, iron could be drawn into wire far more easily than bronze, allowing its use to make chainmail. This was developed by the Celts, who were skilled ironworkers, and later adopted by the Romans. It was later replaced by the *lorica segmentata*, body armor made of articulated small plates of bronze or iron shaped to fit the torso.

A lighter form of armor was a form of cloth cuirass made by gluing multiple layers of linen together. This was used either by itself or as a base for a lighter form of scale. Linen cuirasses wrapped around the torso and tied together on the left.

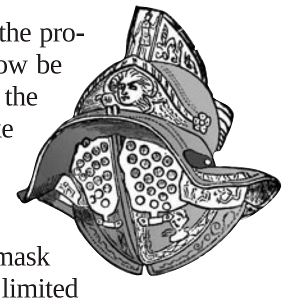
Both Greek and Roman warriors wore bronze greaves for lower leg protection. Greek greaves were hinged and clipped around the leg, offering front and rear protection. Roman greaves were strapped onto the leg through ring attachments, offering no rear protection. It was not uncommon for warriors to wear greaves only on the forward leg (usually the left).



Persian cavalrymen and later Roman officers and cavalrymen gained some leg protection from their studded leather skirts.

Roman gladiators wore distinctive armor shaped as much by the need for dramatic fights as by the need for protection. A bronze breastplate, offering protection only to the front of the body, might be combined with a *galerus*, a leather and bronze covering for one arm that could be used in parrying. When so used, it adds PD 2 to the parry, but any parry roll that succeeds by less than 2 points causes the attack to hit the arm (the DR of the galerus protects normally).

Helmets

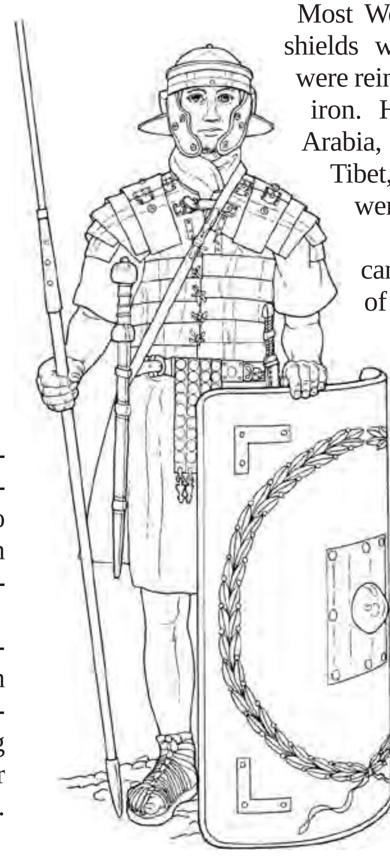


Similar developments occurred in the production of helmets. Pot-helms could now be made out of iron for better protection of the head. Chainmail could be used to make coifs.

Again, gladiators had a distinctive form of protection for the head: a heavy bronze helm with an attached mask made of a net of bronze wire that gave limited security against impaling attacks.

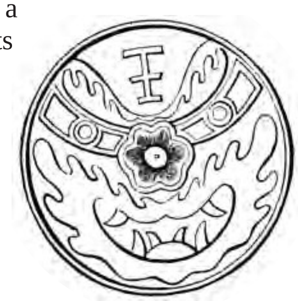
Shields

As in the Bronze Age, shields remained essential equipment for most warriors. The Greek phalanx and Roman legion deployed their shields in close formation to provide both the first line of defense and the offensive thrust to break through the enemy lines. The freewheeling, individualistic Celtic sword-fighting style also demanded a shield to be effective. Even light cavalry units used shields for protection as they rode into the fray to throw their spears.



Most Western European and Chinese shields were of wood, though many were reinforced with leather, bronze, or iron. However, throughout Africa, Arabia, the Middle East, India, and Tibet, shields of hardened leather were the norm.

The characteristics of shields can generally be defined in terms of the list of standard shield types in the Appendix. The Persian *gerron* was a medium leather shield on a wicker framework with a bronze boss, and can be considered as studded leather. The Greek *hoplon* was a large round bronze-faced shield with an armband rather than a handgrip; it partly protected the user (PD 3) and partly the man on his left, if they maintained formation (PD 1). A leather curtain was sometimes hung from its bottom to give +1 PD to the user's legs (hit locations 12-14). The Greek *aspis* was a medium round bronze-faced wooden shield with two slots cuts out of the rim to let the bearer hold a two-handed spear or pike; when used this way it gave reduced protection to the shield arm and hand (see the figure-eight shield, p. 49). The Celts used a large oval iron-faced shield. The Roman *scutum* was originally a large oval wooden shield with an iron boss, but by the late Empire it had evolved into a lighter medium wooden shield.

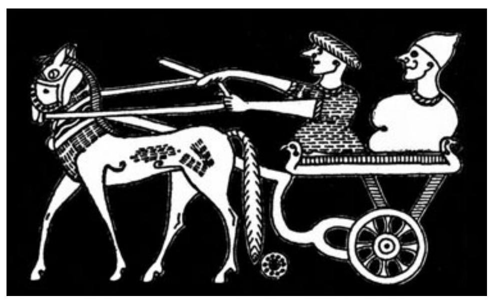


A distinctive technique of the late Empire was the *testudo* ("tortoise"), in which shields were locked together to form a continuous wall around the men carrying them. A variation on this technique was raising the wall overhead. There are accounts of soldiers running on top of such a raised testudo to get over a low fortification.

Vehicles and Transportation

Land Vehicles

In most Iron Age cultures, chariots disappeared as a military unit once cavalry horses were available. Iron Age chariot units were only used by three cultures – the Assyrians, the Persians, and the Celts. The Persian army experimented with scythed-wheel chariots, but these seem to have been fairly easily avoided in actual combat.



Celtic chariots were two-man designs similar to those used by the Egyptians, though their riders tended to use javelins rather than bows. Celtic chariot warriors "ran the pole" to fight enemies positioned in front of the chariot.

Running the Pole (Hard) *Defaults to Acrobatics or Teamster -4* *Prerequisite: Teamster; cannot exceed Teamster skill*

This is running out along the yoke-pole of a chariot to strike at an enemy. On a critical failure, the pole runner falls under the chariot's wheels; on an ordinary failure, across a horse or the front of the chariot. An ordinary success allows an attack at -2 to combat skill; a critical success eliminates the penalty.

Finally, the chariot was used for racing, notably in the Roman arena. Chariots for this purpose had a specialized design that eliminated as much weight as possible for the sake of speed (see Appendix, p. 118).

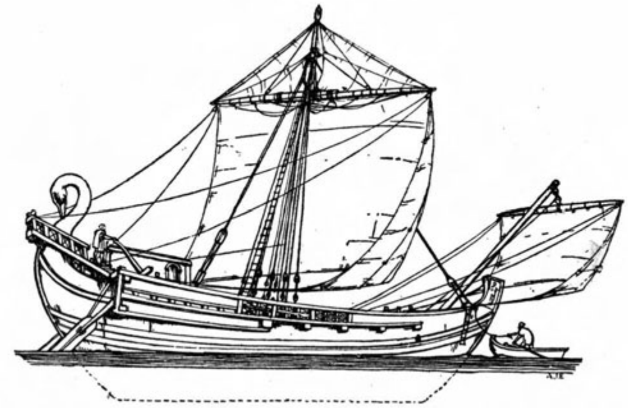
Ships

Iron Age warships embodied a new approach to naval warfare. The Bronze Age warship, like the Bronze Age chariot, was a mobile platform for archers, who attacked the crews of enemy ships. But the Iron Age warship was designed to attack the enemy ship itself. All the tools of siegecraft, from the ram to the catapult, were used to sink enemy ships, overwhelm their crews, or board them. Specialized ship designs were created for warfare, while equally specialized cargo ships served the needs of commerce.

Construction

Iron Age ships were not fundamentally different from Bronze Age ships in construction; they were still built shell first, with planks set edge to edge, and had frames for strength. However, Greek ship construction used a form of the mortise-and-tenon technique for joining planks, providing a hull that could withstand very strong stresses and remain watertight. This technique was retained until the later Roman Empire, when governments short of funds began using less sophisticated – and cheaper – methods of construction (see the discussion of Byzantine ships, p. 101).

Classical shipwrights built ships of unprecedented size. An early example was the *tessarakonteres* ("40") built by Ptolemy IV. According to historical accounts, it was 420' long and 5' wide, built on a catamaran style hull with a double bow, a double stern, and seven separate rams. The ship could carry 2,850 marines, 400 other crewmen, and 4,000 rowers, though this was on a trial run and may have exceeded the normal crew size. There is no indication that this craft ever fought in combat, but its sheer unwieldiness inspired the invention of the dry dock.



More practical large ships were built for the grain trade between Egypt and Rome. One such was the *Isis*, used during the second century A.D. This freighter was 180' long, 45' wide, and nearly the same distance from the deck to the bottom. An estimate of her capacity based on Venetian ships of similar design works out to just over 1,200 tons of cargo, 10 times the burden of a typical cargo ship.

Propulsion

Ships of the Iron Age had one major innovation in propulsion: the use of multiple oarsmen on each side of the ship. This began with Phoenician biremes, in which one row of oarsmen occupied the normal position and a second sat above them. The Greeks altered this design, placing a row of oarholes low in the hull and seating the second row of oarsmen there. Then they began to construct triremes, with light superstructures overhanging the sides to shelter an upper row of oarsmen.

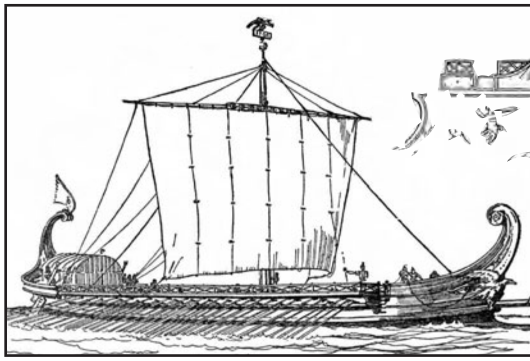
The trireme made the Greeks masters of the seas. It was purely a warship, built to ram enemy ships, cutting off their oars or steering gear or damaging their hulls; the Greek poet Aeschylus compared it to an arrow fired at the enemy. Power came from lower and middle rows of 27 men on a side and an upper row of 31 men. Sails were used for long journeys but were discarded before battle, to save weight, rather than trusting to the unreliable wind. A trireme carried five officers, 11 crewmen, and 14 marines.

An enormous fleet carrying grain from Egypt enabled Rome to exceed a million inhabitants.

The trireme had only one man per oar. Later ships put more men on some or all of the oars. This had the advantage that only one man per oar had to be a skilled seaman; the others followed his lead. For example, the quinquereme had two men on the top oar, two on the middle oar, and one on the bottom oar. The Romans took this principle further, with a version of the quinquereme that had five men working a single oar. Experimental shipwrights created ships with almost every possible number of oars, from the *hemiolia*, with one full row of oars on each side and half of another row to leave room for handling the sail, up to Ptolemy's tessarakonteres. Ship design became more stable under the Roman Empire, which used triremes, quadriremes, and quinqueremes, with one "six" as flagship, supplemented by lighter ships called *liburnians*.

Chinese Iron Age ships, such as the *yichuan* (warship) and the *louchuan* (multidecked ship), almost certainly were similarly powered by multiple oarsman at each side. The standard complement for a warship was 50 rowers, but a ship 60'-80' long could not have accommodated 25 men per side. Whether they had two oars per position, or two men pulling one oar, is not certain.

Classical ships still used the square-rigged sail. However, triremes and many later ships added a second sail carried forward of the main sail. This somewhat increased the speed they could attain, but also gave them more flexibility in maneuvering against the wind. Early experiments with lateen-rigged sails were made in the Mediterranean, but this design is discussed under TL3, where it came into common use.



Roman Trireme and Ram

There is some evidence for the use of sails on Chinese and other East Asian watercraft in this period. However, it is unclear whether the Chinese used sails on ships (as opposed to boats). The TL2 designs in the appendix (p. 119) are based on documented ship designs powered by oarsmen.

Ships' Weapons

A ship ramming another ship causes damage to the other ship and to itself, as follows. Multiply the body HP of the ship by its Move, and divide by 100; this is the number of dice of damage it inflicts. (For over 20d, round to the nearest multiple of 6d.) If it actually has a ram, it inflicts +1 damage per die, but suffers -1 damage per die.

Later Greek and Carthaginian quinqueremes supplemented their rams with mechanical artillery. A typical Greek quinquereme might carry four 110-lb. scorpions (ST 37); a Roman quinquereme might increase this to nine and add two ballistas firing 15-lb. stones.

The *corvus*, or raven, named for its protruding beak, consisted of a boarding plank 36' long by 4' wide with a spike at the end, mounted on a galley's prow. When a galley armed with a corvus closed on the enemy, the plank was swiveled into position and dropped – the spike stuck in the opponent's deck and locked the two ships together. Marines then crossed the plank two abreast, resting their shields on the side rails to give them protection. The corvus gives +2 to Shiphandling on all boarding rolls (CII, p. 98) made by the attacking ship's captain. However, it also makes the attacking ship topheavy, with turns requiring a Shiphandling roll at -1; perhaps for this reason it did not long remain in use. It has DR 3 and 54 HP. Weight: 1,080 lbs. Cost: $432.

The *harpago* was a heavy metal bolt trailing a length of rope that could be shot from a catapult to catch another ship and pull it close for boarding. Its range is one-half the normal range of the catapult; if the damage it inflicts exceeds the DR of the target it is embedded. An attached harpago adds +4 to Shiphandling for boarding rolls made by the attacking ship's captain. The harpago is destroyed if it takes 25 points of damage to its metal grapnel or 10 points of cutting damage to a specific section of the connecting rope.

Roman warships carried collapsible fighting towers 6' high that could be erected fore and aft. A tower has DR 3 and 80 HP. It provides the benefit of added elevation in missile combat and also provides DR 3 from the waist down for men standing in it.

Fleet commanders in a number of historical campaigns found occasion to utilize vessels for tasks outside their normal roles. The outstanding example was in 480 B.C., when the Persian King Xerxes marched his army across the Hellespont by creating a mile-long pontoon bridge out of 300 boats lashed together with cables and paved over with stout planking.

Tartessians were real voyagers, not like the Achaeans, who composed an epic on their own bravery if they spent one night out of sight of land.

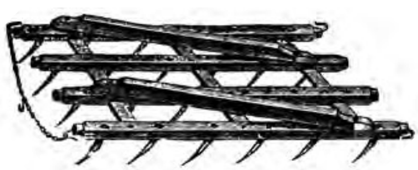
– S.M. Stirling, *Island in the Sea of Time*

Tools and Equipment

Many new types of equipment became available for the first time in the Iron Age.

Agricultural Tools

Harrow



Commonly used in China during TL2, the harrow consisted of a heavy wooden frame with metal teeth or disks mounted on its front. It was pulled by draft animals across plowed ground to level it for planting. Harrows did not appear in Europe until TL3. Weight: 20-100 lbs. Cost: $20-$200. Pulling a harrow is equivalent to dragging a load of 480 lbs. (see *Animal Traction*, p. 37).

Moldboard Plow

Created by the Slavs and improved by the Chinese, this iron-bladed three-part plow could cut through heavy soils and clay to turn the soil for planting. It enabled farmers to turn forests, steppe, and other marginal terrains into arable farmland. It was not especially useful in the light soils of the Mediterranean and Near East and was not adopted there. Weight: 40-200 lbs. Cost: $40-$400. Pulling a moldboard plow is equivalent to dragging a load of 960 lbs. (see *Animal Traction*, p. 37).

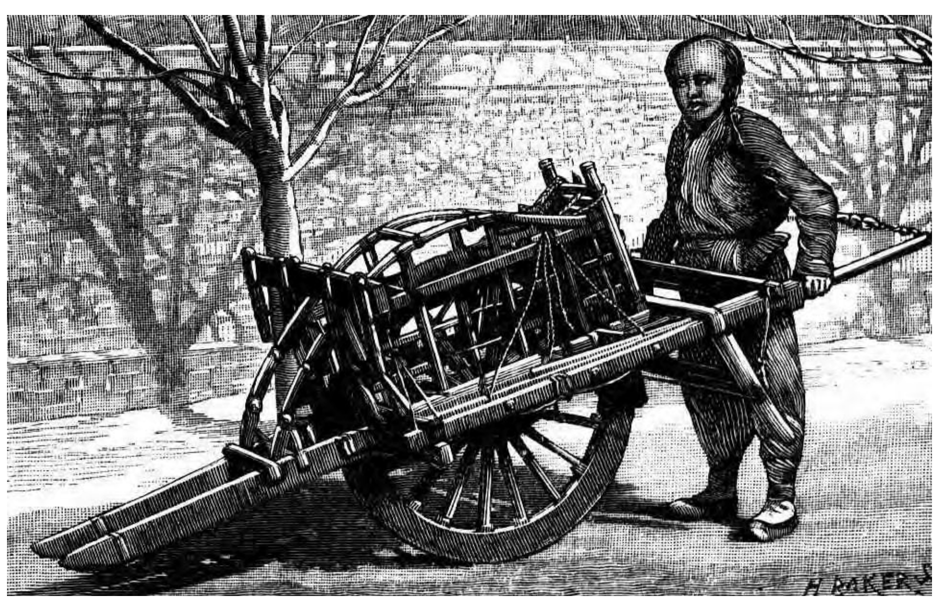
Push-Scythe

This Chinese reaping tool had a single blade attached to a Y-shaped pole with a wheel on each side. Its operator moved along a row of grain cutting down the stalks, while others followed to pick them up. Weight: 15 lbs. Cost: $50.

Wheelbarrow

The wheelbarrow was invented in China somewhere between the first and third centuries A.D., though it was not introduced to Europe for another thousand years.

Those using a wheelbarrow should divide the effective weight of any load carried in it by 5. As with all wheeled vehicles, bad terrain can slow its movement (pp. B187-188). Weight: 18 lbs. Cost: $60.



Craft Tools

Bellows

The bellows is a pleated leather bag with a nozzle, through which air is pumped by alternately opening and closing a pair of wooden sideboards. It was used by ironworkers to get a hotter fire. A one-man model weighs 5 lbs. and costs $100.

Screw

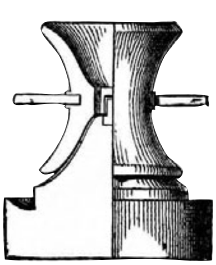
The screw was invented around the fourth or third century B.C. but never attained common use during antiquity, because screws had to be laboriously cut and filed by hand. Weight: negligible. Cost: $25.

> This is the race of iron. Neither day nor night will give them rest as they waste away with toil and pain. Growing cares will be given them by the gods . . .
>
> – Hesiod, *Works and Days*

Survival Gear

There was little change to the traveler's basic kit during TL2, except that carrying containers and eating implements might be made of iron instead of tin or bronze. Survival gear still included ropes, light sources, foul weather clothing, bedding, and several days' rations, plus packs or knapsacks to hold and carry these things. Armies on campaign carried a variety of tools including shovels, axes, and sickles (see p. 29). They also carried other tools:

Hand Mill



This is a small rotary hand mill to be operated by one man. Most soldiers and other travelers carried them as standard equipment. Output in pounds of flour per hour equals the ST of the user; an average man can grind grain for five men in an hour. 5 lbs., $20.

Mattock

A digging tool with its blade set at right angles to the handle and swung with a downward motion. It is shaped like a modern hoe (unlike the blade of a TL2 hoe, which typically extended straight down from the end of its handle), but swung into rather than dragged over the ground. Weight: 6 lbs. Cost: $20.

Pickaxe (Dolabra)

A socketed wood-handled tool with a slender (3" wide) axe blade on one side of its iron head, which tapers to a point at the opposite end, useful for chopping brush and breaking rock. It often comes with a sheath that covers the cutting edge to keep it sharp. Weight: 7 lbs. Cost: $18.

Turf Cutter

A digging tool with a T-shaped shovel handle and a short crescent-shaped cutting edge that comes to a point at both ends. Weight: 4 lbs. Cost: $15.

Riding Gear

The cavalry forces of the Iron Age did not use the stirrup; it is considered to be a TL3 device. Riding with and without stirrups are considered to be different familiarities within the skill of Riding: Horse (see p. B43). They default to each other at -3. Stirrupless riders cannot use the Lance skill.

Mounting a horse under ordinary circumstances does not call for a skill roll. A rushed or untrained horseman must roll against Riding to mount, at -2 per Encumbrance level (-2 for light, -4 for medium, etc.).

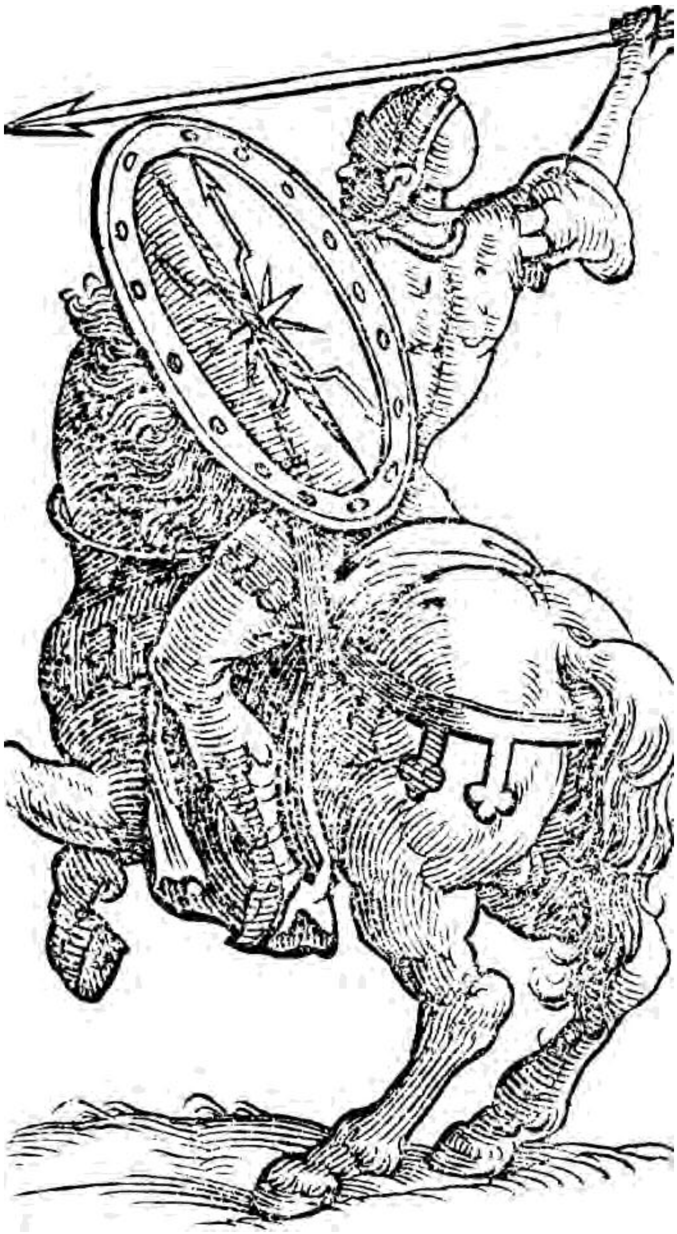
Mounting without stirrups under these circumstances is at an additional -2.

The use of stirrups and other riding gear affects other aspects of horsemanship. For a rider with no equipment, rolls to control the horse are at -4, as are rolls to keep his seat if hit (see pp. B136-137). Weapons skills are at -2. If the horse is ridden all day, it may become chafed or suffer a split hoof. Roll against the horse's HT. A failure means that the horse needs to rest for 1d days. A critical failure indicates a split hoof or other severe injury; the horse must be put down.

The following gear offsets some of these problems. Except as specified, the modifiers may only be used to offset penalties, not to gain bonuses to Riding skill.

Bridle

A simple bridle, with no bit, gives +1 to rolls to control the horse if used one-handed, or +2 to rolls if used two-handed. Bridles become available at TL1, since they are essential to controlling chariot horses. Weight: 1 lb. Cost: $10.



Bit

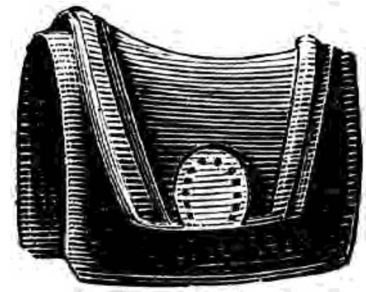
A bit must be used with a bridle. The combination gives +2 to control the horse if used one-handed, or +3 if two-handed. Bits also date from TL1 charioteering. Weight: 2 lbs. Cost: $25.

Certain types of bits give an extra +1 to rolls to control the horse, which may provide an actual bonus to Riding skill. However, they are also harsh and may damage the horse's mouth, or cause it to spook, on a critical failure to Riding.

Blanket

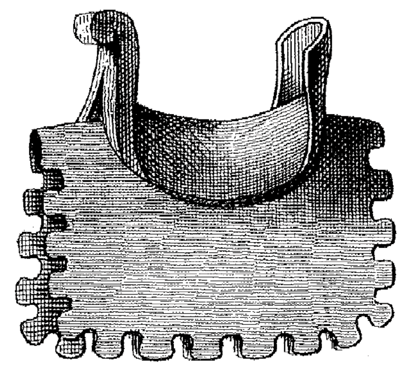
Placing a blanket on a horse's back gives +1 to its daily HT rolls after being ridden long distances. Blankets are available at TL1. Weight: 5 lbs. Cost: $50.

Riding Saddle



Invented about 500 B.C., the saddle distributes the rider's weight so that it is easier for the horse to carry. It gives +1 both to rolls to control the horse and to rolls to stay seated. Riders accumulate Fatigue at intervals of 3 hours. It takes about 5 minutes to saddle a horse. A riding saddle (including the saddle blanket) weighs 15 lbs. and costs $150.

Roman Cavalry Saddle



Cavalrymen in the later Roman Empire used a saddle especially designed to help them stay mounted in combat. Effects as above, except it gives +2 to rolls to stay seated. A Roman cavalry saddle (including the saddle blanket) weighs 25 lbs. and costs $300.

Spurs

Emblematic of horsemen throughout history, spurs give +1 to rolls to control a mount; these may give an actual bonus to Riding skill. Weight: negligible. Cost: $25 for utilitarian spurs; potentially much higher for ornamental spurs worn by aristocrats.

Some of the limitations of TL2 equipment can be overcome with suitable maneuvers:

Vaulting (Hard) Defaults to Riding-2 or Equestrian Acrobatics
Prerequisite: Riding or Jumping at 12

The vaulting maneuver lets a horseman leap from the ground into the saddle without the aid of stirrups, in 1 second. It cannot be raised above Riding or Equestrian Acrobatics skill; that is, full training in this maneuver is a normal part of Equestrian Acrobatics.

Couching (Hard) Defaults to Spear-5
Prerequisite: Riding-12

The couching maneuver enables a spearman to brace himself on a horse so that he can use a spear like a lance. If the maneuver succeeds, a successful attack roll causes damage based on the ST of the mount, not that of the rider. The maneuver cannot exceed Spear skill. A Roman cavalry saddle gives +1 to Couching.

Also, the Horse Archery maneuver (p. CI169) is available at TL2; in fact, the cavalry of many nations specialize in it.

Barding

With the development of heavy cavalry in the later Iron Age, horses began to be armored to protect them in combat. Early armor usually protected just the front quarters, while later forms extended back along the horse's flanks. (See p. CII54 for quadruped hit locations.)

The chanfron is a face-guard that extends from the horse's forehead to the bridge of its nose. Simple versions provide no cover for the eyes; more advanced designs include perforated eye guards. Hit location 5.

Neck armor is usually combined (and often completely integrated) with a chanfron. Hit location 6.

Barding is body armor for a horse, taking the form of a "blanket" over its back and wrapped around its chest. It may be combined with a chanfron and neck armor, and the three items may actually be integrated. It protects hit locations 7-9, but does not protect against attacks from directly behind the horse.

Horse armor may be made of leather and quilted cloth (PD 2, DR 2), mail (PD 3, DR 4, but PD 1, DR 2 vs. impaling weapons), or scale (PD 3, DR 4).

Element	**Leather/Cloth**		**Mail**		**Scale**	
	Wt.	*Cost*	*Wt.*	*Cost*	*Wt.*	*Cost*
Chanfron	3 lbs.	$40	7 lbs.	$60	12 lbs.	$200
Neck Armor	6 lbs.	$80	15 lbs.	$100	20 lbs.	$320
Barding	22 lbs.	$260	50 lbs.	$440	60 lbs.	$480

The *peytral* is a bronze chest plate. Hit location 7 (PD 3, DR 4). Weight: 30 lbs. Cost: $250.

Elephants

Elephants had several military uses at TL2: as shock troops placed ahead of infantry formation or held in reserve to exploit a breakthrough in the enemy lines; as mobile platforms for missile troops; to tear down palisades in siege warfare; or against cavalry, since horses dislike their smell. (A Riding roll is needed to avoid a horse spooking, as defined on p. B136, the first few times it encounters elephants.) They were used in the West by Alexander and Hannibal, in Persia under the Seleucids, and also in Nubia, India, Burma, and Ethiopia.

The elephant driver sat forward near the animal's ears, while warriors occupied a rawhide-covered frame cinched around the elephant's neck and waist with chains. Any elephant could carry a two-man tower manned with archers or javelineers; Indian elephants could be equipped with a larger four-man tower.

Bronze or brass caps were sometimes placed on elephants' tusks, giving +1 to damage from goring. Weight: 2 lbs. Cost: $50.

Miscellaneous

New categories of personal belongings that may be of interest to player characters include:

Bandages

Surgeons in many armies had assistants who were assigned to bandaging duty and had First Aid skill. A supply of bandages sufficient for half a dozen wounds weighs 2 lbs. and costs $30.

Burning Glass

A small circular glass lens used to focus the sun's rays to ignite flammable materials like tinder.

Soap

The first known European soap was a Gallic invention, appearing between 700 and 900 and spreading to the rest of Europe. It was made of animal fats treated with soda ash and had a soft consistency like a liquid soap. In Muslim lands, soap was made using olive oil, an alkali, and *natron* (sodium carbonate). This hard soap was imported into Europe starting in the 11th century. Soft soap (in flask): 1 lb., $5, lasts 12 baths. Hard soap (bar): 1/2 lb., $8, lasts 10 baths.

Surgical Instruments

Army surgeons carried a variety of specialized surgical tools, including scalpels, saws for amputations, drills for getting sling bullets out of bones, probes, forceps, needles, and catheters for drainage. A full kit weighs 15 lbs. and costs $300.

Windrose

This rectangular box contained 32 compass points around its exterior, each of which corresponded to the rise or set of one of 15 fixed stars. Latitude was determined by measuring the height of the sun or pole star. A windrose was effective only in the hemisphere in which it is produced, and was only available in advanced TL2 cultures. It reduces the penalty for lacking navigational equipment to -1. Weight: 1 lb. Cost: $25.

CHAPTER V

THE MIDDLE AGES: TECH LEVEL 3

"Friendship, when a friend meant a helping sword,
"Faithfulness, when power and life were its fruits, hatred, when the hatred
"Held steel at your throat or had killed your children, were more than metaphors."
– Robinson Jeffers, ***No Resurrection***

In terms of technological development, the break between the Iron Age and the Middle Ages is less sharp than between the Stone and Bronze Ages or the Bronze and Iron Ages. Many of the technological developments of the Middle Ages represented wider application of Iron Age inventions, from the water wheel to the lateen-rigged sail.

A common image of the Middle Ages is as a period of technological retrogression, in which ancient knowledge was lost. This is at best a partial truth. In Western Europe, the collapse of the Roman Empire meant that few people had time for ancient books or abstract curiosity, and this affected some practical sciences, particularly medicine. But on the small scale of village life, little useful knowledge was lost.

Globally, there is even less evidence of overall retrogression. The Muslims actively sought out the knowledge of the ancients, sending copyists to the Byzantine Empire to acquire classical texts for their libraries. In many ways, a truer picture of TL3 capabilities can be gained from the Near East than from Europe. And the Chinese – and, under their influence, the Japanese and Koreans – continued to follow their own path, on which some innovations emerged earlier than in the West, and others later.

Man and His Environment

Perhaps the most substantial advances of the Middle Ages occur in the areas of agriculture and related fields.

Farming

During the Middle Ages, most northern European countries adopted the moldboard plow and the harrow (see p. 77). The moldboard plow required a team of eight oxen. Since few farmers could afford so many, groups of farmers pooled their draft animals and took turns plowing their fields. Later, heavy draft horses were adopted for plowing (see *The Horse Collar*, p. 84).

A major advance in crop rotation, the three-field system, is generally credited to the English. Each farm was divided into sets of three fields. They were planted with winter crops such as wheat and spring crops such as peas, barley, and oats in a three-year cycle:

Life in the Middle Ages

Life in the later Iron Age was shaped for many people by the economic and political instability of their governments. The Dark Ages began with invasions by the Franks, Goths, and Huns. Later invaders in Europe included the Vikings, Arabs, and Mongols.

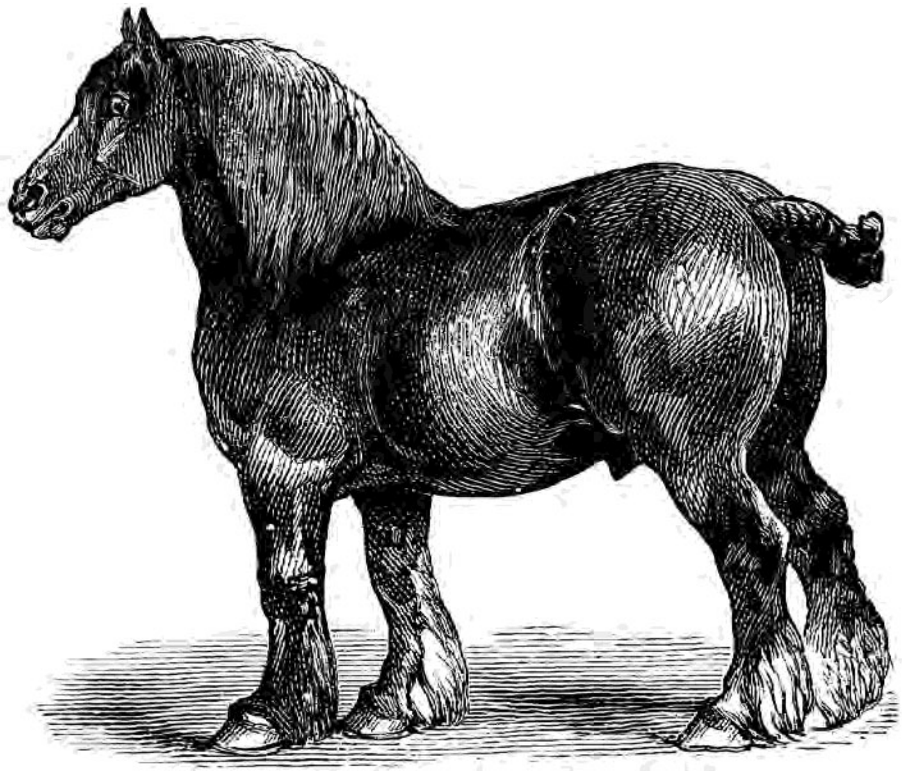
China, too, went through invasions and internal unrest around 300 A.D.; but, unlike the Roman Empire, China didn't disintegrate into total anarchy. By 550 A.D., the northern provinces had reunited with the southern areas, which resulted in a cultural renaissance. However, China was conquered by the Mongols in 1280 A.D.

In regions afflicted with chronic warfare and economic problems, large cities more or less vanished. Without large, stable agricultural regions to draw resources from (as, for example, Rome consumed huge quantities of grain from North Africa), large settlements could not thrive. Large cities shrank and new towns appeared, growing only to the extent that local agricultural produce and water supplies could support them. As cities disappeared, expensive urban luxuries such as aqueducts and plumbing with went them. However, TL3 empires such as China and Byzantium could still maintain cities with huge populations.

Despite Europe's forced decentralization, some technology survived and even became more widespread. For example, the Domesday Book, the Norman survey of England's population and resources, recorded one water mill per 350 inhabitants. Effectively, every large village had a technology that existed in only a few Roman cities. Similarly, almost every large village supported a knight equipped with armor and a heavy warhorse and living in a fortified hall. And important innovations increased economic productivity, especially in agriculture.

	Year One	Year Two	Year Three
Field One	Winter crop	Spring crop	Fallow
Field Two	Spring crop	Fallow	Winter crop
Field Three	Fallow	Winter crop	Spring crop

The three-field system spread out the labor of plowing more evenly through the year. In addition, it brought two-thirds of the land under crops at a time, rather than one-half. Appropriate crops better maintained the fertility of the soil, as well. As a result, the same land area could support more population.



Domestication of Animals

Horses continued to increase in size during the Middle Ages, with the development of the heavy warhorse, able to carry a knight in full armor, and of the draft horse, able to pull massive loads. New developments in the technology of horsemanship (see p. 84) led to increased use of horses. European farmers begin raising more oats, an ideal food for horses doing heavy work.

Europe's farmers made greater use of manure for fertilizer, especially from sheep. Whose field sheep should be pastured in was often the subject of lawsuits.

Fishing

During the Middle Ages, European fishing fleets grew larger than ever before. The herring fisheries of the Baltic added substantially to Europe's food supply. Large fishing fleets also sailed from China.

Forestry

From 1100 to the end of TL3, mankind's rapid growth placed incredible demands on forest resources, especially those of Western Europe.

The Ladby Ship Jarl

In 1935, the remains of a burial mound were excavated in Ladby, on the large island of Fünen in Denmark. Buried in the mound was a Viking ship, 72' in length and with a 9' beam. This was the grave of a Viking jarl, and one of only three known ship burials in Denmark. The Ladby Ship has been preserved *in situ*, and can still be seen inside its burial mound by visitors to Ladby. The grave had long been looted of most valuables, but enough fragments and mundane items remain to give an insight into the life of the man buried there.

"Ladby" was a significant jarl, or chieftain, of Fünen. He commanded the area around the Kerteminde Fjord, north of the modern city of Odense. Although his burial in a ship shows Norwegian cultural influence, his grave and those of several of his townfolk found nearby contain no artifacts of Norwegian or Swedish workmanship; Ladby may have discouraged contact with their neighbors across the Kattegat strait. With a fleet of ships and a fjord set up for defense, any potential traders – or attackers – could easily be repelled. Trade with fellow Danes would have been necessary, because the bulk of Danish iron came from deposits of ore on the mainland of Jutland. As a jarl, Ladby would have spent most of his time administering his town and settling disputes between residents. In times of crisis, though, he would command a force made up of farmers and craftsmen, skilled in fighting on land or at sea.

Ladby owned weapons and armor typical of a jarl: Two swords of fine pattern-welded steel, ornamented with hilts of gilded bronze inlaid with garnets; a functional iron axe decorated with silver inlay; several knives; a longbow and bundle of 45 arrows; an iron helmet; and a wooden shield with an elaborate iron boss. He had many horses and leather riding tack with bronze stirrups and spurs, as well as several pet dogs. His clothing was wool, richly decorated with gold and silver filigree, and his feet were clad in well-made leather boots. Other items buried with him include wooden buckets with iron bands, a decorative gilded bronze dragon's head, flints, and cushions filled with down. He commanded many ships, one of which served as his passage to the afterlife. The ship was of clinker-built wood with iron nails and had seats for 32 rowers. Iron shroud-rings aft held the sail when it was lowered. A row of iron spirals formed the mane of a dragon's head carved into the prow, and iron spikes adorned its tail at the stern.

Continued on next page . . .

Vast amounts of woodland were deforested. To aid in the preservation of the resources that remained, many rulers enacted strict laws limiting wood-cutting, foraging, and hunting. Some regions also began to use alternate fuels such as coal and peat. The use of coal in London, beginning in the 13th century, gave rise to the first severe man-made air pollution.

Mining

Quarrying stone was the principal mining industry in the medieval world. Virtually every city or large town maintained one or more quarries. Local sources of stone were essential, as its weight made it expensive to transport.

In China, gunpowder (see p. 91) was applied to stone quarrying. The explosive force of 1 lb. of black powder could break off 1,000 lbs. of rock.

As the best ores were worked out, mines went deeper than before. The survival of miners increasingly depended on water pumps and the first ventilation systems. Metallurgists also learned to work with lower-grade ores, if necessary.

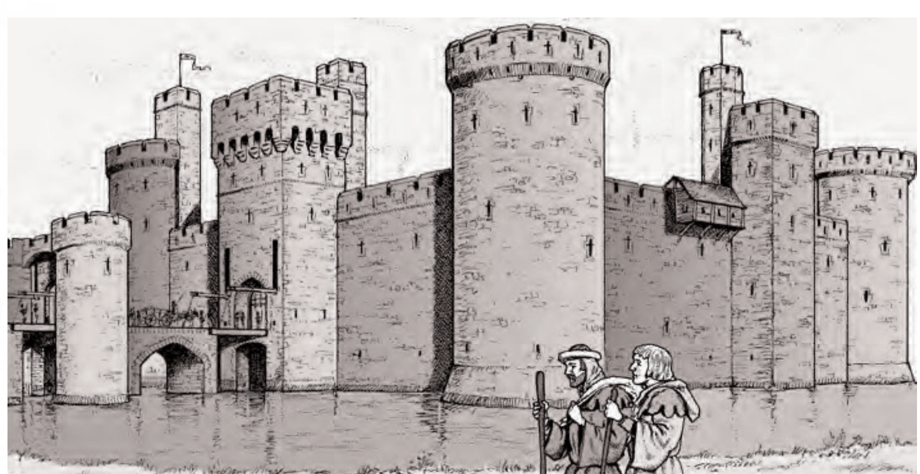
Technologies

The needs of church and state, in particular, stimulated a variety of advances in technology during the Middle Ages.

Architecture and Fortifications

Although not unprecedented (small hill-top forts date back to the Neolithic), the castle, in the sense of a fortified residence, reached a pinnacle of development at TL3. Most European castles were simply towers or keeps – thick-walled stone buildings two to four stories tall, small and cheap enough for even a minor lord to build and defend. A tower had one or two entrances; a well-built tower might have an entrance on the second floor, with defensible steps leading up to it. Upper stories might have shuttered windows, but lower floors had only arrow slits, which let defenders fire arrows from relative safety (-5 to hit someone on the inside). Floors were connected by ladders or spiral staircases. In early castles the ground around the tower or keep, known as the bailey, was surrounded by a wooden palisade. A ditch, or moat, ran around the palisade.

Later castles were more sophisticated than the simple moat and bailey design. Large castles had concentric sets of curtain walls 6-10' thick, or inner and outer courtyards divided by sections of defensive wall, moats, and a



The Ladby Ship Jarl (Continued)

The Ladby Ship Jarl
177 points

Age 35; 5'9"; 165 lbs.; a middle-age man with light brown hair and piercing blue eyes in a stern, distinguished face with a full beard.

ST 12 [20]; **DX** 12 [20]; **IQ** 13 [30]; **HT** 11 [10].

Speed 5.75; Move 5.

Dodge 5; Parry (Sword) 7; Block 7.

Advantages: Charisma +1 [5]; Filthy Rich [50]; Reputation +2 (Great Leader, Kerteminde Fjord area) [5]; Status 5 [20].

Disadvantages: Bad Temper [-10]; Code of Honor (Viking) [-10]; Intolerance (Norwegians and Swedes) [-5]; Stubbornness [-5].

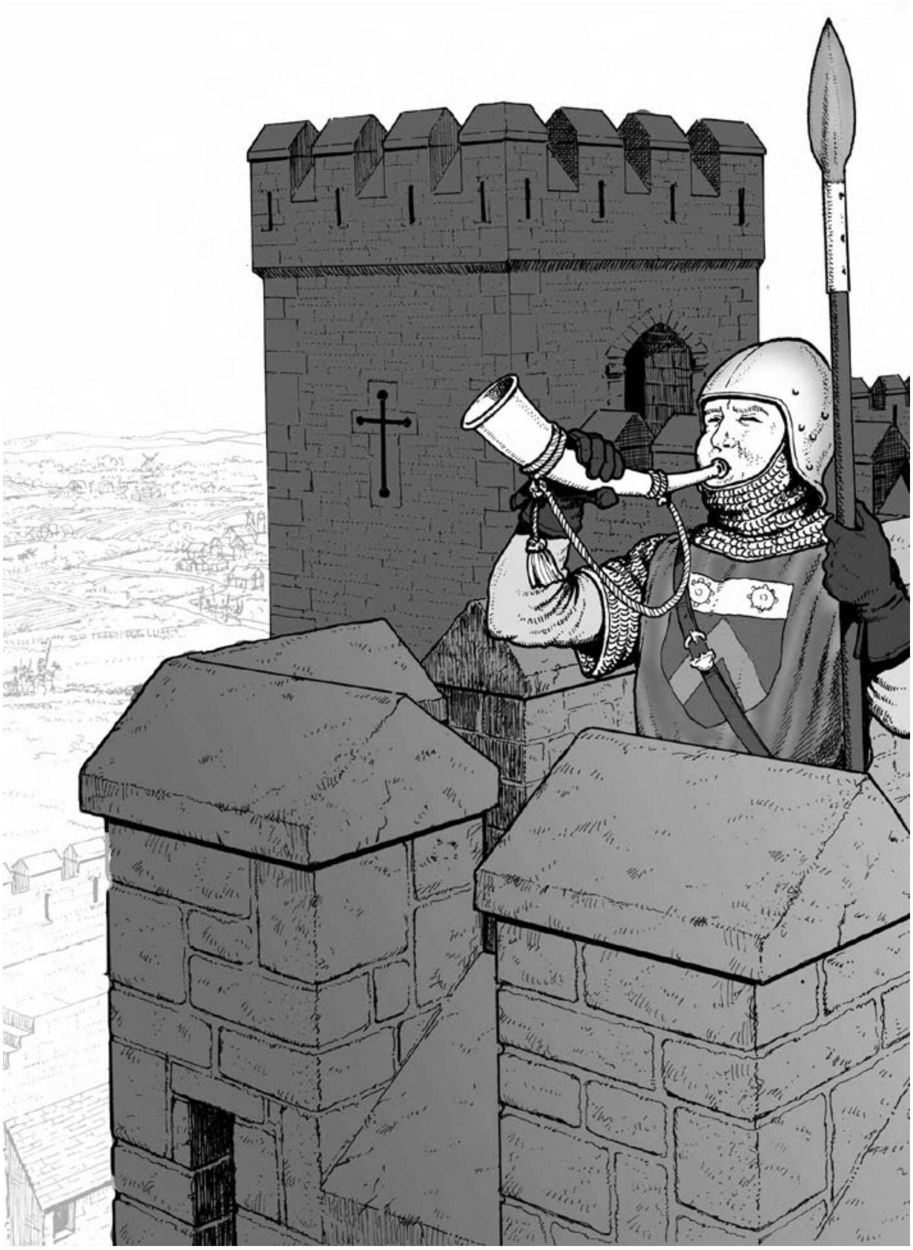
Skills: Agronomy-11 [1/2]; Animal Handling-11 [1]; Area Knowledge (Kerteminde Fjord)-13 [1]; Axe Throwing-11 [1/2]; Axe/Mace-11 [1]; Boating-12 [2]; Bow-11 [2]; Brawling-12 [1]; Broadsword-14 [8]; Games (Hnefetafl)-12 [1/2]; Knife-11 [1/2]; Law-12 [2]; Leadership-14 [4]; Navigation-12 [2]; Riding (Horse)-12 [2]; Seamanship-13 [1]; Shield-14 [4]; Shiphandling-13 [4]; Skating-11 [2]; Skiing-10 [1]; Tactics-12 [2]; Tactics (Naval)-13 [4]; Weather Sense-12 [1].

Languages: Old Norse (Native)-13 [0].

Further Reading: Glob, P.V., *Danish Prehistoric Monuments*, Faber and Faber, London,1971.

The Horse Collar

Around the 10th century, a new form of harness replaced the yoke and pole: the shaft-and-collar harness. A stiff collar moved the pressure of a load from the horse's windpipe to its shoulders. The efficiency factor is 0.15. Two draft horses (total ST 120, effective ST 18) could out-pull two oxen (total ST 160, effective ST 16 with a yoke and pole). Horses came into use for heavy work such as plowing (p. 82) and pulling wagons (p. 87).



strong keep as a last line of defense. The enclosed space held barracks, stables, storehouses, and sometimes siege engines to return fire at the attackers. Curtain walls followed the contours of the land to maximize their effective height; perfectly square or round castles were rare.

Gates, the weakest part of a fortification, received lavish protection. A well-protected castle might have extra gatehouses: small fortifications guarding a drawbridge or an uphill pathway leading to the main gate. Gateways had loopholes along the sides and machicolations (also called murder holes) in the ceiling, through which defenders could drop stones or fire arrows. The gates were built of hard wood as much as 6-8" thick and might have fire-resistant metal or leather coverings. In India, gates were often fitted with thick spikes to keep elephants from ramming them.

To enable defenders to fire at attackers close to the walls without exposing themselves to counterfire, European castles were built with long galleries overhanging the tops of the walls, with machicolations allowing downward fire. Indian castles used a different solution, downward-sloping loopholes in the crenels themselves. Defenders could fire from between crenels at distant attackers or from behind them at close ones.

Windmills and Water Mills

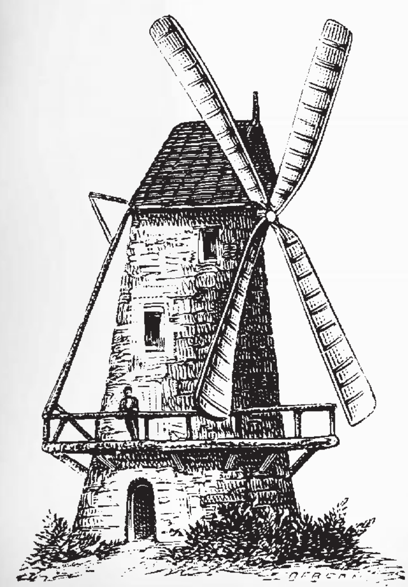
The first known wind-powered mills were developed in Iran around 500 A.D. Called vertical shaft windmills, these mills looked like a modern-day revolving door. They were turned by the wind blowing against the blades and required walls on one side to produce asymmetric pressure.

The invention spread to Europe after 1000 A.D. In the process, the horizontal shaft windmill was developed, powered by the wind blowing past its blades and creating lift.

A windmill's basic attribute is the diameter of its blades, equal to twice the length of a single blade. To find the cost in dollars, square the diameter in feet and divide the result by 2. Windmills are normally built in locations with reasonably steady winds. The power available from a windmill is ST equal to the square of its blade diameter, divided by 20. Cost is $10 per point of ST. For example, a windmill with 40' blade diameter would have effective ST (40 × 40)/20 = 80 and cost $800. This would let it grind 80 lbs./hour of grain.

Windmills are also used to pump water, for irrigation or drainage. Use any of the water lifting technologies described in previous sidebars (pp. 36 and 63).

The use of water mills increased substantially at TL3 as well. Mills served primarily to grind grain, but were adapted to a variety of other industrial functions, as they were stronger than men and didn't suffer fatigue.



Like Clockwork

Clockwork first appeared in early and experimental forms at late TL3, reaching maturity at TL4. Earlier cultures had used a huge range of devices for short-period timekeeping (burning graduated candles or incense, sundials, hourglasses, water clocks, and astronomical observation using astrolabes), but all suffered from practical problems of one sort or another, for those few members of the population who really cared.

The first application of complex mechanisms to the problem involved advanced water clocks. Large and ingenious water clocks were constructed in the Muslim world (apparently drawing on Hellenistic and Byzantine traditions of hydraulic engineering), but the supreme masterpiece was built in China in 1088 A.D., by a mandarin named Su Sung. This clock used a complex "linkwork" mechanism to regulate the movement of a wheel driven by water from a constant-level tank. The whole device was the size of a small house, and was built to allow the astrological configuration of the heavens to be determined for the emperor's children, even on cloudy days. It was probably more accurate than any clock produced in Europe before the 17th century. However, Su Sung's technological accomplishment was forgotten within a few years.

The earliest versions of modern clockwork were invented in Europe, again for ritual purposes. The rules of Christian life required prayer at specific hours, especially for monks, and clocks were invented to mark these times. Clockmakers worked on suitable mechanisms throughout the 13th century, culminating in the invention of the "verge-and-foliot" mechanism, applied to weight-driven clocks, at the end of that century. The first clock of which a detailed description survives was built for the English Abbey of St. Albans around 1328 by its abbot, Richard of Wallingford, the son of a blacksmith. This used an oscillating mechanism rather than the verge-and-foliot system.

These early clocks had no faces, and simply chimed the hours; the word "clock" comes from the medieval Latin word for "bell." The modern clock face probably evolved from clockwork-driven displays of the positions of the sun, moon, and planets, which became fashionable in Europe in the 14th century. By 1450, clockwork (built of brass rather than the cruder iron of early models) was both quite sophisticated and well known in large towns, but these devices were grossly inaccurate by modern standards, and still far from portable.

Feudalism in Japan also led to castles across the country, but of a very different shape. Control of access was the governing principle. Approaches to Japanese castles were broad ramps or winding steps up sharp slopes. An attacker approached through a long, narrow uphill passage which frequently twisted to break the force of a charge and was open to fire from defenders above. The structures of the castle were placed close together, which forced attackers through a maze of narrow passages exposed to crossfires. The Byzantines used a similar approach, building fortifications with bent entryways to slow attackers. Despite the advantage, bent entrances were equally difficult to launch attacks from.

Another major development in TL3 architecture is better known from churches than castles: the flying buttress. This was an arch placed against the outside of a building to provide support against sideways forces on the walls. This method of construction made it possible to build to heights of 300', as in Gothic cathedrals.

Crafts

Metalworking

Until the development of furnaces able to produce steel, smiths used a technique called pattern weaving to create steel blades. Small amounts of steel were forged into the edges of the blade, while softer irons were used to make the core. A more advanced variant on this technique was used by Japanese swordsmiths.

Folded metal ironwork treated the surface of the metal to attain a suitable percentage of carbon, and then folded the metal over to produce an interior layer of steel. Repeated applications of this technique produced a strong, light sword that could take a superb edge.

Steel made in certain areas had unusually fine qualities for such uses, whether because of superior ores or superior workmanship. Damascus steel was much in demand; in the later Middle Ages, European cities such as Solingen also gained good reputations.

Textiles

Several technological advances took place in textile fabrication. The spinning wheel was developed in China in 1035 A.D. to speed the production of silk thread. The use of a flywheel enhanced the speed of spinning roughly six times, reducing the total labor needed to produce cloth. The same technology was in use in Europe by the end of the Middle Ages.

Hand-operated horizontal looms developed in China during the Iron Age and made their way to 11th-century Europe by way of Muslim lands. In the 12th century, a mechanized horizontal loom appeared, operated by foot-treadles. These pedals raised alternate rows of warp threads above the body of the work, so that the loom's heddle bar could pass the shuttle through all of them in a single movement. Used with a new boat-shaped shuttle that contained a bobbin wound with thread, the new loom increased the weaver's efficiency.

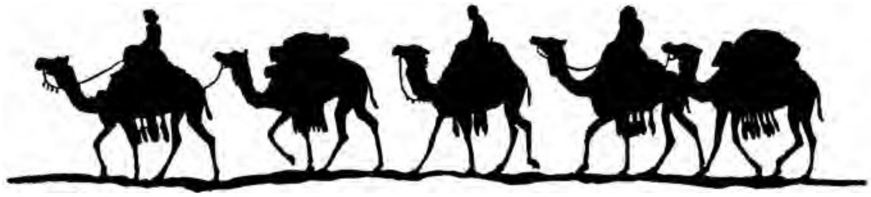
Starting in the ninth century, the water-powered fulling mill transformed the task of degreasing rough wool fabric. For centuries, fullers had used their own feet. A water wheel that drove a set of beaters tripled the amount of fabric a fuller could process.

Knit clothing made its first appearance in Egypt before 1000 A.D., where stockings were knitted with hooked needles of bone. Based upon evidence from medieval gravesites and from paintings of the Virgin Mary knitting, the practice was adopted in Europe by the 13th century. Knit goods from this period were knitted in the round, using double-pointed needles or a set of four needles, and then cut to finished form.

Glass

After the Roman period, glassworking techniques were most advanced in the Muslim world and Japan, until the end of the Nara period in 800 A.D. The crown glass technique, in which a partially blown lump of glass was attached to a pole and spun to produce a disk a few feet across, made possible the production of fairly flat glass. Leaded mirrors were available in Europe after the twelfth century.

However, the most striking development in medieval glassmaking was a European one: stained glass. The assembly of glass of varied colors into windows presenting religious images, first recorded in 1110 A.D., transformed the appearance of European churches.



Travel and Transportation

In Europe, horses were used more often as draft animals. Thanks to the horse collar (p. 84), they could pull enough weight to justify the cost of keeping them. Horse-drawn wagons came into regular use. By contrast, over nearly the entire Muslim world, animal-drawn vehicles were abandoned and the use of the wheel in transportation was forgotten. Pack trains of camels took their place. The expense of elaborate highways was unnecessary; outside cities, there were few roads.

Locks

The various styles of locks invented at TL2 (see p. 67) remained in use at TL3, with few innovations. The ingenuity of European locksmiths turned instead to cleverly hidden keyholes. Secret doorways are a characteristic medieval technology.

The Concept of Feudalism

In its simplest form, feudalism was a contract between the ruler of an area and his people. The ruler allowed a tenant or vassal to become "his man." The man swore an oath of fealty to his lord and was given a section of land as a fief. To keep this land the holder had to supply his lord with gifts of whatever his land produced. In addition, the holder had to give his lord men and arms. Failure to meet these terms might cause the lord to take his land back. Because these arrangements rested on an exchange of oaths, feudal Europe developed a ethical code that emphasized personal honor.

The laws and institutions of Japan during this time period are also commonly described as feudal. Like Europe, Japan had a class of aristocratic swordsmen, the *samurai*, in the service of great lords, the *daimyo*. The samurai, like the knight, was expected to live by a strict code of honor, though many of its details were quite different (see pp. J10-11).

The Papacy

In the early Christian church, the bishops of Rome held special authority. Rome was the imperial capital and the largest European city; and Christian tradition held that St. Peter, to whom Christ gave the keys of Heaven, was martyred in Rome, whose bishops were his successors, known as Popes. They counted as patriarchs of the Church, along with the bishops of Alexandria, Antioch, Jerusalem, and later Constantinople.

After the fall of Rome, the papacy's religious authority made it a source of stability; its estates gave it enough wealth to support political rule also. Reforming Popes, including Gregory I (590-604), Leo IX (1049-1055), and Gregory VII (1073-1086), claimed increased judicial powers, eventually including the right to depose emperors. This led to a split from the Orthodox Church in Constantinople, which remained under the imperial control.

Rome became the site of the College of Cardinals which, after 1059, elected the Pope, and of a growing bureaucracy. The power of the Church made it the target of political manipulation; from 1378 to 1417 rival Popes claimed leadership. The Church's wealth and power led to corruption and demands for reform, from which Protestantism emerged.

Long-distance travel still took place, both by land and by sea. The Silk Road carried goods between Byzantium and China, and Arab seafarers still traded in the Indian Ocean. Mediterranean trade was diminished by piracy and warfare (often hard to distinguish), but a major shipping route still connected Byzantium to Venice. In the seas of northern Europe, new shipping routes emerged, and in the 1280s the Hanseatic League was formed to control them. In between, European and Russian travellers used the remains of Roman roads.

Social Organization

Political Systems

TL3 saw relatively little innovation in government beyond the development of European feudalism (see p. 87). Most TL3 areas operated under some kind of monarchy, although a few Italian cities, no longer part of a larger empire, began to revive republican traditions. The other new aspect of TL3 politics was the sudden prominence of religion as a force which transcended traditional political units. Both Christianity and Islam had prominent leaders (the Catholic Pope and the Muslim Caliph) whose supreme religious authority translated into temporal power over nominally independent kingdoms, sometimes leading to conflicts with local monarchs. By the end of the Middle Ages, this supreme authority had collapsed, but ideals of international religious unity remained to be explored and exploited by later politicians and holy men.

China, as always, was an exception. Buddhists were politically active during much of the period, and Buddhism was favored by the Mongols, who ruled China from 1280 to 1368 A.D. However, there was no Buddhist authority comparable to the Pope or the Caliph, while the Emperor was the sole political authority. After 1368, the Ming Emperors suppressed many Buddhist secret societies and stabilized the power of the bureaucracy.

Law

Though often seen as a lawless era, the Middle Ages in fact gave rise to many codes of law. Europe's first systematized code was the English common law, compiled not long after the Norman Conquest of 1066. Not long afterward, scholars on the Continent gained access to the text of the *corpus juris civilis*, the laws of ancient Rome as compiled by order of Justinian, which became the basis for European law. Merchants at fairs across the continent worked out their own rules, the Law Merchant, later incorporated into commercial law.

Far in the north, the tiny nation of Iceland developed its own legal system, with an annual court called the *Thing*. Its laws were initially purely oral, but were written down after Iceland became Christian. Icelandic sagas contain nearly as many lawsuits as fights.

The Near East also generated legal codes, based on Islam. Originally the only valid laws were considered to be statements in the Koran. Later, two other sources were added: recorded sayings of Mohammed on other occasions (the *hadiths*) and analogies to previous cases. Several competing schools of legal scholars developed these sources into a complete body of law.

Law did not have such an independent role in Chinese society, which was ruled by imperial decrees. Judges were expected to base their decisions on moral principles and not on exact rules. But every community had its judge, chosen by the imperial government from men who had passed the civil service examination, who was empowered to investigate and punish improper conduct.

Trade and Money

Slow improvements in agricultural and transportation technology led to developments in trade and economic infrastructure.

Money

In the Middle Ages, as in the Iron Age, money still meant coins. Gold and silver were firmly established as currency metals. The imprint on a coin was a guarantee of its value, and counterfeiters were harshly punished. But the worst threats to sound money were often the very governments that issued it. All over Europe, silver coins were regularly brought in, melted down, mixed with lead, and reissued as a larger number of coins, with the excess going to the government. Every coinage had a different value, and all the values fluctuated over time.

In China, block printing was used to manufacture paper currency. Merchants began the practice in the eighth century, but it was made a government monopoly in 1023 A.D. Massive inflation followed and eventually led to the abandonment of paper money.

Business Organization

In Europe, TL3 saw the rise of merchant companies and partnerships. Most partnerships were short-term, existing only for a single ship voyage or season of trading. Often, one partner (or consortium of partners) would contribute the bulk of the capital or goods to be traded, while another would take the goods to a distant land, sell them, and bring back a cargo of exotic imported goods. The traveling partner, who undertook greater personal risk, would receive a larger part of the proceeds than his financial contribution might suggest, often a quarter of the profits. Caravans and ship voyages were generally cooperative ventures, with the partners splitting necessary expenses, such as the salary of sailors or a caravan master and guides.

Long-term merchant companies were usually family ventures, or at least organized by people maintaining strong ties beyond the business itself. Late in TL3, instead of sending an expedition to a distant port every year, merchant companies would permanently station agents in cities where they traded. The agent could keep an eye on local markets, make connections, and better organize shipments home. A similar pattern emerged in China, where families belonging to the same clan acted as each other's agents in different cities.

Despite the economic importance of merchant companies, they remained small relative to modern companies. Even the largest had fewer than 100 people carrying out their daily operations.

Paper and Printing

Invented in China in the Iron Age, paper remained confined to that country for over six centuries. The knowledge of paper first left China in 753 A.D., when the Arabic forces that conquered Samarkand captured some Chinese paper makers and brought them back to practice their trade. By 1000 A.D., paper was in general use throughout the Muslim world, and in the 13th and 14th centuries, it reached Christian Europe.

By the early Middle Ages, most European written documents were produced in the form of bound books. The earliest books were produced by copyists in Christian monasteries. After 1000 A.D., book production shifted to the universities. By the 1300s, commercial book producers, often in the form of lay religious groups, begin to emerge.

Block printing was developed in China, more out of a desire for accuracy than a need for mass production. An expert could block print up to 2,000 sheets a day from a carved wooden block. By the 11th century, the Chinese replaced simple block print with movable type, in which each character was a separate piece that could be reassembled to duplicate any document. The Arabian sailors who traded with the East were aware of these technologies, but printing never became significant in Muslim lands, as it was considered profane not to hand-copy the Koran.

Alchemy/Chemistry

Although medieval alchemists hoped to find either the philosopher's stone (the substance that could transmute base metals into gold) or the elixir of life (the nectar of immortality), their researches resulted in the discovery of a number of useful chemicals, including nitric, sulfuric, and hydrochloric acids, and alcohol. Acids can be used as corrosive agents, but require careful handling. Ammonia, produced by distilling stale urine or the horns of beasts, may be found under the name of spirits of hartshorn. Ammonia can be used in spirit form (alcohol solution) as smelling salts.

One important development in alchemical experimentation was distillation, in which a liquid mixture is heated gradually through the boiling points of its various constituents. As each constituent boils off, it is condensed in cooling tubes and collected in relatively pure form.

Continued on next page . . .

Alchemy/Chemistry (Continued)

One of the most important purified substances is ethyl alcohol. Distillation allows the production of substances with much higher alcohol ratings (see p. CII162) than beer (alcohol rating 1-2) or wine (alcohol rating 2-4). Such distilled spirits are much more effective intoxicants. However, distillation can be tricky; on a failed roll, the product is watery or tastes unpleasant, while on a critical failure, it is actively poisonous.

In addition to its recreational uses, alcohol can serve as a fuel, a cleaning substance, or a solvent. In the last capacity, it provides new routes for the administration of medicinal herbs:

Tincture: Most of the volatile components of medicinal plants and herbs are soluble in alcohol. By immersing dried or fresh parts of plants in alcohol, the active principles are easily extracted at higher concentrations than those that can be achieved by infusion or decoction. These highly concentrated solutions will last for one to two years and are a convenient way to store and use herbal constituents. Ideally, tinctures should be made using pure ethyl alcohol distilled from cereals. However, any distilled spirits with 35-45% alcohol can be used. The extraction is fairly quick. A 50% mixture of herbs and alcohol in a tightly closed jar will hold a tincture ready for use at the prescribed dosage.

Essential Oils: These are the volatile oily components of aromatic plants, trees, and grasses. They are found in tiny glands located in the leaves (eucalyptus), flowers (neroli), roots (calamus), resins (frankincense), and wood (sandalwood). Essential oils are extracted by four main methods. In steam distillation the oil is extracted by the action of hot steam, selectively condensed with water, and then separated. In expression the oil is extracted by pressure. In solvent extraction the oil is dissolved in a volatile solvent. When evaporated it leaves a heavy natural wax called "concrete." When separated from the wax, the resulting liquid is called an absolute and is the most concentrated form of aroma available. Efleurage is a longer process involving the dissolution of the oils in animal fat and its separation using alcohol. Although essential oils' main use is in cosmetics and perfumery, many have improved therapeutic properties. Essential oils keep indefinitely if stored properly.

Banking

Another earlier development that gained importance during TL3 was banking. For the most part, this meant moneylending. Both Christianity and Islam prohibited lending money for interest, so bankers devised ways to get around this prohibition, including making a loan in one currency to be repaid in another. Banks also would accept a deposit of money in one city and issue a letter of credit which could be redeemed in a different city, making it unnecessary to carry cash on a journey.

Sources of Information

As merchant houses established branches in distant cities, information was disseminated through correspondence. Merchants used local informants to keep abreast of trends, fashions, slumps, and even religious activities. In the later Middle Ages, private postal services carried messages between a handful of major cities. Firms compiled books recording tides and nautical hazards, mathematical tables, calendars, weights and measures, exchange rates, and goods wanted and available. All this information was kept secret from rivals, but it played a major part in training new members of a firm.

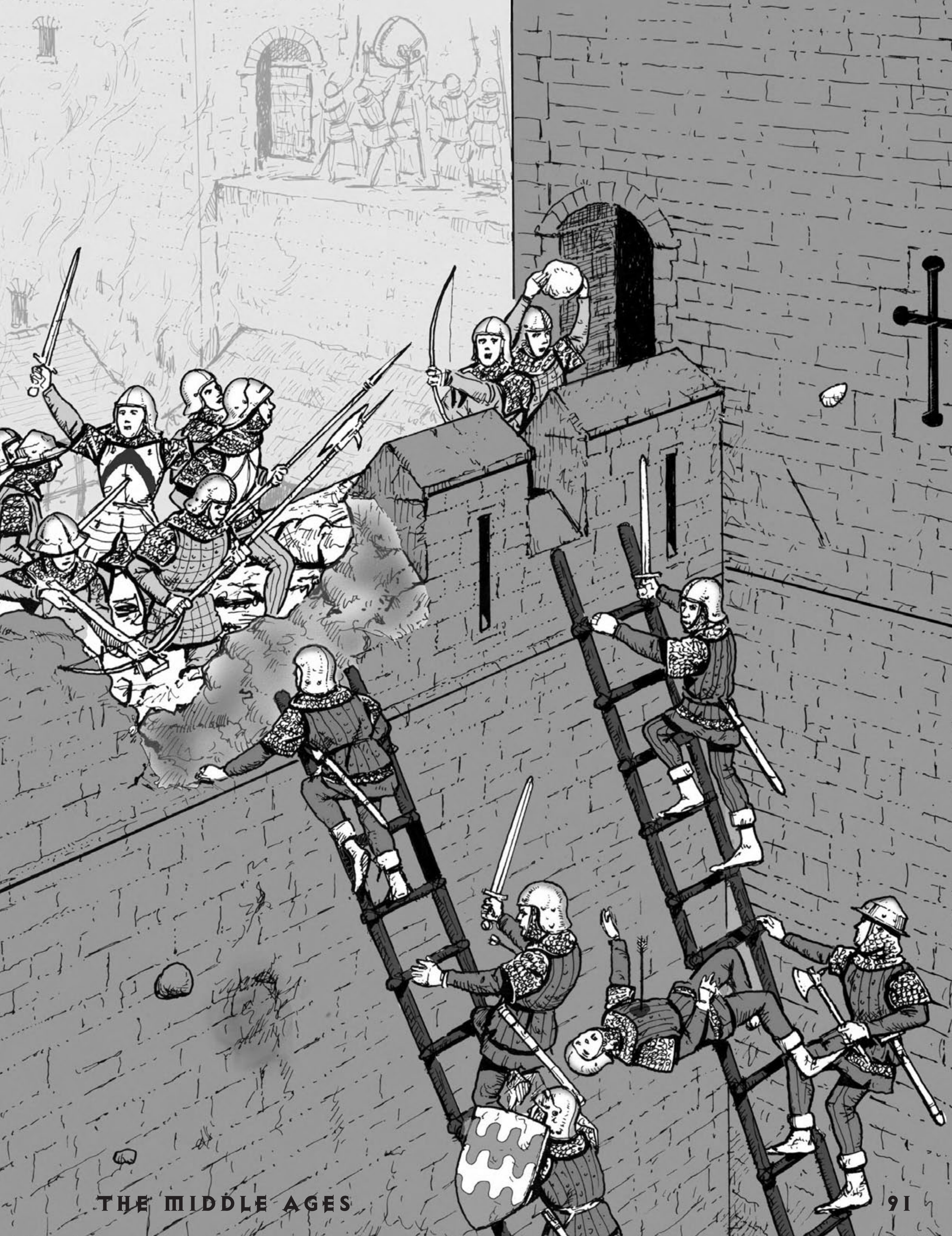
Warfare

The most visible change in warfare was an increased reliance on cavalry. A Central Asian invention, the stirrup (see p. 104), made cavalry more effective, though exactly how much more is still heatedly debated. The European adoption of the stirrup made the mounted knight possible, and led to the breeding of warhorses that could carry a fully armored man at charging speed. The couched lance became a primary weapon in feudal Europe.

While horses, ships, and weapons grew more powerful, the shift from regular to feudal armies led to a reduction in drill and group training. Individual heroism had always been admired, but now it became the heart of codes such as chivalry. (The Vikings, the Arabs, and the Japanese, among others, had comparable traditions.) Esprit de corps and unit solidarity were less important that in the classical ages.

Later in the Middle Ages, the longbow, the crossbow, and, finally, firearms made it possible to strike down armored cavalrymen from a distance. Counterweight siege engines and cannon could level castle walls. Swiss pikemen and Hussite wagoneers developed other ways of defeating knights. Even apart from gunpowder, medieval advances in warfare were making the knight obsolete by 1450 A.D.

In naval warfare, the heavier hulls of Viking and Chinese ships made them more seaworthy, carrying the Chinese to Africa and the Vikings from North America to Sicily. Later European ship designs, from the cog and hulk to the carrack, supported "castles" at prow and stern from which armed men could fight more effectively. Though much smaller than Chinese vessels, European ships rivaled and finally exceeded their achievements, making possible the global exploration and conquest of TL4.



Pyrotechnics

A major application of alchemy was the creation of inflammable substances. These served a variety of purposes, but many of their applications were military.

Greek Fire

The great military secret of the Byzantine Empire was said to have been invented by Callinicus, a Greek engineer from Syria, and was first used against Arab fleets besieging Constantinople in 673 A.D. Greek fire was such a closely guarded secret that its precise formula is no longer known, but its ingredients probably included one or more petroleum fractions distilled from naphtha (Arabic *naft*). Greek fire remained a key strategic weapon of the Byzantine Empire well into the 11th century.

Greek fire was primarily used against wooden siege engines and ships rather than as an antipersonnel weapon. It was originally placed in firepots lit by fuses and thrown like grenades, with the effective range of an oil flask. Later, Greek fire was loaded into bronze tubes mounted on Byzantine *dromons* and fired under pressure at enemy vessels, producing a much larger jet of burning liquid – the fire siphon. Greek fire continued to burn on top of water and could only be extinguished by being smothered, a useful property for naval warfare.

Continued on next page . . .

Advances in Learning

In Europe, economic collapse left most people little time for learning; illiteracy became nearly universal. Only the monasteries preserved reading, as monks patiently copied and illuminated manuscripts. The Near East was not nearly so afflicted, and after the rise of Islam, scribes were sent to the Byzantine Empire to buy or copy classical books. But there, too, knowledge was the primary concern of religious teachers, with schools being held in mosques. Only Imperial China preserved a tradition of learning for its own sake, with literature and history examinations as the gateway to government jobs.

Later in the Middle Ages, Europe developed its first universities, some of which are still in operation. Students from many countries would come to hear a famous teacher. Teachers and students organized into guilds, claiming the right to make their own laws – a right that earned students a reputation as troublemakers.

Writing and Literacy

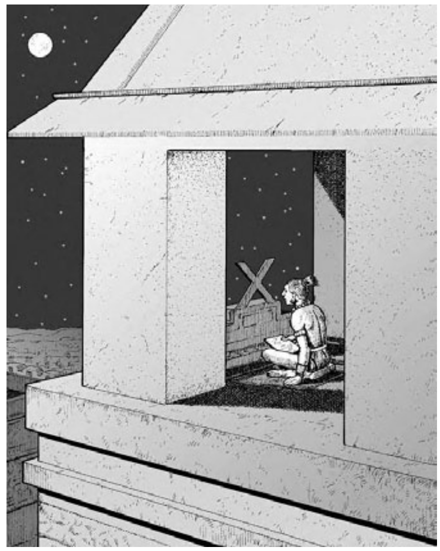
No major changes took place in writing systems; the major scripts were already well established. Each script was identified with one major language – the Roman alphabet with Latin, the Arabic alphabet with classical Arabic, and Chinese characters with classical Chinese. To be literate meant not merely knowing the use of a script, but knowing its standard language. Germans and Spaniards learned Latin, Spaniards and Persians learned Arabic, and the Japanese learned Chinese; such knowledge defined educated men. A German who read and wrote German but knew no Latin might be called illiterate.

A less important, but striking development was silent reading. St. Augustine (see pp. WWii20-21) wrote of his astonishment at seeing St. Jerome run his eyes down a page without speaking the words on it; apparently this was a novel skill in ancient Rome. By the end of the Middle Ages it was part of the definition of literacy.

Mathematics

Mathematical knowledge advanced rapidly during the Middle Ages. The Indian reinvention of the zero and place notation was picked up, first by the Arabs and then by Europeans, who referred to the new symbols as Arabic numerals. A treatise on using place notation in multiplication and long division by the mathematician al-Khwarismi gave Europe the word "algorithm."

The Near East led the world in developing new mathematics, stimulated partly by religious concerns such as the time of prayer, the dates of festivals, and the direction of Mecca. Much of trigonometry was created in this period, including spherical trigonometry, which aided astronomical calculations.



Another new branch of mathematics came to Europe under an Arabic name, algebra. The use of symbols to represent known and unknown numbers in general formulas advanced both practical calculation (represented by Cyphering) and abstract mathematical reasoning (represented by Mathematics).

Astronomy and Navigation

For many years, the leading astronomers of the Middle Ages were Muslims. The first observatory was founded in Baghdad in 828 by Al-Ma'mum; others followed it, including many in Central Asia.

Precision of measurement was vitally important to these astronomers, leading to the invention of new instruments, such as a sextant at Samarkand with a radius of 130'. Muslim astronomers clearly distinguished astronomy from astrology – which was always under suspicion of heresy.

Increased knowledge of the heavens was incorporated into navigation; this is the first age in which the skill of Navigation can routinely be used without a penalty. Celestial measurement allows a ship to "run down the latitude," piloting a course due east or west to a known destination. (No reliable means of determining longitude was available.)

Pyrotechnics (Continued)

Black Powder

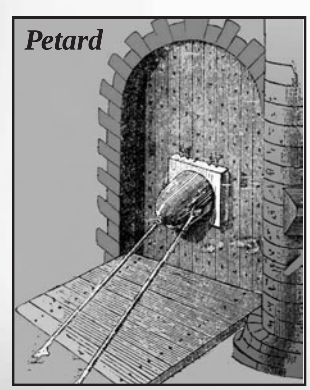
Gunpowder was developed in China by Taoist alchemical experimenters before 1000 A.D. It found its way to Europe by 1240 A.D., when Roger Bacon described its composition and properties. By late TL3, its use in cannon was well established, and experimental cannonlock and matchlock handguns had been made (see pp. HT32-37).

The Chinese first used black powder in rockets, starting in the 11th century A.D. They went on to develop a variety of other black powder weapons, such as the fire lance, effectively a large Roman candle mounted on a long pole (see the table of polearms, p. 108). The effective range is based on the length of the exhaust. Some fire lances had pieces of iron embedded in the fuel; these give +2 to damage, not counted as fire damage, but are not projected to a significant range due to the lack of a true barrel.

In Europe, black powder was used mainly in massive artillery weapons known as bombards. Unlike cannon, these had fixed bases; it was very difficult to change their aim once they were set up. Early gunpowder artillery often fired stone balls. Since these are lighter than metal, treat them as low-powered ammunition if using the firearms design rules on pp. VE100-113.

The full development of gunpowder weapons takes place at TL4 and is discussed in ***GURPS High-Tech***.

Gunpowder could also be used as an explosive, if it was confined in a small space such as a container. In sieges, this ability is applied to blasting through fortress walls or gates, using a small bomb called a petard (from a French word meaning "to break wind") that was fastened to the wall or gate. See pp. HT22-27 for rules for using gunpowder as an explosive.



Petard

Medicine

During the early Middle Ages, medical knowledge in Europe declined; ancient texts were copied in monasteries, but not always understood. European medicine can be considered to be effectively TL1. The revival of medical knowledge after 1000 A.D. reflected the influence of the Near East, initially transmitted through the School of Salerno.

Medicine in the Near East also looked back to ancient texts as authoritative. A Nestorian Christian school and hospital translated ancient Greek texts into Arabic, and they were relied on by Christians, Jews, and Muslims, from Persia to Moorish Spain. This led to new encyclopedic compilations of medical knowledge that were the basis for true TL3 medicine in the Near East, and later in parts of Europe. Greek humoral theories were combined with careful clinical observation. Many new drugs were discovered in the Near East as well.

Similar encyclopedic compilations of medical knowledge were produced in India and in China. The Indian surgeon Sushruta listed 20 sharp and 101 blunt instruments as needed for surgical practice. Indian surgeons developed the operation of lithotomy, or surgical removal of bladder stones; this can be considered minor surgery (see pp. 21-22).

The first dissections took place in Europe near the end of the period, and the first anatomy was published in 1316. However, anatomy did not become a mature branch of knowledge until TL4; medieval dissections must be considered early experiments.

Chinese medicine developed variolation, the first form of immunization. The pus from a light case of smallpox was inoculated into the skin of a healthy person. This calls for a roll against Physician skill. On an ordinary success or failure the inoculated person is mildly ill for a few days. On a critical success there is no illness; on a critical failure a full-blown case of smallpox results. This procedure was introduced into India, but reached Europe only after 1700.

Diagnosis made little use of instruments, relying mainly on the physician's senses and questions about the patient's diet and habits. Collection of urine specimens to check for blood, sugar, or sediment was known in the Near East and Europe.

Making Things Burn

Apart from causing direct injury to living beings, flame attacks can set things on fire. The following rules represent this process for the incendiary agents available at TL3 and below.

Materials are classified into six categories of readiness to burn:

Type A (super-flammable): black powder, distilled naphtha
Type B (highly flammable): alcohol, paper, tinder
Type C (flammable): dry wood, kindling, light clothing, oil
Type D (resistant): heavy clothing, leather, pitch, rope, seasoned wood
Type E (highly resistant): flesh, green wood
Type F (non-flammable): brick, metal, rock

When a material is first exposed to a heat source, it will be set on fire immediately if sufficient burning damage is inflicted. Damage required is as follows:

Type A: negligible (candle flame or spark)
Type B: 1 point
Type C: 3 points
Type D: 10 points
Type E: 30 points
Type F: does not burn

If a heat source could cause enough damage to set a material on fire, but does not do so immediately, roll once per second so long as contact continues. Materials one or two categories above the highest category it could so affect may be set on fire through prolonged contact, if they are not of category F. For each 10 seconds of contact, roll 3d; fire results on a 16 or less for materials one category up, and on a 6 or less for materials two categories up.

Some examples of incendiary agents are as follows:

Torch	1 (added to crushing damage)
Flaming arrow	1 (added to arrow damage)
Large, hot fire (1 hex)	1d-1
Fire lance	1d-1
Greek fire	1d
Furnace	3d
Molten bronze/iron	3d

For example, a bonfire causes up to 5 points of damage. One roll could set light clothing on fire, so roll every second for this. It cannot set heavy clothing or flesh on fire with one roll, so roll after every 10 seconds; heavy clothing starts to burn on 16 or less, flesh on 6 or less.

Once a material starts burning, it may act as a further source of ignition; make separate rolls for it as if it were the nearest comparable incendiary source. For material to be rendered structurally unsound, it must suffer cumulative fire damage equal to its hit points. Take its DR into account for each second in which damage is inflicted.

Weapons and Warfare

Military technology at TL3 made extensive use of steel, both to improve older forms of equipment and to create new ones, such as plate armor and the two-handed sword. Much of this equipment was designed for use by heavy cavalry, such as European knights. Equipment was also developed to defeat heavy cavalry, including the longbow, the crossbow, and the pike.

Hand Weapons

For the most part, the hand weapons of TL3 are those in the ***Basic Set*** (pp. B206-207). They do not require detailed discussion here. Rather, this section traces the historical development behind those weapons and mentions a few exotic types.

Indian Swords

Swords

In Medieval Europe, the late-TL2 shift from shortswords to broadswords progressed further. Surviving Celtic cultures continued to use swords of broadsword length (see p. 107). The *sax*, used in Northern Europe between 500 and 700 A.D., was a single-edged sword 28” long. The Arabs, India, and China had their own versions, such as the Chinese *jiann*, a long thrusting sword. As various techniques for producing steel (see p. 86) came into use, the greater strength of steel made longer weapons more effective.

By 900 A.D. smiths learned that if the blade was tapered more sharply, the balance point came closer to the hilt, resulting in a blade which was faster and more manageable than past swords. This design was the basis for the true broadsword. Guards and pommels large enough to permit a two-handed grip created the bastard sword and the Celtic claymore. In the 14th and 15th centuries, knights began using the two-handed greatsword, giving up shields and relying on full plate armor for safety.

Japanese Sword

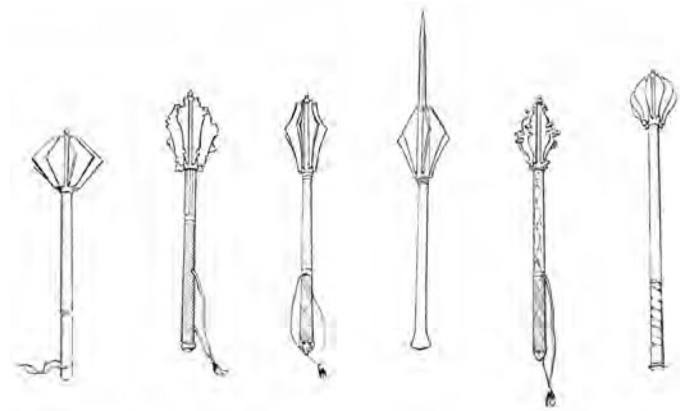
Japanese swordsmiths developed the *tachi*, a long sword designed to be used on horseback, after 1000 A.D. Somewhat later this gave rise to the *katana*, a very well-balanced sword that could be used either one-handed or two-handed. The Korean *gum* was a similar design.

A variety of curved sword designs came into use, originally in Central Asia among the Turks. These included the *yataghan*, the *mamluk* used in Egypt against the Crusaders, and the relatively late scimitar. All these weapons can be treated as broadswords or bastard swords. A Chinese weapon called the *dau* was a variant on this design.

A more extreme version of this principle was the falchion, primarily a woodsman’s and hunter’s weapon. See the appendix for rules for designing falchions (p. 110).

Axes

The advent of steel made axes a more effective weapon. The great axe came into use, notably among the Vikings, including the mercenaries who served in the Byzantine Empire.



Maces

Maces saw renewed use in the Middle Ages, especially by cavalrymen for downward blows at footsoldiers. The Persians favored the mace and often used it as a throwing weapon. Nearly all maces in this period had spikes, flanges, or the like; it was common to make these out of steel, but the solid core out of less expensive iron. Heavy two-handed crushing weapons such as the maul typically had smooth surfaces, relying on their weight for damage potential.

Polearms

Polearms were used earlier in history, but the Middle Ages saw an amazing proliferation of new designs, both in Europe and in East Asia. The appendix (p. 108) lists a small sample of these designs, including the widely used glaive, halberd, and *naginata*, together with a few exotic types such as the Chinese horse-cutter and monk’s spade and the Indonesian *latajang*. But nearly every conceivable combination of crushing, cutting, and impaling surfaces was used on one or both ends of a pole somewhere in the world. The appendix provides rules for customizing hand weapons designs (p. 110). Some combination of these options will describe nearly any polearm in ***GURPS*** terms.

While it is classified as a spear rather than a polearm, the pike found a similar role in combat. The first Swiss pikemen emerged in the Middle Ages and became known for the same ability to stand off cavalry that ancient Greek hoplites had displayed with comparable equipment.

Halberds

Lances

European knights developed the true couched lance, and their training, equipment, and social position were centered on its use. This skill was not used in the Muslim world, and was one of the main advantages of Europeans over Muslims. The Arabian *kontos* was very similar to a lance in design, but used like a long spear.

Ranged Weapons

Bowmanship was not highly regarded in most of Europe or in the Arab lands, where attacking from a distance was considered dishonorable. This attitude was not shared in China, India, or central Asia, where the crossbow and composite bow were the primary weapons of many armies. Mounted archers were crucial to the success of the Mongol armies and of the Turks. The Japanese developed their own design for an asymmetric bow usable on horseback.

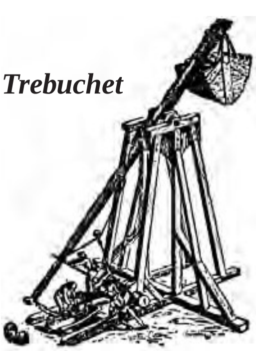
The British Isles did not share the European disdain for the bow. The longbow, whose use the English learned from the Welsh in many battles, brought them a number of one-sided victories in France.

Arrow and Bolt Heads

Beginning in the late 13th century, specialized arrowheads and bolts were developed for different purposes. See the descriptions in the appendix (p. 113).

Artillery

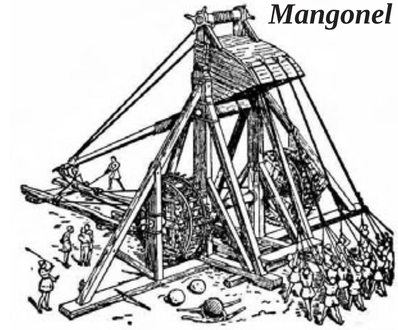
During the Middle Ages, a new type of mechanical artillery was developed in both Europe and China: the trebuchet. Where earlier artillery stored energy in a bent bow or in twisted springs of hair or sinew, the trebuchet used a counterweight to propel its ammunition. Counterweighted artillery was often massive and could propel huge stones, able to smash through fortress walls.



Trebuchet

The trebuchet had an important limitation: since its ammunition was fired upward in an arc, it had a minimum range. This can be taken as 25% of the half-damage range for any trebuchet.

Chinese stone throwers used sheer manpower in the form of large numbers of laborers pulling on ropes. Crews ranged from 40 to 500. Use of this apparatus spread steadily West from Central Asia to the Middle East, where it was known as a *manjaniq* (mangonel).

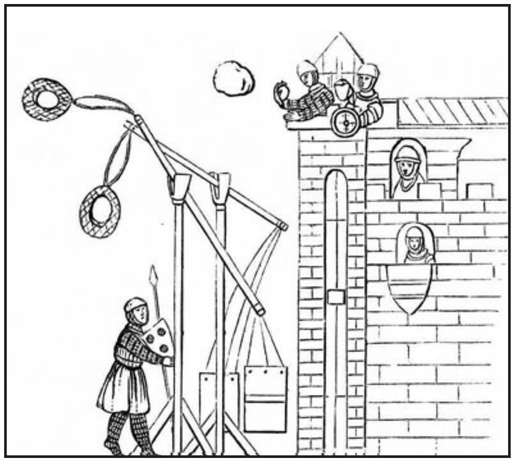


Mangonel

During the same period, the *arcuballista*, or arbalest, was developed. This was a huge crossbow, firing up to 10 bolts in a single shot.

Various incendiary and explosive devices are discussed in a sidebar (pp. 92-93) and in the Appendix (pp. 106-125).

Armor



In Western Europe, dramatic changes in armor occurred during the later Middle Ages.

The well-armored fighter in 1250 was attired in the same fashion as one from the fifth century – a chainmail shirt that extended to the waist or knee, a round or conical metal helm, and some form of shield. Mounted knights added chainmail *chausses* (leg armor) to protect their legs from infantrymen. From the 13th century on, plate armor came into use on the battlefield.

Similar trends can be observed in the Byzantine Empire, the crusading states and Muslim lands, and the steppes of Russia and Central Asia. Armor types thought of as "Western" by early medieval historians often have precursors from other lands. In Japan, China, and Southeast Asia, however, plate armor never gained popularity. Lacquered lamellar armor – consisting of *lamellae* made from hardened leather, bamboo, horn, bone, or metal – remained the dominant form of armor, one uniquely suited to the humid climate of these lands.

Armor made at TL3 can be classed into three broad types, depending on the underlying structural material.

Cloth Armor

Quilted and padded cloth garments can be worn under other armor for comfort or worn alone as low-cost armor. Quilted armor was worn in Europe and India, while the Byzantines employed fabric defenses made from felt.

By the 12th century, asbestos cloth was being produced in India, while in the Near East, garments were impregnated with talc, magnesium silicate, and powdered mica to make them "fireproof." Garments produced by either method were worn on the battlefield by troops using incendiary devices.

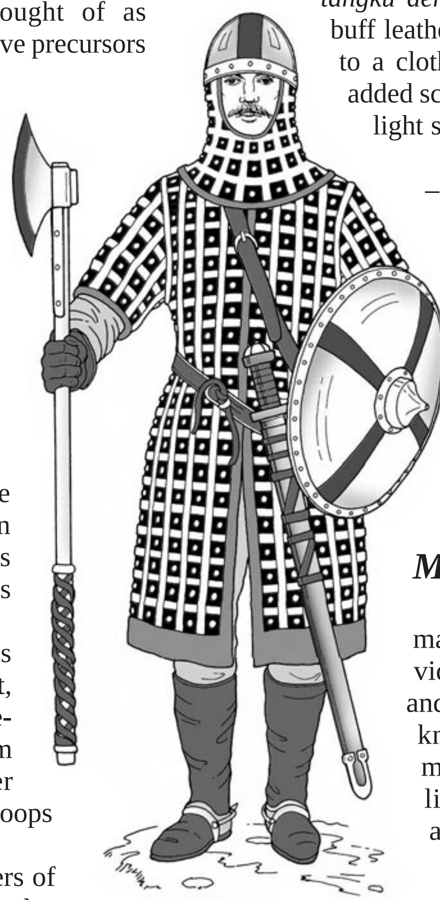
The jack consisted of inner and outer layers of stout canvas or leather, stuffed with cotton, wool, or tow or lined with discs of horn. To prevent the contents from settling, it was often separated into six panels (two front, two rear, and one for each shoulder) by a series of lacings. Other jacks were composed of 25-30 layers of stiff linen beneath deerskin. Either sort is effectively equivalent to the cloth cuirass.

Splinted armor consisted of metal plates, scales, or studs attached to the outside of fabric (most commonly linen). It was equivalent to light scale. Splinted substitutes were most often used for arm and leg defenses for greater freedom of movement. A variant was the coat of a thousand nails, an Indian overgarment that combined fabric with an interior layer of metal nails.

The coat of plates was an oblong, poncho-shaped garment with a curved hem, with large steel plates riveted underneath. It extended from the base of the neck to the armpits and down to just below the hips.

Leather Armor

Cuirboilli (literally, boiled hide) was first produced in Western Europe around the end of the 12th century. The prepared leather was pressed or molded into the desired finished shape while still soft and then left to cool and dry. The result can be considered as equivalent to heavy leather (in the appendix, to leather armor).



Capetian warrior in studded leather armor (10th century)

Mongol for "coat as hard as steel," the *khan-tangku dehel* consisted of soft armor of felt or buff leather with additional padding, equivalent to a cloth cuirass. Later versions of this coat added scale linings, making them equivalent to light scale.

The basic concept of lamellar armor – overlapping plates (*lamellae*) of leather, horn, or iron, laced together by wires or thongs – remained unchanged from TL1. The best-known TL3 version is the *o-yoroi*, knee-length, short-sleeved lamellar armor associated with the Japanese samurai. The lamellae in this design were formed into long horizontal bands and lacquered, at the expense of some flexibility.

Metal Armor

Chainmail (also known as ring mail) was extremely flexible and provided excellent defense against cutting and edged weapons such as swords and knives. Against crushing weapons, mail softened the concussion but did little to prevent the bruising that accompanied the blow; consequently, it was worn with a padded undergarment that helped absorb the blow and protected the wearer's skin from chafing. Chainmail was ineffective against impaling attacks.

Several variants to basic four-link ring mail were also developed:

The reinforced coif and armored shirt, developed by the Arabs, were light, tightly woven chainmail that were designed to be worn under clothing.

First produced during the 13th century, augmented mail consisted of chainmail with leather thongs threaded through every row or every alternate row. The leather strips gave added solidity to the fabric, stiffening it against impaling attacks.

Teutonic knight in chainmail (1250)

Double mail was identical to simple chainmail, except that the wire had twice the weight and 40% greater thickness. This provided greater protection, especially vs. impaling attacks, by leaving less space for blows to pass through.

Steel plate armor did not appear until the 13th century, and its initial use was limited to specialized pieces covering vulnerable parts of the body. During the 14th century, armor combined chainmail with increasing amounts of plate, used for limb defenses and later to protect the torso.

It was not until the beginning of the 15th century that full plate armor became available. Plate armor was custom-fitted and designed to allow a knight to fight effectively. Its weight, unlike that of mail, was distributed evenly over the entire body, and its joints were articulated to flex wherever movement was necessary.

Brigandine

Some medieval armor was made to conceal the fact that its wearer was armored. In England and France, such armor was called brigandine, from its use by brigands. Brigandine was equivalent to scale, light scale, or splinted armor, but with a layer of cloth or leather on the outside. Jazerainted mail, developed in the Near East, is effectively the same thing.

Brigandine comes in four levels of quality, based on how carefully it is tailored for concealment. Cheap brigandine adds $10 to the cost of torso armor, good brigandine $30, fine brigandine $100, and very fine brigandine $500. Double the cost to screen armor on all hit locations. Regardless of quality, add 1 lb. to the weight of the armor for torso only, 2 lbs. for all hit locations.

Detecting that someone is wearing brigandine calls for a Holdout roll (see p. B66) – but not a contest of skills, as the concealment is a function of the tailoring, not of the wearer's skill. Any tactile search will reveal the armor, except on a critical failure. For visual inspection, roll against Holdout skill, modified for range and for quality (+2 for cheap, no modifier for good, -2 for fine, -5 for very fine). Cutting, impaling, or fire damage gives +1 per point; 5 points makes the cover useless until it is repaired, and 10 points destroys it.

Other armor can be worn under clothing, but does require a contest of skills. The wearer's Holdout skill is at -1 for isolated pieces such as a skullcap, -3 for torso armor, or -5 for full body armor; double these penalties for armor with an awkward shape or irregular surface. Heavier clothing makes concealment easier, per p. B66. Again, this is for a visual search, which is modified by range; a tactile search succeeds except on a critical failure. The reinforced coif and armored shirt are specifically designed for ease of concealment, adding a +3 to Holdout checks for ×9 price.

Helmets

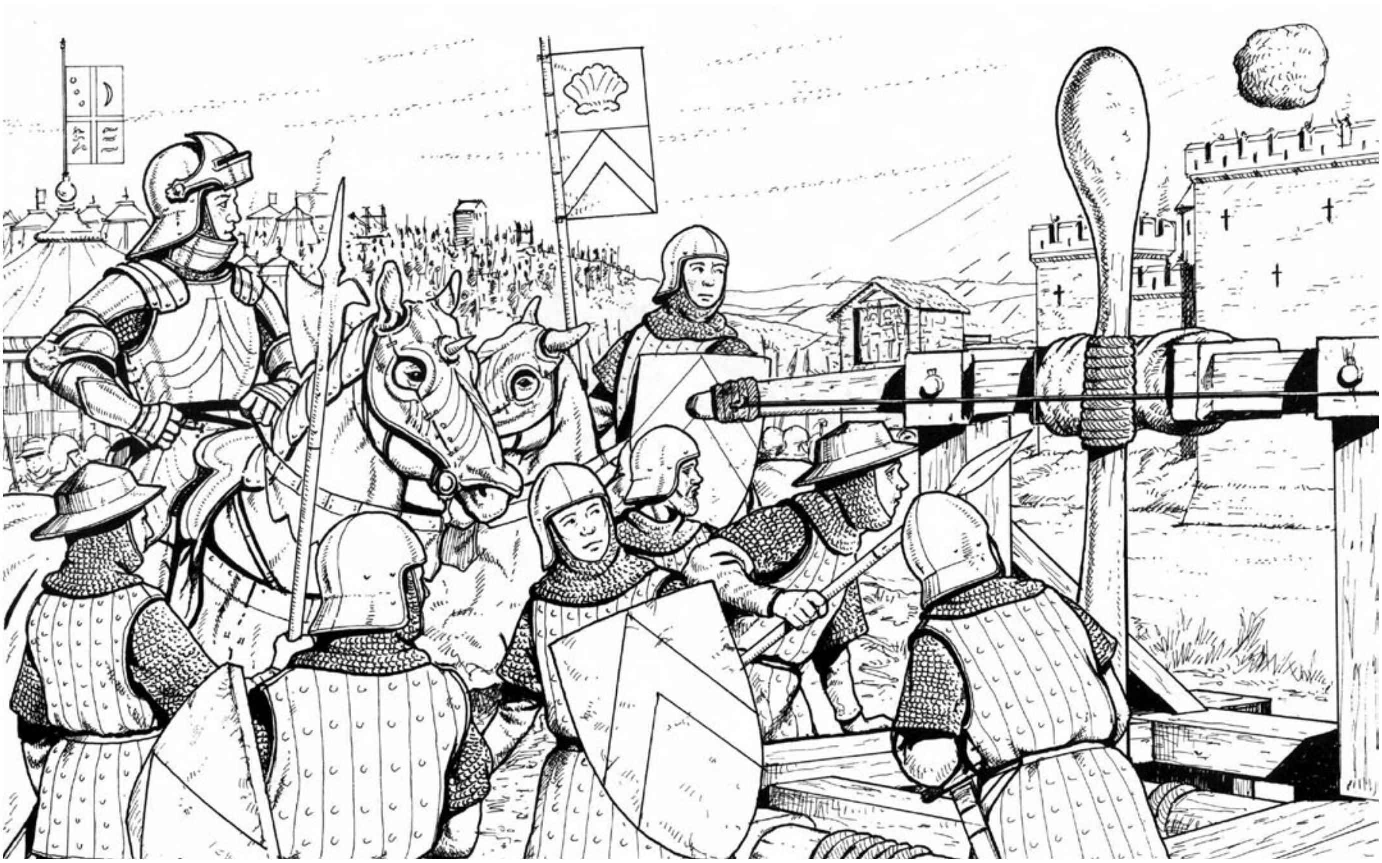
Metal (iron and later steel) helmets underwent two substantial transitions during TL3. At the outset, metal helms consisted of separate plates or strips of metal joined together to form a framework. Pieces of thinner metal, leather, or horn were riveted to the central ribs to fill in the empty spaces between them. In the seventh to 11th centuries, armorers developed one-piece helms. Although sturdier, these still had the form of a skull piece that protected the top and back of the head. The skullcap could be attached to appendages that protected parts of the face or neck (see Appendix, p. 114).

French knight in chainmail and plate armor (1346)

In the later Middle Ages, a variety of new helmet styles that covered the entire head were created.

The best known was the barrel helm, which originated in Western Europe in the 13th century – a flat-topped cylindrical helmet that fully covered the wearer's face except for tiny vision slits. Precursors have been identified in Iberia, Russia, and the Muslim lands dating back to the 11th century.

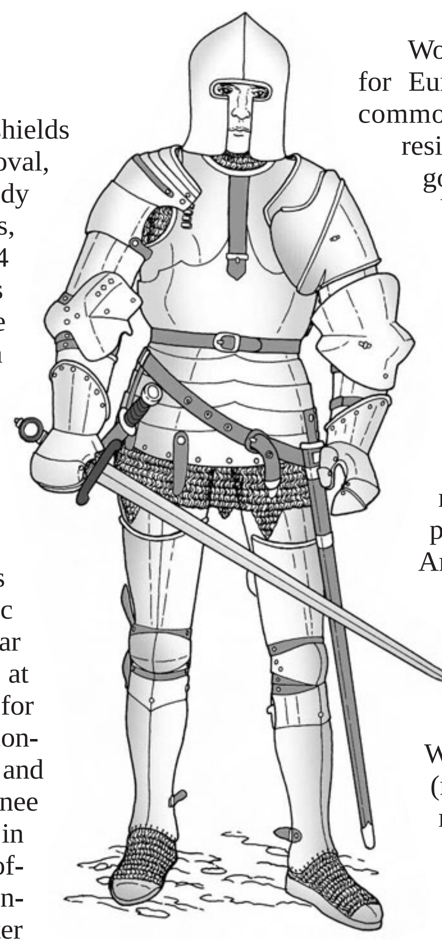
Later variants, including the *bascinet*, *armet*, and *sallet*, were shaped to deflect blows to the head.



Shields

Over the course of the Middle Ages, shields became smaller as armor improved. Large oval, tower, and kite shields that covered the body from eye to knee gave way to mid-sized heaters, to small target shields, and at the cusp of TL4 to hand-held bucklers. The only exception was the *pavise* (see p. 117), a missile defense employed by archers and besieging infantry in the 14th century, effectively a wall shield.

Prior to 1000 A.D., most shields were round or conical, often equipped with a boss of iron or bronze, generally spherical. Some versions of the boss incorporated a metal spike protruding from the center that added +1 to damage from a bash, but increased the shield's weight by 5 lbs. Beginning with the Islamic *tariqah* and Norman kite, shields begin to appear in more triangular shapes, tapering to a point at the base. This style was primarily designed for cavalry use, as the contours of the shield conformed to the space between the horse's neck and the rider's thigh, protecting to the left leg and knee of the knight. Similar shields were also used in Russia. The heater, the classic European coat-of-arms shield, was a shorter waist-length descendant of the Norman shield that dominated later medieval tournament grounds.



Milanese knight in full plate armor (1450)

Wood remained the dominant material for European shields. The timber most commonly used in was linden wood, resistant to splitting and particularly good at trapping spears when used to block an attack. Wooden shields could be faced with a thin layer of metal or a thicker layer of hide. Wood-based shields were also available in China (in the form of large shields used by infantrymen) and in the Byzantine and Muslim lands.

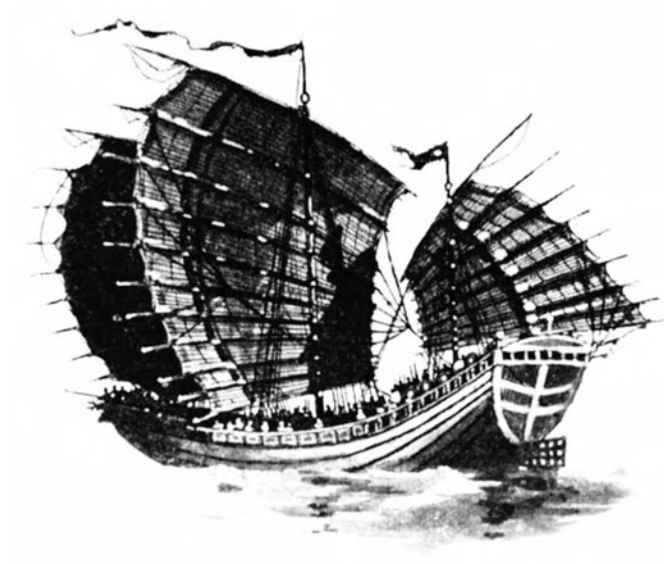
Many alternative materials remained in use. Leather shields predominated in the Mideast and Arabia, India, and Tibet (a noted exporter). One example was the *lamt*, an oval or rectangular large leather shield tanned with bark and treated with animal fat, made in Morocco. Woven shields made of spiral cane (rattan) bound with cotton, reeds, or rush matting, and sometimes faced with leather, were manufactured in Egypt and other Mideast lands and in lands influenced by the Mongols.

Vehicles

Improvements in wagon design during TL3 resulted in better land transportation. The most important was a pivoting, free-turning front axle, which provided independent support to turning maneuvers (previously, wagons had to be literally dragged sidelong to a new facing). In addition, four-wheeled vehicles with rear wheels larger than the front pair also began to appear, first in the East and some centuries later in the West. The horse collar (see p. 84) provided more effective traction for wagons.

The Bohemian Hussite leader Jan Zizka devised massive oak-armored wagons that could carry 20 soldiers or a cannon and its crew. Using them, he won major victories against German mounted knights in the early 1400s, anticipating TL4 artillery tactics.

However, much greater changes took place in travel by water.



Ships

Civilizations at TL3 developed a variety of innovations in shipbuilding. Several different traditions of seafaring emerged, sometimes influencing each other and sometimes remaining separate. No one civilization made use of all the new technologies.

Advances in sail configuration took place in several cultures. The fore-and-aft rig, with triangular sails oriented roughly along the long axis of the ship, can achieve 80% of full speed running before the wind; 90% with the wind from port or starboard; and 30% sailing into the wind. Full-rigged ships, with elaborate combinations of square and triangular sails, can achieve 80% of full speed running before the wind or with the wind from port or starboard, and 20% of full speed sailing into the wind. Many ships at TL3 became capable of tacking (see p. 53).

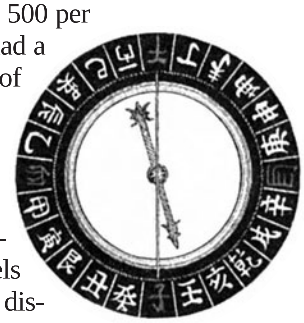
The Chinese Tradition

The Chinese began building seagoing sailing ships before the end of the first millennium A.D. Chinese sails were typically lugged (set at an angle to the wind), enabling them to function in the same manner as fore-and-aft sails. These sails may reflect the influence of a non-Chinese shipbuilding tradition that was active in the South China Sea by the third century A.D., whose ships had up to four woven mat sails rigged fore and aft.

The first Chinese sailing ship, the *fuchuan* ("Fuzhou ship," named for its native province), had a V-shaped bottom and a single sail. For greater seaworthiness, many fuchuan had bilge keels not far below the waterline to enhance their stability. The *shachuan* ("sandbar ship"), developed around 800 A.D., was the prototype of the junk. It had a distinctive flat bottom that enabled it to navigate in shallow water, either near the shore or up China's many rivers. It had a deep single rudder at the rear that performed the same function as a keel, but could be raised to pass over obstacles.

In the 12th century the Chinese developed the batten sail, reinforced by horizontal pieces of bamboo that could be used to fold the sail up and that helped maintain its shape as the wind shifted. This was used on ships of a hybrid design. They typically had multiple masts; three were common, but the flagships of Admiral Zheng He's 15th-century fleet had as many as nine.

The hulls of Chinese ships were constructed not from planks laid edge to edge, but from overlapping planks, a style known in Europe as "clinker-built." To hold the hull together, shipwrights used iron nails, as many as 500 per ton of displacement. These ships also had a heavily compartmentalized design, one of the most seaworthy ever created.



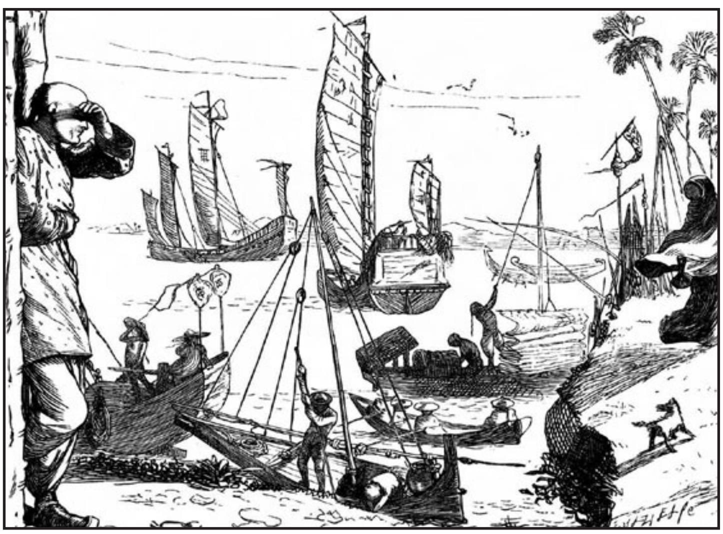
Chinese shipwrights experimented with another form of propulsion: the paddle wheel. In 1131 the Chinese navy launched a fleet of "flying tiger warships" driven by eight paddle wheels powered by 42 men on treadmills. The discovery that the wheels could be jammed by logs or reeds led the Chinese navy to abandon them for more conventional ships; however, the paddle wheel can be considered late TL3.

The Chinese were the first to create a device that spread across the world: the compass (see p. 103).

The Arabian Tradition

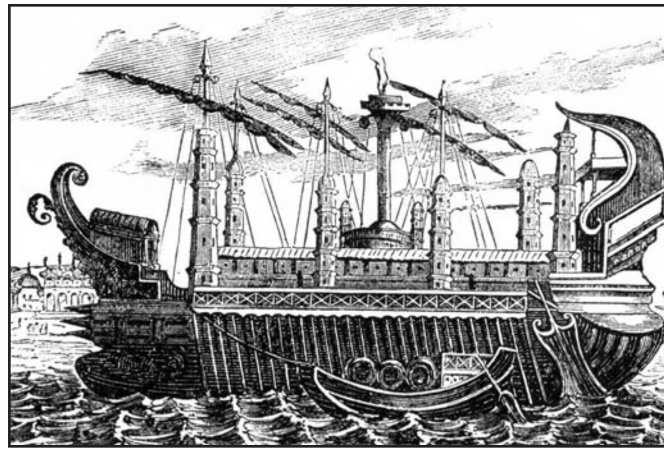
Arab seafarers built boats and ships that preserved an ancient Egyptian construction technique: a hull made of planks sewn together with coconut fiber. The smallest boats had no other frame. Larger ships had framing elements inserted, like ribs, in the style of classical shipbuilding. Generically, ships of this type are called *dhows*, but many different models were created, from small boats such as the *shashah* up to large ships such as the *boum* (pointed at both ends), *sambuk* (squared at the stern), or the European-influenced *baghala*, with a square stern from which five windows looked out (arguably an early TL4 design).

The Arabs adopted a new type of sail, one only occasionally experimented with in the ancient world: the triangular lateen rig. Unlike the square-rigged sail, lateen sails are set fore and aft at a slight angle to the mast. Where square sails give stability to large boats and in heavy seas, the lateen sail provides greater maneuverability in unfavorable winds. Due to the extreme height of the sail, Arabian ships seldom attempted to make the adjustments needed to beat upwind, but rode the seasonal monsoon winds back and forth over the Indian Ocean.



The Byzantine Tradition

Byzantium, the inheritor of Rome, was (for much of its history) a strong naval power, maintaining an extensive fleet, largely to protect Byzantine shipping from Arab raiders. From



the seventh century A.D. on, Byzantine warships preserved many classical features, including banked oars and the use of ramming and artillery in naval warfare. However, their construction was less sophisticated: a hull with fewer joints holding the planks together was reinforced by a strong internal frame.

The Byzantines added a novel weapon to their armament: the Greek fire siphon. The Byzantines also adopted the lateen sail from the Arabs as an auxiliary propulsion system after 800 A.D.

The most common warship in the Byzantine navy was the *dromon*. Dromons ("runners") were biremes, similar in size to the Roman liburnian, with two ranks typically of 50 oars. There were three basic variations on this vessel design:

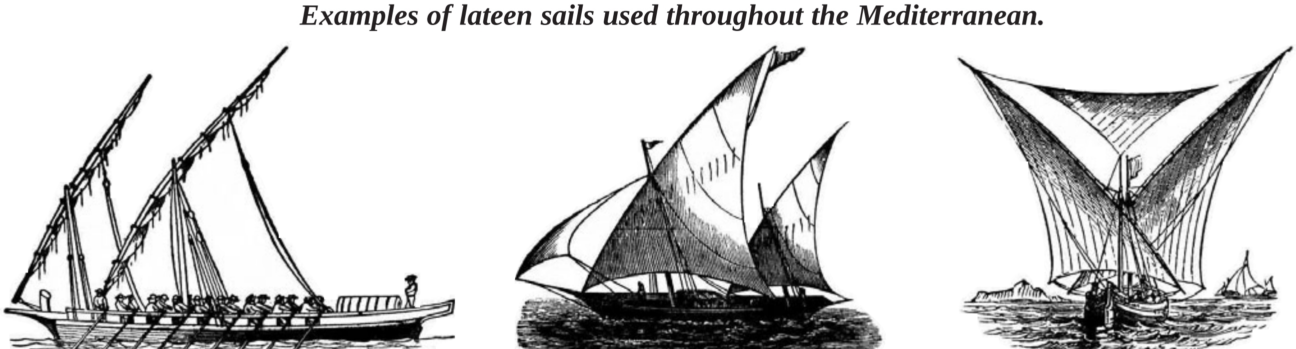
The *ousiakos* carried one company (*ousia*) of 108 men, with one man per oar; the upper rank alternated as rowers and marines as required.

The *pamphylos* carried 120-160, with one man on each lower oar and two men on each upper oar.

The true dromon was the largest, carrying one man on each lower oar, two men on each upper oar, and 50 dedicated marines.

All three versions of the dromon lacked oar boxes to provide protection for rowers; instead, rows of shields were hung along the sides. Their primary methods of attack were with catapults and Greek fire, projected under pressure through tubes built into the bow of the craft. The pamphylos added a second fire siphon to the stern, and the dromon a third located amidships. The dromon was protected from fire by hides soaked in vinegar.

Examples of lateen sails used throughout the Mediterranean.



The Venetian Tradition

After 1000 A.D., the Venetians developed their own fleet, influenced by their long trade with Byzantium but embodying some novel ideas. Venetian galleys did not have banked oars but wide bodies able to hold multiple oarsmen side by side. Early designs used the *alla zenzile* system, in which each man had his own oar, with benches carefully slanted so all the oars could be used together. Later (mainly at TL4) the *a scaloccio* system was adopted, in which, as in Roman quinqueremes, several men pulled the same oar. In both designs, a ship with 30 benches on each side was typical.

Ships built to transport the soldiers of the Ninth Crusade adopted a similar design, though broader in the beam and relying mainly on sails for propulsion. One form of this ship was a Genoese craft called the *tarida*. Similar ships were later used for cargo. However, in the Mediterranean, true galleys were also used to carry cargo; their large crews and ability to travel independent of the wind gave them protection from corsairs.

In the 15th century, Venetian ships began to carry guns, typically one very large gun at the front, pointing forward, sometimes with two smaller guns on either side. However, their tactics continued to emphasize boarding. The final naval battle using galleys was the Battle of Lepanto, fought in 1571, in which a Christian fleet led by Don John of Austria defeated a Turkish fleet; this may be considered the end of TL3 navies.

The Viking Tradition

From the opposite end of Europe came a very different approach to shipbuilding. Viking ship construction techniques were still shell-first, but the planks were not laid edge to edge, but overlapped, as on Chinese ships of the same period. This heavier construction produced ships that could more easily cope with long ocean voyages. Viking ships came in two basic designs: round ships such as the *knarr*, designed for hauling cargo, and long ships such as the *karve* and the *drakkar*, designed for war or carrying messages.

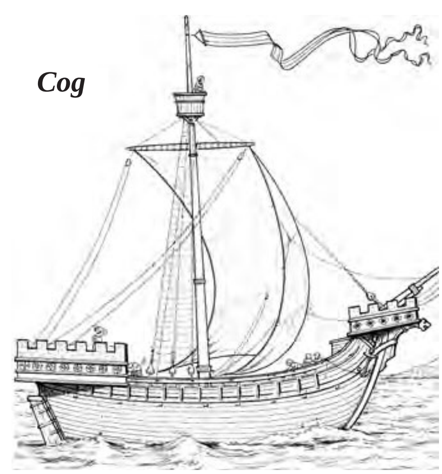
The knarr was the standard Viking cargo vessel, with a length-to-beam ratio between 3:1 and 5:1. It was primarily a sailing ship, with a single fixed mast and a square-rigged sail made of *vathmal* (finely woven homespun wool). These were the ships that carried colonists to Iceland; one large knarr could carry the people of a farmstead and their beasts and household goods.

The karve was a relatively small longship; the drakkar, named for its dragon-headed prow, was larger, up to 150’ for a ship that could carry a king and his bodyguards and servants. With length-to-beam ratios from 4.5:1 to 7:1, these ships were built for speed, bringing all of Europe into reach of Viking raiders. Similar ships that traveled down the Russian rivers were named *monozyla* by the Byzantines. Their shallow draft allowed them to land on virtually any beach, disembarking their warriors within a few strides of land, or travel up even small rivers. Longships had enough cargo capacity to cart away a raiding party’s booty or to transport 8-10 horses that could extend a raid beyond the immediate coast.

The European Tradition

As trade grew in the seas surrounding Europe, followers of different nautical traditions encountered each other and borrowed each other’s techniques. In the centuries that followed, entirely new ideas for ship construction emerged, culminating in the three-masted full-rigged ship of the 15th century. From the late 12th century onward, ships featured a bowsprit, a large spar extending over the stem of the ship, to which the bowlines for the sail could be attached. This advance permitted greater effect for the sail, letting the ship sail closer to the wind and respond yet more quickly to changes in wind direction and intensity.

Cog

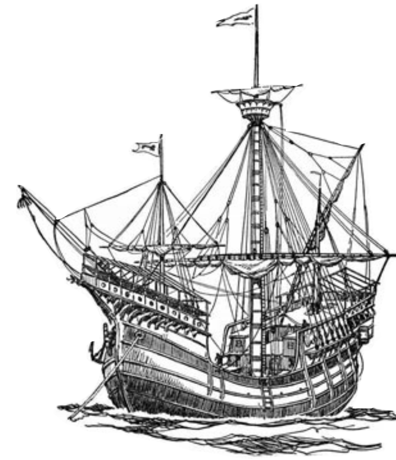


Apart from the novel arrangement of the sails, such ships were built in a new style, frame first, with the planks of the hull supported by the frame rather than by each other. After 1200, cogs and other European ships used the single stern rudder. Fleets of such ships carried European explorers to Africa, India, and the Americas.

The cog, the staple of the Hanseatic League’s merchant fleet, evolved from Celtic flat-bottomed boats. Cogs had sharp prows and sterns rising at an angle from the bottom of the ship, letting them be landed on sandbars at low tide and floated off at high tide; early models were keelless, but after 1000 A.D. keels were added, making them suitable for sea travel. A wide body with high sides gave them a large cargo capacity; the sides also made boarding more difficult for raiders. A single mast, usually with a square sail, propelled them. By 1300 A.D., it was determined that cogs equipped with castles (fighting platforms) fore and aft were

Communications at sea between the various vessels of the treasure fleet was made possible by an elaborate system of sound and sight signals. All ships were equipped with one large flag, signal bells, five banners, one large drum, gongs, and ten lanterns.

– Louise E. Levathes, *When China Ruled the Seas*



Carrack

virtually impregnable to marauding longships and could themselves be utilized as warships to attack other cogs or blockade enemy towns. Cogs became a crucial part of the English fleet and defeated French and Castilian galleys during the Hundred Years' War.

The cog's main rival was the hulk, a wide one-masted sailing ship with a rounded bottom, prow, and stern and a wide body that let it carry a heavy load. It was the first northern European ship to have wales, reinforcements running along the sides of the ship. Its design was especially suited to river traffic. After 1400, shipbuilders' designs often incorporated features from both designs, to the point where the names became interchangeable.

In southern Europe, shipwrights developed the caravel, a relatively fast ship typically carrying two masts with lateen sails. Ships of this type were used by the Portuguese in their early voyages of exploration, starting about 1440. Later, the same basic design was adapted to full-rigged sails; a third mast was often added. Ships on voyages of exploration normally carried crews twice as large as ships on shorter voyages.

The final evolution of the medieval vessel, the carrack, combined elements of the Northern European cog and the Mediterranean roundship and new technologies such as the stern-hung rudder to produce a ship suitable for both trade and war, displacing more than 500 tons. Carracks carried two or three masts (either lateen sails, or a hybrid with a square-rigged mainsail and lateen-rigged mizzen), with fore and aft castles and a stable enough deck to support stone-throwing artillery (and later bow and stern guns). The carrack is the basis for TL4 shipbuilding.

Tools and Equipment

Apart from combat gear, a variety of other equipment and personal items became available in the Middle Ages.

Agricultural Tools

Horse Collar

The horse collar allowed the use of draft horses at full efficiency, in contrast to the earlier yoke, which tended to choke the horse. A stiff collar transferred the load to the horse's shoulders and was attached to shafts on both sides of the horse, fairly low. The effective ST of a team of horses with horse collars is 15% of their actual total ST, making them more effective draft animals than oxen. The horse collar was first developed in China in the 5th century A.D. but was not generally available in the rest of the world until roughly 1000 A.D. Weight: 30 lbs. Cost: $300.

Craft Tools

Knitting Needles

Available in Europe in the later Middle Ages, knitting needles provide a new method of creating fabric. Weight: negligible. Cost: $5 per pair.

Spinning Wheel

The introduction of the spinning wheel increased the production of thread or yarn roughly sixfold, revolutionizing fabric work. A typical model weighs 40 lbs. and costs $100.

Survival Gear

Compass

Early magnetic compasses appeared in the Western world around 1000 A.D., originally no more than a magnetized needle floating in water or mounted on a pivot. This technology was widely used in the Orient long before this; Chinese compasses were oriented toward the south while Western ones pointed north. Navigation rolls with a compass are made with no penalty for equipment. Weight: 5 lbs. Cost: $25.

Sun Shadow Board

A Viking navigational device consisting of a semicircle of wood mounted on a handle that can be used as a crude sextant to navigate by "comparative latitude." The device measures the distance between the bottom of the sun's disc and the horizon at noon each day. If the measurements decreased on succeeding days, the ship was heading north, while an increase meant the ship was heading south. A sun shadow board reduces the penalty for Navigation rolls made using the noonday sun to -1. Weight: 10 lbs. Cost: $20.

Sunstone

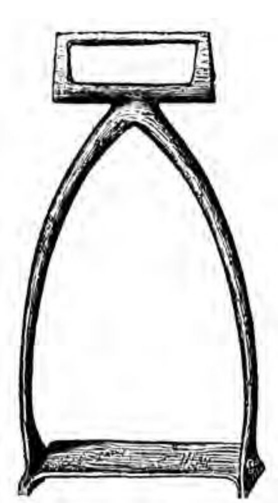
This crystal naturally polarizes light; it enabled the Viking sailors who discovered it to locate the sun even when it was screened by clouds or fog. It reduces all daytime weather modifiers to Navigation rolls to -1. Weight: 1 lb. Cost: $30.

Riding Gear

The Middle Ages saw major improvements in the technology of horsemanship. The use of the horse both as a draft animal and as a warrior's mount was greatly enhanced.

Horseshoes

The origin of the iron horseshoe nailed to the bottom of the horse's hoof is unknown. However, their common use dates to the tenth or eleventh century. A shod horse gets +2 to daily HT rolls (see p. 78). A set of horseshoes (installed) costs $50 and weighs 4 lb.; replacing a single shoe costs $20. Horsemen with Blacksmith skill can purchase a set of shoes for $10 and install them in 1-2 hours.



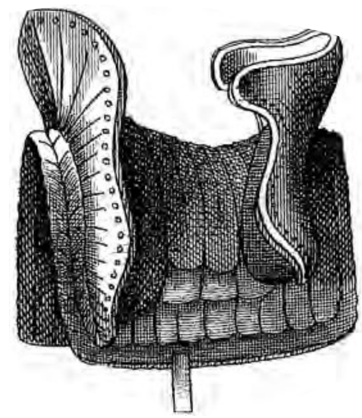
Stirrups

Stirrups were introduced by the Huns; they require a saddle designed to have them attached. Stirrups were known in Byzantium by 580 A.D., in China and Japan by 600 A.D., and in the Arab lands by the end of the 7th century. Western Europe lagged in adopting stirrups, not making extensive use of them until the 9th century. Stirrups greatly simplified the act of mounting a horse: the basic -2 penalty is removed and penalties for encumbrance are halved (-1, not -2 per level). A riding saddle with stirrups gives +1 to offset penalties to Riding skill to control the horse, and cancels all penalties to remain seated and to weapon skill. A rider with stirrups can use the Lance skill. Weight of saddle plus stirrups: 20 lbs. Cost: $125.

War Saddles

The war saddle had a high back and front, and may grant +1 PD to the rider's legs and groin at the GM's discretion. This type of saddle has a 50% chance of keeping an unconscious rider in the saddle. Over and above the usual benefits of saddle plus stirrups, it gives an extra +1 to Riding skill to stay seated, which may act as an actual bonus to skill. Weight of war saddle plus stirrups: 35 lbs. Cost: $250.

Barding



Armor for horses developed in parallel with armor for their riders. At the beginning of TL3, horse armor typically protected only the front – a chanfron for the face and a peytral for the chest and forelegs. During this period horse armor was made of leather and quilted cloth (PD 2, DR 2) or occasionally mail (PD 3, DR 4, but PD 1, DR 2 vs. impaling weapons). With the emergence of the mounted knight, barding covered the horse from head to tail, leaving only its legs exposed. Full barding in the 12th and 13th centuries consisted of a chanfron and peytral, plus a *crinet* covering the back of the horse's head and neck, *flanchards* protecting its midsection beneath the saddle, and a *crupper* protecting its hindquarters. In the 14th and 15th centuries, horses as well as knights were outfitted with plate armor (PD 4, DR 5). By the 15th century, only the crinet was still commonly made of mail, with the remainder composed entirely of plates. A few bards included leg pieces as well, though they proved restrictive to the horse's natural gait.

Barding Table

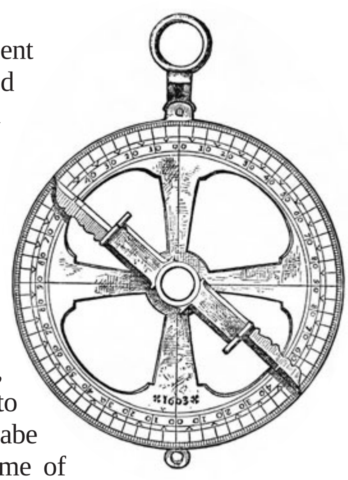
Element	Leather/Cloth		Mail		Plate	
	Weight	*Cost*	*Weight*	*Cost*	*Weight*	*Cost*
Full Trappings	39 lbs.	$470	81 lbs.	$830	120 lbs.	$2,180
Chanfron	3 lbs.	$45	7 lbs.	$60	12 lbs.	$200
Crinet	6 lbs.	$80	15 lbs.	$100	18 lbs.	$330
Peytral	10 lbs.	$115	25 lbs.	$250	30 lbs.	$550
Flanchards (pair)	10 lbs.	$115	17 lbs.	$210	30 lbs.	$550
Crupper	10 lbs.	$115	17 lbs.	$210	30 lbs.	$550
Leggings					20 lbs.	$400

Note: Plate leggings cover hit locations 3-4 (front) and 10-11 (rear). Each set worn reduces Move by 1.

Barding may be purchased as a complete set or assembled by the piece, using the Optional Hit Location system. If the latter method is chosen, assume that the chanfron covers hit location 5 and the crinet hit location 6. The peytral, flanchards, and crupper all cover roughly equivalent portions of the horse's body (hit locations 7-9).

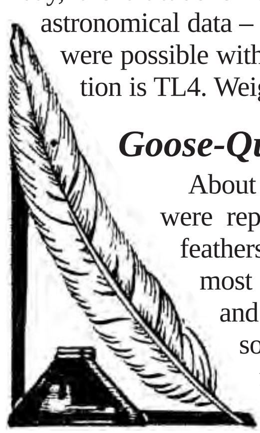
Miscellaneous

Astrolabe



First developed in ancient Greece, the astrolabe was used extensively by Muslim astronomers and navigators. It had a circular outer rim on which the degrees of the full circle were marked. A variety of scales marked on interior circles, some capable of being aligned with the observed position of a star, and two pointers comparable to clock hands made the astrolabe capable of calculating the time of day, the altitude of a star, and other astronomical data – as many as 300 different computations were possible with complex astrolabes. Its use in navigation is TL4. Weight: 2 lbs. Cost: $500.

Goose-Quill Pens



About 700 A.D., writing sticks and styluses were replaced by quill pens made from bird feathers. Goose quills were the strongest and most durable. Crow feathers (for fine lines) and eagle, hawk, and owl feathers were sometimes used. Quill pens were good for around a week before wearing out. Weight: negligible. Cost: $5.

Mirror

Although polished bronze mirrors similar to those used by the Greeks and Romans remained in use during the medieval period, glass mirrors with a lead backing were manufactured beginning in the late 12th century. The glass protected the metal backing from scratching and corrosion. Hand mirror: 1 lb., $15. Dressing mirror: 10 lb., $125.

Paper

Paper could be purchased as single sheets or in folded folios containing four, eight, or 16 sheets of equal size. Weight negligible, $2 per sheet ($10 per 8-sheet folio).

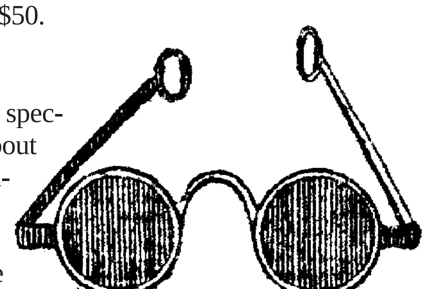
Pocket Sundial

This small device, developed around the 10th century, enabled travelers to keep track of time on the road. Typical models could identify midday and four "tides" of the sunlit day. A more elaborate English version identified high and low tides and compensated for seasonal changes in the sun's altitude (see *Clocks*). Weight: 1 lb. Cost: $40.

Scribe's Kit

A scribe's pen case contains several quills, bottles of ink (made from iron salts, nut galls, and gum), and a special sharpener (pen knife), as well as a supply of paper or parchment. Weight: 1-2 lbs; $50.

Spectacles



The earliest usable spectacles were invented about 1290 A.D. and are usually credited to an Italian monk, Salvino D'Armate. During the 14th and 15th centuries, they became common among scholars. Quartz lenses were held in bone, metal, or even leather mountings that could perch on the nose. Weight: 1 lb. Cost: $150.

Hand Weapons Table

Weapons are listed in groups according to the skill required to use them. Within each group, weapons are listed by TL and then alphabetically within a TL.

Each weapon can be made out of a variety of materials available at different TLs. The TL for a weapon is the first one at which available materials make its construction practical. The base cost and weight for the design concept are the same at all TLs.

A major effect of improved materials is enhanced capacity to resist breakage. Each material is assigned a Breakage Rating, as follows:

Obsidian	Special
Sandstone	-1
Flint	0
Jadeite	1
Copper	0
Bronze	1
Iron	2
Steel	3

For metals, Cheap, Fine, and Very Fine workmanship can modify Breakage Rating by -1, +1, or +2. This cannot be done with stone – the equivalent result is obtained by choosing a better stone. For these purposes "sandstone" represents any grainy stone; "flint" represents any crystalline stone; and "jadeite" represents any extremely dense stone.

If any weapon is used to parry a very heavy weapon (see pp. B74, B99, B111), it is treated as Cheap, Good, Fine, or Very Fine if its Breakage Rating is lower, equal, one higher, or two or more higher than that of the heavier weapon. For example, if a bronze shortsword with Very Fine workmanship (Breakage Rating 1+2 = 3) is used to parry an iron halberd with Good workmanship (Breakage Rating 2), the shortsword is considered to be a Fine weapon and has a 1/6 chance of breaking. Obsidian is the exception; it has a 5/6 chance of breakage when used to parry any very heavy weapon.

If a knife or sword is deliberately struck with a cutting or crushing blow, in an attempt to break it, the number of hits required depends on the material and the size of the weapon (see p. B111), as follows:

Material Hits to Break

	Dagger	*Shortsword*	*Broadsword*	*Larger Sword*
Stone	2	3	–	–
Copper	2	3	4	–
Bronze	2	4	5	6
Iron	3	5	7	9
Steel	4	6	8	10

The relative quality of the two weapons (as indicated by their Breakage Ratings) affects the amount of damage required (see p. B111).

Wooden weapons and wooden shafts of hafted weapons can be cut through. Wood has a full range of quality based on type of wood: Cheap for light woods such as black willow, Good for typical woods, Fine for woods such as hickory and red oak, and Very Fine for ironwood and teak. This does not affect damage but does affect DR and hit points. A typical wooden shaft of Good quality has DR 3 and 8 hit points; a polearm shaft with metal facings has DR 4 and 12 hit points. Cheap wood is -1 DR and ×0.5 hit points; Fine wood is +1 DR and ×1.5 hit points; Very Fine wood is +2 DR and ×2 hit points.

In terms of damage, Paleolithic chipped stone cutting weapons cause -1 damage owing to the irregularity of their edges; this does not apply to impaling weapons. Obsidian cutting and impaling weapons cause +1 damage – for this purpose, they are treated as Fine. If used to strike DR 2+, they lose their edge; treat them as crushing weapons at -1 to damage. Metal weapons do +1 cut or imp damage if they have Fine workmanship and +2 if they have Very Fine workmanship.

The price of a stone or metal weapon is based on its Breakage Rating. For BR less than TL, the weapon is available at Cheap prices; for BR equal to TL, at Good prices; for BR equal to TL+1, at Fine prices; for BR greater than TL+1, at Very Fine prices. The price of a wood weapon is based on the quality of the wood. (This scheme applies only at TL3 or lower.) For this purpose, prices for various types of weapons are as follows (note that the existence of Cheap and Very Fine weapons other than swords is a change from the ***Basic Set*** rules):

Weapon Class	***Cheap***	***Good***	***Fine***	***Very Fine***
Knives/Swords	×0.4	×1	×4	×20
Other Cutting/Impaling	×0.2	×1	×10	×100
Crushing	×0.4	×1	×3	×10
Wooden	×0.4	×1	×3	×10

These prices are adjusted in two cases. In general, chipped stone materials are half price, since they routinely break and are replaced. Obsidian, despite its fragility, does not have this modifier, and it is priced as if it had Breakage Rating 1.

Weapon	Type	Damage	Reach	Cost	Weight	Min ST	TL	Special Notes

AXE/MACE

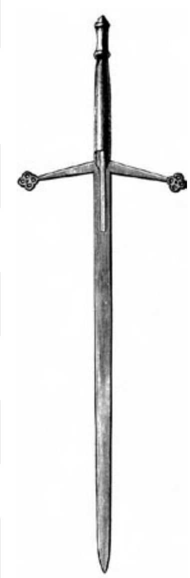
Axe	cut	sw+2	1	$50	4 lbs.	12	0	[2]
Hatchet	cut	sw	1	$40	2 lbs.	7	0	[1] [2]
Knobbed Club	cr	sw+1	1	$20	2 lbs.	7	0	[2]
Round Mace	cr	sw+2	1	$35	5 lbs.	12	0	[1] [2]
Small Axe	cut	sw+1	1	$45	3 lbs.	11	0	[2]
Small Round Mace	cr	sw+1	1	$25	3 lbs.	11	0	[1] [2]
Small Throwing Axe	cr	sw+1	1	$55	3 lbs.	11	0	[1] [2]
Throwing Axe	cut	sw+2	1	$60	4 lbs.	12	0	[1] [2]
Epsilon Axe	cut	sw+1	1	$40	4 lbs.	12	1	[2]
Sickle	cut	sw-1	1	$40	2 lbs.	10	1	[2]
Mace	cr	sw+3	1	$50	5 lbs.	12	2	[1] [2]
Small Mace	cr	sw+2	1	$35	3 lbs.	11	2	[1] [2]
Pick	imp	sw+1	1	$70	3 lbs.	11	3	[2] [3]

BRAWLING

Hand Axe	cut	thr-2	C, 1	$30	2.5 lbs.	6	0	[4]
Hiltless Knife	cut	thr-2	C, 1	$20	0.5 lb.	–	0	Max. dam. 1d+1. [4]
Bagh Nakh	cut	sw-2	C, 1	$100	1 lb.	–	3	Brawling/Karate bonuses.

BROADSWORD

Light Club	cr	sw+1	1	$10	2 lbs.	10	0	
	cr	thr+1	1					
Macauitl	cut	sw+1	1	$500	3 lbs.	10	0	[2]
	cut	thr	1	$550	3 lbs.	10		If sharp (most are blunt).
Khopesh	cut	sw+1	1	$450	4 lbs.	11	1	[2]
Broadsword	cut	sw+1	1	$500	3 lbs.	10	2	
	cr	thr+1	1					
Shotel	imp	thr+1	1	$500	3 lbs.	11	2	[2] [6]
Thrusting Broadsword	cut	sw+1	1	$600	3 lbs.	10	2	
	imp	thr+2	1					
Bastard Sword	cut	sw+1	1,2	$650	5 lbs.	11	3	[2] [7]
	cr	thr+1	2					
Dau	cut	sw+2	1	$700	5 lbs.	11	3	
	imp	thr	1					
Estoc	imp	thr+2	1	$500	2 lbs.	10	3	
	cr	sw+1	1					
Jiann	cut	sw	1	$700	3 lbs.	8	3	
	imp	thr+1	1,2					
Thrusting Bastard Sword	cut	sw+1	1,2	$750	5 lbs.	11	3	[2] [7]
	imp	thr+2	2					



FLAIL

Grain Flail	cr	sw+2	2,3*	$20	8 lbs.	12	1	[2] [8]
Flail	cr	sw+4	1,2*	$100	8 lbs.	13	3	[2] [8]
Morningstar	cr	sw+3	1	$80	6 lbs.	12	3	[2] [8]

GARROTE

Cord/Thong	cr	thr	C	$20	negligible	–	0	See p. CI134.
Stick Noose	cr	thr	1-2	$30	2 lbs.	–	0	See p. CI134.

KATANA

Katana	cut	sw+1	1,2	$650	5 lbs.	11	3	One-handed.
	cut	sw+2	1,2					Two-handed.
	imp	thr+1	1					
Katana (Scabbarded)	cr	sw+1	1,2					One-handed, to subdue.
	cr	sw+2	1,2					Two-handed, to subdue.

Weapon	*Type*	*Damage*	*Reach*	*Cost*	*Weight*	*Min ST*	*TL*	*Special Notes*
KNIFE								
Large Knife	cut	sw-2	C,1	$40	1 lb.	–	0	Max. dam. 1d+2. [1]
	imp	thr	C					
Small Knife	cut	sw-3	C,1	$30	0.5 lb.	–	0	Max. dam. 1d+1. [1]
	imp	thr-1	C					
Dagger	imp	thr-1	C	$20	0.5 lb.	–	1	Max. dam. 1d. [1]
Knife-Wheel	cut	thr+1	C	$75	1.5 lbs.	–	3	Usually used in pairs.
	imp	thr-1	C					Max. Dam. 1d. [9]
Slashing Wheel	cut	thr+1	C	$60	1 lb.	–	3	Usually used in pairs. [9]
Small Katar	cut	sw-3	C,1	$40	1 lb.	–	3	Perpendicular grip. Parries
	imp	thr+1	C					at DX/2 or 2/3 Brawling.
LANCE								
Lance	imp	thr+3	4	$60	6 lbs.	12	3	See p. B136 for readying. [4]
POLEARM								
Dagger-Axe	cut	sw+2	2,3*	$150	9 lbs.	11	1	[10]
Gaff/Boarding Hook	cut	thr-1	2,3*	$100	7 lbs.	10	1	Max. dam. 1d-1. [5]
Fire Lance	Spcl.	1d-1	3-5	$50	5 lbs.	9	3	Burns for 10 seconds.
Glaive	cut	sw+3	2,3*	$100	8 lbs.	11	3	[10]
	imp	thr+3	1-3*					[11]
Halberd	cut	sw+5	2,3*	$150	12 lbs.	13	3	[10]
	imp	sw+4	2,3*					[3] [10]
	imp	thr+3	1-3*					[11]
Heavy Horse-Cutter	cut	sw+5	2,3*	$150	12 lbs.	13	3	[10]
	imp	thr+3	1-3*					[11]
Latajang	cut	sw+2	1,2*	$100	7 lbs.	10	3	[2]
	cut	thr+1	1,2*					[11]
Light Horse-Cutter	cut	sw+4	1,2*	$120	8 lbs.	12	3	[10]
	imp	thr+3	1,2*					[11]
Monk's Spade	cut	sw+1	1,2*	$100	6 lbs.	10	3	[2]
	cr	sw+1	1,2*					[2]
	cut	thr+2	1,2*					[11]
Naginata	cut	sw+2	1,2	$100	6 lbs.	9	3	[2]
	imp	thr+3	2					
Poleaxe	cut/cr	sw+4	2,3*	$120	10 lbs.	12	3	[10]
SHORTSWORD								
Baton	cr	sw	1	$20	1 lb.	7	0	
	cr	thr	1					
Stabbing Shortsword	imp	thr	1	$300	2 lbs.	7	1	
Falchion	cut	sw+1	1	$375	3 lbs.	10	2	
	cr	thr-2	1					
Long Knife	cut	sw-1	1	$120	1.5 lbs.	7	2	
	imp	thr	C,1					
Shortsword	cut	sw	1	$400	2 lbs.	7	2	
	imp	thr	1					
Large Katar	imp	thr+1	1	$400	2 lbs.	7	3	Parries at DX/2 or
	cut	sw-1	1					2/3 Brawling.
SPEAR								
Fire-Hardened Spear	imp	thr	1*	$20	2 lbs.	8	0	One-handed. [1]
	imp	thr+1	1,2*					Two-handed.
Small-Pointed Spear	imp	thr+1	1*	$30	3 lbs.	8	0	One-handed. [1]
	imp	thr+2	1,2*					Two-handed.
Spear	imp	thr+2	1*	$40	4 lbs.	9	0	One-handed. [1]
	imp	thr+3	1,2*					Two-handed.

Weapon	Type	Damage	Reach	Cost	Weight	Min ST	TL	Special Notes
SPEAR (CONTINUED)								
Wooden Spear	imp	thr-1	1*	$10	2 lbs.	8	0	One-handed. [1]
	imp	thr	1,2*					Two-handed.
Javelin	imp	thr+1	1	$30	2 lbs.	–	1	One-handed. [1]
Iklwa	imp	thr+2	1	$40	3 lbs.	10	2	One-handed.
Long Spear	imp	thr+2	2,3*	$60	5 lbs.	10	2	One-handed. [4] [12]
	imp	thr+3	2,3*					Two-handed.
Pike	imp	thr+3	4-6	$180	3 lb./yd.	12	2	Two-handed. [4] [13]
Trident	imp	thr+3 (0.5)	1*	$40	5 lbs.	10	2	One-handed. [2] [14] [15]
	imp	thr+4 (0.5)	1,2*					Two-handed.
Kontos	imp	thr+4	2,3	$90	6 lbs.	12	3	Two-handed. [4]
STAFF								
Quarterstaff	cr	sw+2	1,2	$10	4 lbs.	6	0	
	cr	thr+2	1,2					
Muchan	cr	sw	1	$10	1 lb.	7	1	Two-handed baton.
	cr	thr	1					
Tetsubo	cr	sw+4	1,2	$100	10 lbs.	13	2	
	cr	thr+2	1,2					
Light horse-cutter	cr	sw+2	1,2	$120	8 lbs.	12	3	Using staff technique.
	cr	thr+2	1,2					
Naginata	cr	sw+2	1,2	$100	6 lbs.	9	3	Using staff technique.
	cr	thr+2	1,2					
TWO-HANDED AXE/MACE								
Great Axe	cut	sw+3	1,2*	$100	8 lbs.	13	0	[2]
Maul	cr	sw+4	1,2*	$80	12 lbs.	14	0	[2]
Two-Handed Mace	cr	sw+3	1,2	$60	9 lbs.	13	0	[2]
	cr	thr+2	1					
Scythe	cut	sw+2	1	$15	5 lbs.	12	2	-2 to hit when impaling. [2]
	imp	sw	1					[6]
Warhammer	imp	sw+3	1,2*	$100	7 lbs.	13	3	[2] [3]
	cr	sw+2*	1,2					
TWO-HANDED SWORD								
Quarterstaff	cr	sw+2	1,2	$10	4 lbs.	9	0	Using sword technique.
	cr	thr+1	2					
Two-Handed Macauitl	cut	sw+2	1,2	$650	5 lbs.	12	0	[2]
	cut	thr	1,2	$700				If sharp; most are blunt.
Tetsubo	cr	sw+4	1,2	$100	10 lbs.	13	2	Using sword technique. [2]
	cr	thr+2	2					
Bastard Sword	cut	sw+2	1,2	$650	5 lbs.	10	3	
	cr	thr+2	2					
Greatsword	cut	sw+3	1,2	$800	7 lbs.	12	3	
	cr	thr+2	2					
Naginata	cut	sw+3	2	$100	6 lbs.	9	3	Using sword technique. [2]
	imp	thr+3	2					
Thrusting Bastard Sword	cut	sw+2	1,2	$750	5 lbs.	10	3	
	imp	thr+3	2					
Thrusting Greatsword	cut	sw+3	1,2	$900	7 lbs.	12	3	
	imp	thr+3	2					

Notes: [1] Throwable. [2] One turn to ready after swing (see p. B104). [3] May get stuck (see p. B96). [4] Cannot parry. [5] Quick Contest of weapon skill vs. DX to engage target; Contest of ST for wielder or target to pull each other; damage inflicted only while pulling; hold on target lost after crippling damage to a limb. [6] Target at -1 to block/parry. [7] Becomes unready if used to parry. [8] Target at -2 to block, -4 to parry. [9] Gives PD 1. [10] Two turns to ready after swing. [11] One turn to ready after thrust. [12] May be thrown at -2. [13] Takes one full turn to move point to a new hex. [14] Target at -1 to dodge, +1 to block/parry. [15] Armor DR is doubled against the trident. * Must be readied for one turn to change between long and short grip.

Customization

The ingenuity of armorers has created numerous small variations on these designs for hand weapons. Polearms especially exist in almost unlimited variety. Some variations are purely ornamental, making no difference to performance; their cost is left to the GM's discretion. The following variations make a difference to performance:

Back Hammer: This is a flat striking surface protruding from the back of a swung weapon. It allows a crushing attack equal to the weapon's cut or imp damage. Applicability: axes, picks, polearms. Weight 0.5 lb.; cost +25%.

Back Spike: This is a substantial spike mounted on the back of a swung weapon. It allows an impaling attack based on the weapon's cut damage, at -1. Applicability: axes, halberds. Weight 0.5 lb.; cost +50%.

Barbs: Harpoons are normally barbed, and other thrusting weapons may be barbed as well. This has no effect on damage, but pulling the weapon out requires an ST roll (see p. B96) and inflicts half the damage it caused going in. Applicability: spears, polearms with spear points. Weight negligible; cost +150%.

Butt Spike. This comes in two versions. One is a metal shoe used to aid in planting a weapon shaft in the ground. If it is used in a butt strike, treat the weapon as a quarterstaff; the spike does not do imp damage but gives +1 to cr damage from a thrust. Applicability: spears, polearms with spear points. Weight negligible; cost +25%. The other version is a small spear point, which allows a butt strike doing imp damage at -1 from the weapon's normal damage. Applicability: spears. Weight negligible; cost +50%.

Falchion: The falchion option redesigns a weapon to be used primarily for cutting and chopping; the class is named for the shortsword version. Start with a blunt-pointed blade of the same type (if starting from a sharp-pointed blade, apply a -1 modifier to thrusting damage and change to cr); then give +1 cut for a swing and -1 cr for a thrust. Applicability: knives, swords. Weight is +50%; cost is +25%. Falchions have +1 Breakage Rating; falchions of broadsword size or higher take 1 turn to ready.

Flanges: Maces and flails are typically flanged (or have multiple small spikes, which are treated as equivalent). Flanges on other swung weapons give +1 cr damage. Applicability: hammers, mauls. Weight negligible; cost +40%. Unflanged versions of typically flanged weapons cost 30% less and do -1 cr damage.

Hook: As on a gaff, this can be used to catch and tug at an opponent. A Quick Contest of weapon skill against DX determines if the hook engages; if it does, a Contest of ST is used for the two to pull each other off their feet or horses. The hook also inflicts cut damage while pulling, equal to thr-1 for a two-handed weapon, thr-2 for a one-handed weapon, minimum 1, maximum 1d-1. If the target continues to struggle it inflicts half of the initial damage for each turn (armor gives full DR). Applicability: polearms, swords. Weight negligible; cost +25%.

Point: This is a full-sized spear point mounted on the end of a shaft and used to thrust. It causes imp damage at +1 from the cr damage a thrust with the weapon would cause (if not specified, treat as a quarterstaff). Applicability: polearms. Weight 0.5 lbs.; cost +100%.

Short Handle: The 3-yard-long polearms in the ***GURPS Basic Set*** are intended for formation fighting; such lengths are necessary when your foe is being held at bay by pikes. Shorter versions are better suited for self-defense. Short polearms have -1 swing damage, -1 reach (minimum 1), and -1 turn of ready time. All require two hands, take a turn to ready after a swing (but not a thrust) or to change grips, and can parry with the haft without becoming unready. Applicability: polearms of length 3 hexes and up. Weight -2 lbs.; cost -20%.

The added weight of customizations may affect the minimum ST of a weapon. The following rules can be used to estimate Min ST for any hand weapon:

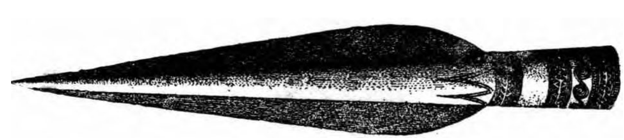
Multiply weight by 1 if the weapon is used one-handed and by 2/3 if the weapon is used two-handed. Lances are considered to be one-handed weapons for this purpose. Consult this table:

Effective Weight	***Min ST***
Less than 2.00 lbs.	4
2.00 lbs.-2.99 lbs.	7
3.00 lbs.-3.99 lbs.	10
4.00 lbs.-5.99 lbs.	11
6.00 lbs.-7.99 lbs.	12
8.00 lbs.-9.99 lbs.	13
10.0 lbs.-11.9 lbs.	14
12.0 lbs.-13.9 lbs.	15
14.0 lbs.-15.9 lbs.	16
+2 lbs.	+1

Use the listed Min ST for non-hafted weapons (including knives and swords, lances, one-handed flails, pole weapons and spears grasped mid-shaft, and staves and sticks of all kinds).

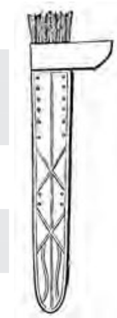
Add the longest Reach of the weapon to the Min ST of hafted weapons only (any weapon with a heavy head at one end, grasped near the end of the haft, including one- and two-handed axes, hammers, maces, and two-handed flails).

Actual Min ST can vary by one point, depending on fine details of weapon design. For instance, the hatchet should be Min ST 8 by these rules, but is rated as Min ST 7 due to its exceptionally short haft; the two-handed sword should be Min ST 11 using these rules, but is given Min ST 12 because its weight is controlled using only one hand much of the time. The Min ST for the spear is an average of the one-handed and two-handed figures.



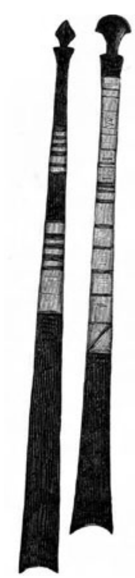
Ranged Weapons Table

Weapons are listed in groups according to the skill required to use them. Within each group, weapons are listed by TL and then alphabetically within a TL.

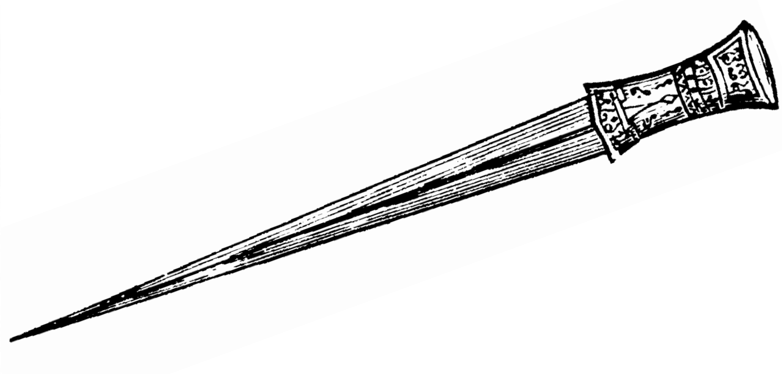


Weapon	Type	Damage	SS	Acc	1/2D	Max.	Cost	Weight	Min ST	TL	Special Notes
AXE THROWING											
Hatchet	cut	sw	11	1	ST × 1.5	ST × 2.5	$40	2 lbs.	7	0	
Round Mace	cr	sw+2	12	1	ST × 0.5	ST	$35	5 lbs.	12	0	
Small Round Mace	cr	sw+1	11	1	ST	ST × 1.5	$20	3 lbs.	11	0	
Small Throwing Axe	cut	sw+1	11	1	ST	ST × 1.5	$55	3 lbs.	10	0	
Throwing Axe	cut	sw+2	10	2	ST	ST × 1.5	$60	4 lbs.	11	0	
Mace	cr	sw+3	12	1	ST × 0.5	ST	$50	5 lbs.	12	2	
Small Mace	cr	sw+2	11	1	ST	ST × 1.5	$35	3 lbs.	11	2	
BLACK POWDER WEAPONS											
Midfa			23	1			$400	12 lbs.	13	3	[1]
w/Bullet	cr	2d			30	200	$2				
w/Dart	imp	1d+2			20	120	$3				
BLOWPIPE											
Blowpipe	–	Spcl.	10	1	–	ST × 4	$30	1 lb.	–	0	See p. B49.
BOLAS											
Bolas	Spcl.	thr-1	12	0	–	ST × 3	$20	2 lbs.	–	0	See p. B49.
BOW											
Longbow	imp	thr+2	15	3	ST × 15	ST × 20	$200	3 lbs.	11	0	Max. dam. 1d+4
Pellet Bow	cr	thr	12	0	ST × 10	ST × 15	$75	2 lbs.	7	0	Max. dam. 1d+3
Regular Bow	imp	thr+1	13	2	ST × 15	ST × 20	$100	2 lbs.	10	0	Max. dam. 1d+4
Short Bow	imp	thr	12	1	ST × 10	ST × 15	$50	2 lbs.	7	0	Max. dam. 1d+3
Composite Bow	imp	thr+3	14	3	ST × 20	ST × 25	$900	4 lbs.	10	1	Max. dam. 1d+4
CHAKRAM											
Disk	cr	thr+2	12	2	ST × 4	ST × 6	$40	2 lbs.	–	0	
Chakram	cut	thr+1	9	1	ST × 1.5	ST × 2.5	$50	2 lbs.	–	2	Max. dam. 1d-1
CROSSBOW											
Chukonu	imp	thr+2	10	4	ST × 15	ST × 20	$500	10 lbs.	9	2	[2]
Crossbow	imp	thr+4	12	4	ST × 20	ST × 25	$150	6 lbs.	7	2	Max. dam. 3d
Gastraphetes	imp	thr+4	15	6	ST × 20	ST × 25	$500	20 lbs.	10	2	Max. dam. 3d. [3]
Pistol Crossbow	imp	thr+2	10	3	ST × 15	ST × 20	$150	4 lbs.	7	2	Max. dam. 1d-1
Composite Crossbow	imp	thr+5	12	4	ST × 25	ST × 30	$950	7 lbs.	7	3	Maximum damage 3d+2. [4]
Prodd	cr	thr+4	12	2	ST × 20	ST × 25	$150	6 lbs.	7	3	Fires lead pellets.
HARPOON											
Wood Harpoon	imp	thr+3	11	2	ST	ST × 1.5	$120	3 lbs.	9	0	[5]
Metal Harpoon	imp	thr+5	11	2	ST	ST × 1.5	$60	6 lbs.	11	2	[5]
KNIFE THROWING											
Dagger	imp	thr-1	12	0	ST-5	ST	$20	0.25 lb.	–	1	Max. dam. 1d
Large Knife	imp	thr	12	0	ST-2	ST+5	$40	1 lb.	–	1	Max. dam. 1d+2
Small Knife	imp	thr-1	11	0	ST-5	ST	$30	0.5 lb.	–	1	Max. dam. 1d+1

Weapon	Type	Damage	SS	Acc	1/2D	Max.	Cost	Weight	Min ST	TL	Special Notes
LASSO											
Lasso	Spcl.	Spcl.	16	0	–	–	$40	3 lbs.	–	2	See p. B51.
NET											
Large Net	Spcl.	–	13	1	–	ST/2+Skill/5	$40	20 lbs.	–	0	See p. B51.
Melee Net	Spcl.	–	12	1	–	ST+Skill/5	$20	5 lbs.	–	2	See p. B51.
SHURIKEN											
Shaken	imp	thr-2	10	2	ST-5	ST	$2	0.1 lb	–	3	Max. dam. 1d
Shuriken	cut	thr-1	8	1	ST-5	ST	$3	0.1 lb.	–	3	Max. dam. 1d+2
SLING											
Bola Perdida	cr	sw	10	0	ST × 6	ST × 10	$20	1 lb.	–	0	
Sling			12	0			$20	0.5 lb.	–	0	
w/Stone	cr	sw			ST × 6	ST × 10	free	1 oz.	–	0	
w/Lead Bullet	cr	sw+1			ST × 12	ST × 20	$0.10	1 oz.		2	[6]
Staff Sling			14	1			$20	2 lbs.	–	1	
w/Stone	cr	sw+1			ST × 10	ST × 15	free	1 oz.	–	1	
w/Lead Bullet	cr	sw+2			ST × 20	ST × 30	$0.10	1 oz.	–	2	[6]
SPEAR THROWER											
Atlatl							$20	1 lb.	–	0	1 turn to ready
w/Dart	imp	sw-1	11	1	ST × 3	ST ×4	$20	1 lb.	–	0	
w/Javelin	imp	sw+1	11	3	ST ×2	ST × 3	$30	2 lbs.	7	0	
Woomera							$40	2 lbs.	–	0	1 turn to ready
w/Fire-Hardened Spear	imp	sw+1	12	1	ST × 1.5	ST × 2	$20	2 lbs.	8	0	
w/Small-Pointed Spear	imp	sw+2	12	2	ST × 1.5	ST × 2	$30	3 lbs.	9	0	
w/Spear	imp	sw+3	12	2	ST × 1.5	ST × 2	$40	4 lbs.	9	0	
w/Wooden Spear	imp	sw	12	1	ST × 1.5	ST × 2	$10	2 lbs.	8	0	
SPEAR THROWING											
Dart	imp	thr-1	9	3	ST × 2	ST × 3	$30	1 lb.	7	0	
Fire-Hardened Spear	imp	thr+1	11	1	ST	ST × 1.5	$20	2 lbs.	8	0	
Small-Pointed Spear	imp	thr+2	11	2	ST	ST × 1.5	$30	3 lbs.	9	0	
Spear	imp	thr+3	11	2	ST	ST × 1.5	$40	4 lbs.	9	0	
Wooden Spear	imp	thr	11	1	ST	ST × 1.5	$10	2 lbs.	8	0	
Javelin	imp	thr+1	10	3	ST × 1.5	ST × 2.5	$30	2 lbs.	7	1	
w/ Throwing Thong	imp	thr+1	12	4	ST × 1.75	ST × 2.75	$35	2 lbs.	7	2	
Plumbata	imp	thr-1	12	2	ST × 2.25	ST × 3.25	$20	1 lb.	–	2	
THROWING STICK											
Boomerang	cr	sw+1	11	2	ST × 6	ST × 10	$20	1 lb.	7	0	
Throwing Stick	cr	sw	11	2	ST × 4	ST × 8	$10	1 lb.	7	0	



Notes: [1] Treat as firearm: Malfunction on 13. Recoil -3, RoF 1/150. [2] Malfunction on 14. Holds 10 bolts, RoF 1/2. Limited to user ST. [3] No stock; must be braced. [4] Two hands to fire. [5] 1d-4 additional damage when removed, minimum 1. [6] Subject to blunt trauma rules (p. HT8): On a damage roll that does not penetrate flexible armor, a "6" on any rolled die indicates 1 point of normal crushing damage.

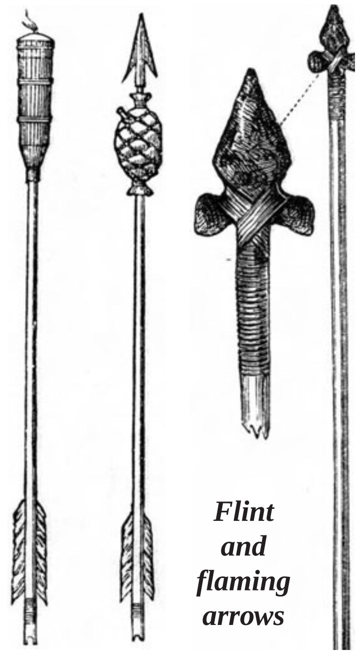


Bows and Crossbows

For bows and crossbows, the ST shown is that of the weapon, not that of the user. For other weapons, the ST is that of the user.

An archer using a bow whose ST exceeds his own faces the usual -1 skill and +1 fatigue after the fight per point of excess. Aiming such a bow requires a Contest of ST for each second spent in aiming; after any second in which the archer loses the contest his accumulated aim bonus is lost. A crossbowman can use a weapon whose ST exceeds his own, at the price of some delay in cocking it (see p. B114); there is no skill penalty, regardless of the ST of the crossbow. An archer or crossbowman using a weapon whose ST is less than his own is limited to its range and damage. For crossbows, increase cost and weight 50% if the crossbow ST is 14-20; double them if it is 21-27.

These rules do not replace, but clarify, the rules in the ***Basic Set***. However, they do replace the rules for extra-powerful bows in ***Compendium II*** (p. CII30); since every bow has a rated ST, special rules are not needed.



Flint and flaming arrows

Specialized Arrows

Several alternative types of arrows are available at various TLs.

Flint-Headed Arrow. TL0. -1 damage; reduce bow ranges by ST × 5. $1.

Obsidian-Headed Arrow. TL0. +1 damage, but breaks if used to strike DR 2+, doing cr damage with no bonus. Reduce bow ranges by ST × 5. $4.

Wood/Bamboo Arrow. TL0. A simple sharpened wood or bamboo shaft. -2 damage; reduce bow ranges by ST × 5. $0.50.

Blunt Arrow. TL1. Change damage to cr. $2.

Broadpoint Arrow. TL1. The standard metal-headed arrow. $2. May have barbs (see p. 110) at cost $6.

Flaming Arrow. TL2. An arrow with oil-soaked rags attached just behind the head, set alight just before it is fired. The weight gives -2 skill; the flame gives +1 damage and may set the target on fire (see p. 94).

Bodkin Point. TL3. An armor-piercing arrow with a very narrow head. These arrows get a (2) armor divisor; the wounding multiplier for armor-piercing ammunition (×1/2) cancels that for an impaling attack (×2), for a net ×1. $2.

Artillery Table

Weapons are grouped by TL, alphabetically within each TL, and then by increasing weight and power.

Weapon	*Malf*	*Type*	*Damage*	*SS*	*Acc*	*1/2D*	*Max*	*Weight**	*RoF*	*Cost*	*WPS**	*CPS*	*Ldrs.*	*TL*
Ballista	Crit	cr	18d	30	2	265	320	4,500	1/60	$13,800	15	$7.50	3	2
Ballista	Crit	cr	23d	30	2	290	360	8,000	1/70	$20,000	20	$10	4	2
Ballista	Crit	cr	6d × 5	30	2	340	425	18,000	1/88	$40,800	30	$15	7	2
Ballista	Crit	cr	6d × 10	30	2	490	610	72,000	1/120	$148,800	60	$30	14	2
Cranked Gastraphetes	Crit	imp	2d+3	20	6	400	500	40	1/23	$1,000	0.25	$2	1	2
Early Ballista	Crit	cr	8d-1	30	2	215	270	625	1/35	$6,100	5	$2.50	1	2
Polybolos	16	imp	2d+3	20	5	400	500	64	1/9	$3,200	0.25	$2	1	2
Scorpion	Crit	imp	3d+2	20	6	405	505	50	1/25	$2,500	0.4	$2	1	2
Scorpion	Crit	imp	5d	20	6	415	520	110	1/30	$5,000	0.9	$2	1	2
Bombard, 9”	13	cr	23d	30	5	210	1,400	2,600	1/172	$5,600	72	$14.40	10	3
Bombard, 18”	13	cr	6d × 8	30	5	300	1,700	10,500	1/344	$21,400	580	$116	24	3
Fire Siphon	14	Spcl.	1d	10	5	15	22	550	1	$2,750	3	$0.50	0	3
Mangonel	Crit	cr	6d×5+30	30	2	160	200	25,000	1/80	$27,400	50	$25	25	3
Trebuchet	Crit	cr	23d+23	30	1	220	275	5,000	1/141	$14,800	20	$10	9	3
Trebuchet	Crit	cr	6d×9+54	30	1	330	410	31,250	1/224	$67,300	50	$25	24	3
Trebuchet	Crit	cr	6d×17+102	30	1	520	650	125,000	1/316	$254,800	100	$50	49	3

* Weight and weight per shot (WPS) are given in pounds.

Note: The gastraphetes, the polybolos, and the early ballista are powered by the elasticity of large wooden bows; the other TL2 engines use torsion springs. The mangonel and fire siphon are man-powered; the other TL3 engines use counterweights.

Armor Table

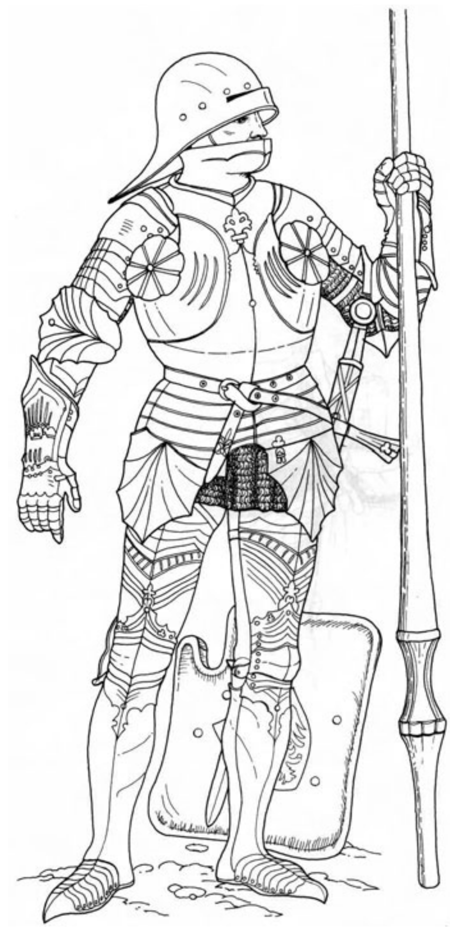
The following list of armor types is grouped primarily by hit location. For each hit location, armor types are grouped by the TL when they are first used, and within TLs by increasing PD and then by increasing DR.

Entire suits of armor were rare in many periods. Mercenary soldiers, free-lance adventurers, poor noblemen, and even the common soldiers of many states assembled their own armor out of whatever pieces they could afford. The best protection will be worn on the most vulnerable areas: the brain and vitals, then the rest of the head and torso, and only then the limbs.

Any armor can be worn over any other armor, subject to GM approval. Add the DR of all layers; use the PD of the outermost layer. Armor must be designed for a specific layering scheme when purchased. This adds no cost, but means that the wearer cannot layer that armor in any order other than the one specified. (This rule ceases to apply at TL6+.)

Massive amounts of armor become bulky and awkward: for every point by which the total DR of the inner layers (every layer but the outermost layer) exceeds 3, reduce the wearer's effective DX by 1. Clothing with PD 0, DR 0 does not count as armor for the purpose of this rule and can be worn over or under armor without appreciable effect.

Weights and prices for armor include appropriate padding worn under the armor. In particular, the weight of chainmail includes the weight of substantial padding beneath.



These rules are an alternative to the armor rules on pp. B71-73, providing a more detailed approach specifically designed for use with the hit location rules. A GM using the basic combat rules, without hit locations, may also allow an adventurer to wear any combination of clothing and armor that makes sense, applying the PD and DR of the torso armor to all attacks against the adventurer. Some examples of complete suits of armor (not covered on pp. B71-73) are listed, for convenience.

The human head has numerous vulnerable points that can be targeted by a blow (see pp. CII52-53). Helmets were designed to protect these in varied combinations. Most of these locations are small parts of hit location 5, and a helmet that protects one of them also provides some protection to hit location 5 – but not complete protection.

To reflect this complexity, the following optional system is provided. A helm is considered to be made up of one or more standard parts. Each part protects certain specific hit locations; in addition, when those locations are included in hit location 5, it has a probability of protecting hit location 5. Each probability is specified as a certain number of chances out of 6; when a helm is described, these chances are added up, and if the total or less is rolled on 1d when a blow is struck at hit location 5, the helm's PD and DR are applied against the blow. A GM who prefers to avoid these complexities can treat a helm that protects any part of hit location 5 as providing its full PD and DR to hit location 5 on every attack.

Skull: The skull is the core of the helm. It protects all of hit locations 3 and 4; that is, the brain.

Cheek-Pieces: The cheek-pieces protect the ears, and have a 3/6 chance of protecting hit location 5. All hearing rolls with cheek-pieces in place are at -3.

Nasal: A nasal is a vertical strip of metal that can deflect blows against the nose, and has a 1/6 chance of protecting hit location 5.

Spectacles: Spectacles are rims of metal around the eyes; they protect the eyes and have a 1/6 chance of protecting hit location 5. A thrusting or missile attack at -10 can target the eyeholes in spectacles. All vision rolls with spectacles in place are at -2.

Visor: A visor is a plate that covers the face; visors are commonly hinged. In place, a visor provides the same protection as cheek-pieces, spectacles, and a nasal and takes their places; it thus has a 5/6 chance of protecting hit location 5. All Sense rolls with a visor in place are at -3, and all combat skill rolls are at -1.

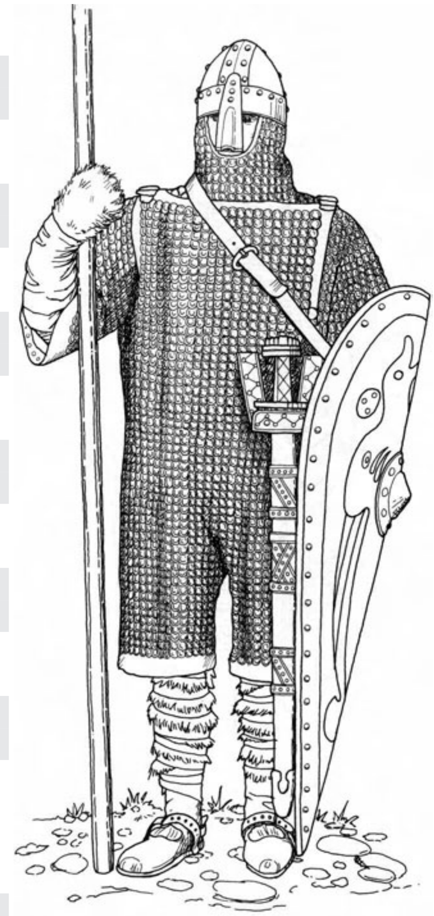
Neck-Guard: A neck-guard protects the neck, including the jugular vein and carotid artery, and has a 1/6 chance of protecting hit location 5. Some forms of neck-guard are worn as separate pieces of armor or are attached to torso armor rather than head armor.

Subtract 1 from the total n/6 protection to get the additional penalty for aiming past the face protection, minimum 1. A nasal prevents aiming for the Nose past armor protection; Neck guard does the same for Jaw. Each 1/6 of protection adds 0.5 lbs. and $20 to weight and cost if metal, 0.25 lbs. and $10 if leather or cloth.

A simpler version of this approach can be applied to arm and leg armor, which may be defined as protecting only the upper limb or only the lower limb (3/6 chance in either case).

Some pieces of armor protect only from the front or only from the back. This question is separate from the system just described and is noted as such when it is relevant.

Armor	*Locations*	*PD*	*DR*	*Cost*	*Weight*	*TL*
HEADGEAR						
Fur Cap	3-4	0	1	$6	negligible	0
Basketry Helm	3-4	1	1	$16	negligible	0
Leather Cap	3-4	1	1	$32	negligible	0
Boar's Tusk Helmet	3-4	1	3	$100	3 lbs.	0
Wooden Helm	3-4	2	2	$20	6 lbs.	0
Wooden Mask	5	2	2	$20	3 lbs.	0
Cloth Cap	3-4	1	1	$5	negligible	1
Copper Pot-Helm	3-4	2	2	$40	5 lbs.	1
Leather Helm	3-4, 5 (3/6)	2	2	$20	0.5 lb.	1
Round Bronze Pot-Helm	3-4	2	3	$60	5 lbs.	1
Shaped Bronze Pot-Helm	3-4	3	3	$80	5 lbs.	1
Bronze Helmet	3-4, 5 (3/6)	3	3	$160	7.5 lbs.	1
Gladiator's Mask	5 (5/6, front)	1	3	$30	1 lb.	2
Chainmail Coif	3-4	3	4	$55	4 lbs.	2
Gladiator's Helmet	3-4	3	4	$120	5 lbs.	2
Pot-Helm	3-4	3	4	$100	5 lbs.	2
Legionary's Helmet	3-4, 5 (3/6)	3	4	$150	6 lbs.	2
Reinforced Coif	3-4, 5 (rear)	2	2	$500	3 lbs.	3
Lobsterback	5 (rear)	2	3	$25	1 lb.	3
Face Mask	5 (front)	3	4	$100	2 lbs.	3
Viking Helmet	3-5	3	4	$200	7 lbs.	3
Double Mail Coif	3-4	3	5	$140	8 lbs.	3
Barrel Helm	3-5	3	7	$240	10 lbs.	3
Greathelm	3-5	4	7	$340	10 lbs.	3
TORSO						
Fur Loincloth	11	0	1	$10	–	0
Fur Tunic	9-11, 17-18	0	1	$25	2 lbs.	0
Parka/Overcoat	6, 8-14, 17-18	0	1	$100	10 lbs.	0
Straw Coat	9-11, 17-18	0	1	$10	10 lbs.	0
Fur Cloak	9-11, 17-18	1	1	$100	3 lbs.	0
Fur Jacket	6, 8-10, 17-18	1	1	$200	5 lbs.	0
Cane Breastplate	9-11, 17-18 (front)	1	2	$50	4 lbs.	0
Cloth Armor	9-11, 17-18	1	1	$30	6 lbs.	1
Leather Jacket	6, 8-11, 17-18	1	1	$50	4 lbs.	1
Cloth Cuirass/Jack	9-11, 17-18	1	2	$50	8 lbs.	1
Feathered Surcoat	9-11, 17-18	+1	–	$2,000	2 lbs.	1
Studded Leather Cloak	6, 8-14, 17-18	1	3	$240	20 lbs.	1
Wood Slat Armor	9-11, 17-18	1	3	$120	10 lbs.	1
Leather Armor	9-11, 17-18	2	2	$100	10 lbs.	1
Reinforced Leather Cuirass	9-11, 17-18	2	3	$120	12 lbs.	1
Lamellar Bronze Corselet	9-11, 17-18	3	4	$420	35 lbs.	1
Bronze Breastplate	9-11, 17-18 (front)	4	4	$400	20 lbs.	1
Bronze Plate Corselet	9-11, 17-18	4	5	$1,300	40 lbs.	1
Bronze Panoply	5 (1/6), 9-11, 17-18	4	6	$3,000	50 lbs.	1
Light Scale	9-11, 17-18	3	3	$150	15 lbs.	2
Chainmail	9-11, 17-18	3	4	$230	25 lbs.	2
Scale	9-11, 17-18	3	4	$420	35 lbs.	2
Lorica Segmentata	9-11, 17-18	3	5	$680	26 lbs.	2
Armored Shirt	9-11, 17-18	2	3	$2,000	12 lbs.	3
Coat of Plates	9-11, 17-18 (front)	2	4	$350	16 lbs.	3
Augmented Mail	9-11, 17-18	3	4	$275	30 lbs.	3
Double Mail	9-11, 17-18	3	5	$520	44 lbs.	3
Lamellar Steel Corselet	9-11, 17-18	3	5	$450	24 lbs.	3
Laminated Steel Corselet	9-11, 17-18	4	5	$900	30 lbs.	3



Torso (continued)

Armor	Locations	PD	DR	Cost	Weight	TL
Steel Breastplate	9-11, 17-18 (front)	4	5	$500	18 lbs.	3
Steel Corselet	9-11, 17-18	4	6	$1,300	35 lbs.	3
Heavy Steel Corselet	9-11, 17-18	4	7	$2,300	45 lbs.	3

Arms and Legs

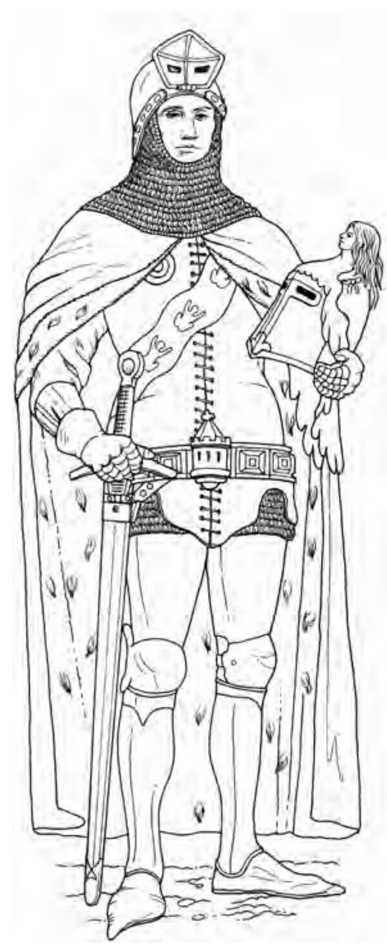
Armor	Locations	PD	DR	Cost	Weight	TL
Fur Leggings	12-14	0	1	$16	2 lbs.	0
Wood Armbands	6, 8 (3/6)	1	1	$60	negligible	0
Wood Wristbands	6, 8 (1/6)	1	1	$30	negligible	0
Cloth Arms	6,8	1	1	$20	2 lbs.	1
Cloth Leggings	12-14	1	1	$20	2 lbs.	1
Light Leather Leggings	12-14	1	1	$40	2 lbs.	1
Leather Arms	6, 8	2	2	$50	2 lbs.	1
Leather Leggings	12-14	2	2	$60	4 lbs.	1
Reinforced Leather Arms	6, 8	2	3	$60	2.5 lbs.	1
Reinforced Leather Leggings	12-14	2	3	$72	5 lbs.	1
Bronze Armbands	6, 8 (3/6)	3	3	$120	6 lbs.	1
Bronze Greaves	12-14	3	3	$270	17 lbs.	1
Bronze Wristbands	6, 8 (1/6)	3	3	$60	3 lbs.	1
Lamellar Bronze Arms	6, 8	3	4	$200	8 lbs.	1
Studded Leather Skirt	12-14 (3/6)	2	3	$60	4 lbs.	2
Chainmail Arms	6, 8	3	4	$70	9 lbs.	2
Chainmail Leggings	12-14	3	4	$110	15 lbs.	2
Galerus	6 or 8	3	4	$105	7 lbs.	2
Scale Arms	6, 8	3	4	$210	14 lbs.	2
Scale Leggings	12-14	3	4	$250	21 lbs	2
Augmented Mail Arms	6, 8	3	4	$85	11 lbs.	3
Augmented Mail Leggings	12-14	3	4	$130	18 lbs.	3
Double Mail Arms	6, 8	3	5	$160	16 lbs.	3
Double Mail Leggings	12-14	3	5	$250	28 lbs.	3
Plate Arms	6, 8	4	6	$1,000	15 lbs.	3
Plate Leggings	12-14	4	6	$1,100	20 lbs.	3
Heavy Plate Arms	6, 8	4	7	$1,500	20 lbs.	3
Heavy Plate Leggings	12-14	4	7	$1,600	25 lbs.	3

Hands and Feet

Armor	Locations	PD	DR	Cost	Weight	TL
Foot Wrappings	15-16	0	1	$10	2 lbs.	0
Mittens	7	0	1	$10	1 lb.	0
Sandals	15-16	0	0	$24	1/2 lb.	0
Cloth Gloves	7	1	1	$15	negligible	1
Shoes	15-16	1	1	$40	2 lbs.	1
Leather Gloves	7	2	2	$30	negligible	1
Reinforced Leather Gloves	7	2	3	$36	negligible	1
Boots	15-16	2	2	$80	3 lbs.	2
Gauntlets	7	3	4	$100	2 lbs.	2
Sollerets	15-16	3	4	$150	7 lbs.	3
Heavy Gauntlets	7	3	5	$250	2.5 lbs	3
Mitten Gauntlets	7	4	6	$300	3 lbs.	3

Overall

Armor	Locations	PD	DR	Cost	Weight	TL
Light Fur Clothing	All	0	0	$20	2 lbs.	0
Medium Fur Clothing	All	0	1	$51	6 lbs.	0
Heavy Fur Clothing	All	1	1	$100	12 lbs.	0
Summer Clothing	6, 8-14, 17-18	0	0	$10	1 lb.	1
Winter Clothing	6, 8-14, 17-18	0	1	$20	3 lbs.	1
Feathered Cloth Armor	All	2	2	$3,130	10 lbs.	1



Armor	Locations	PD	DR	Cost	Weight	TL
OVERALL (CONTINUED)						
Sariam	All	2	3	$840	70 lbs.	1
Bronze Lamellar	All	3	4	$570	45 lbs.	1
Bronze Plate	All	4	6	$3,370	70 lbs.	1
Legionary's Armor	All	3	5	$1,100	29 lbs.	2
Gladiator's Armor	All	4	4	$950	50 lbs.	2
Fireproof Clothing	All	1	1	$90	10 lbs.	3
Augmented Mail	All	3	4	$650	55 lbs.	3
Double Mail	All	3	5	$1,250	90 lbs.	3

Then he took his shield, his battleaxe, and his armful of javelins. Now after I had let his weapons issue forth, I made his arrows pass me by uselessly, one close to another. He charged me, and I shot him, my arrows sticking in his neck. He cried out and fell on his nose. I felled him with his own battleaxe and raised my cry of victory over his back . . . Then I carried off his goods and plundered his cattle.

– The Story of Sinuhe the Egyptian

Notes: The following types of armor have reduced protective value against impaling attacks: the studded leather skirt (PD 1, DR 1), chainmail (PD 1, DR 2), augmented mail (PD 2, DR 3), and double mail (PD 2, DR 3). The various cloaks can protect against attacks from the front, but the wearer must forego attacking to gain this benefit. Fireproof clothing has increased protective value against flame-based attacks (PD 2, DR 4).

Helmets may be decorated with crests, devices, emblems, or plumes, starting at TL0. Weight is 1 lb. or less; cost is at the GM's discretion. Decorations have no combat effect, but crests and plumes add to the wearer's height for Intimidation rolls (see p. CI159).

Shields Table

The table that follows defines both basic shield attributes – PD, weight, cost, and TL – and attributes for use with the optional "Damage to Shields" rules (p. B120) – hits and DR. The DR protects the *shield*, not the user!

Shield Type	PD	DR	Hits	Weight	Cost	TL
Buckler	1	3	5/20	2 lbs.	$25	–
Small	2	3	5/30	8 lbs.	$40	–
Medium	3	3	7/40	15 lbs.	$60	–
Large	4	3	9/60	25 lbs.	$90	–
Wall	–	3	9/100	40 lbs.	$135	1
Improvised	1 or 2	varies	varies	varies	–	0
Wicker	×1	1	×2/5	×2/5	×2/5	0
Hide/Leather	×1	2	×3/5	×1/2	×1/2	0
Studded Leather	×1	3	×3/5	×3/5	×3/5	1
Metal Faced Wood	×1	3	×1	×1	×1	1
Wood	×1	3	×1	×1	×1	1
Bronze	×1	6	×2	×3	×4	2
Iron	×1	6	×2	×2	×5	3

Notes: At TL2-3, a spike can be added to a wood or metal shield. This adds 5 lbs. to weight, $20 to cost, and +1 to damage in a bash attack (see p. B123).

The "wall shield" is actually a man-portable barrier such as the medieval pavise. So used, it confers no PD. Rather, the user treats it as cover; if he looks around it his adversaries are at -4 to hit. Moving it is governed by the rules for "Lifting and Moving Things" (p. B89) and is normally done with a two-handed grip that precludes active combat. A wall shield can also be used as a large shield. This requires Min ST13. The user is at -1 to Block per point of ST below the minimum.

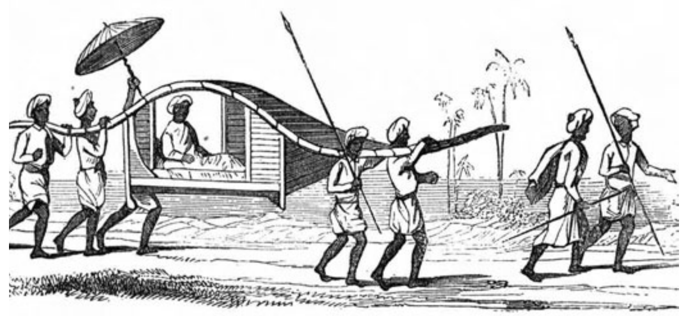
Vehicles Tables

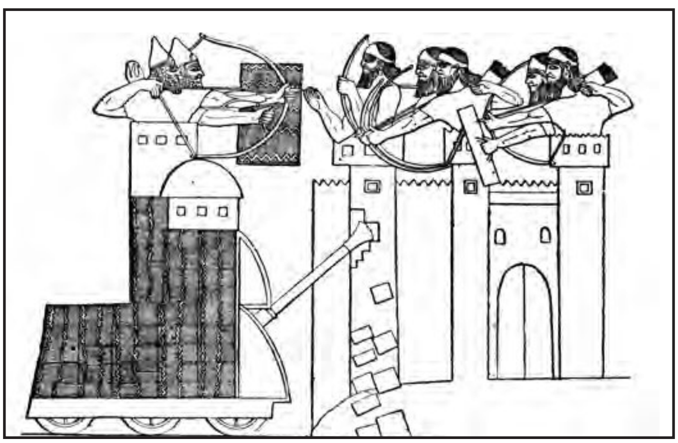
These tables provide game statistics for a variety of land and water vehicles. For a more complete treatment of vehicles, see ***GURPS Vehicles***, which was used to work out full designs for all the vehicles presented here. However, the brief statistics given here can be used with the basic rules as well. They can be interpreted as follows:

Cost is the price of the vehicle in $.

EW (empty weight) is how much the vehicle itself weighs in pounds. Crewmen and passengers can be assumed to weigh 200 lbs. each. In general, cargo can be assumed to weigh 20 lbs. per cf, except for bulk cargoes such as grain, which weigh 50 lbs. per cf. Add these three weights to obtain loaded weight. For ships, this can be compared to *flotation* to determine how heavily loaded the ship is, in pounds.

DR and *HP* have the same meaning as for human beings; see p. B125 for rules on attacking inanimate objects. PD for a vehicle is 1 for DR 1, 2 for DR 2-4, 3 for DR 5-15, or 4 for DR 16 or higher (limited to 2 for bark and leather hulls and 3 for wooden hulls).





Move has the same meaning as for human beings and is the fastest speed the vehicle can attain. For land vehicles, Move is computed from the rules for pulling loads (p. B89) and harness effects (pp. 37, 84); results are comparable but not identical to those of the formulas in ***GURPS Vehicles***. MR is the number of Gs the vehicle can withstand in a turn. To estimate a vehicle's turning radius (see p. B139), square its move and divide by 10 × MR. For a land vehicle, especially a chariot, tighter turns are possible, but require Teamster rolls at penalties based on the turning radius, as follows:

Turning Radius Multiple	***Penalty***
×2/3	-2
×1/2	-4
×2/5	-6
×1/3	-8
×2/7	-10

Daily Travel (given in miles) is usually based on 12.5 hours of travel; however, for deep-sea sailing ships, it assumes 24 hours of travel.

Land Vehicles

Vehicle	***Cost***	***EW***	***Crew***	***Psgrs.***	***Cargo***	***Draft Animals***	***DR***	***HP***	***Move***	***MR***	***Daily Travel***	***TL***	***Notes***
Dogsled	$400	305 lbs.	1	0	4 cf	14 dogs	2	13	6	0.5	30	0	
Battle car	$396	406 lbs.	1	1	–	4 onagers	1	19	4	0.5	40	1	[3]
Light Chariot	$333	181 lbs.	1	1	–	2 ponies	1	19	9	0.5	30	1	[5]
Heavy Chariot	$356	239 lbs.	1	2	–	4 ponies	1	23	9	0.5	30	1	[5]
Oxcart	$280	560 lbs.	–	–	24 cf	2 oxen	1	19	2	0.5	10	1	[1] [2]
Palanquin	$160	88 lbs.	2	1	–	Special	1	7	2	0.5	20	1	[6]
Platform car	$357	263 lbs.	1	–	–	2 onagers	1	11	2	0.5	20	1	[3]
Straddle car	$275	149 lbs.	1	–	3 cf	2 onagers	0	5	2	0.5	20	1	[4]
Assyrian Battering Ram	$2,000	6,220 lbs.	12	0	0	10 men	5	188	2	0.5	30	2	
Racing Chariot	$644	168 lbs.	1	–	–	4 racehorses	1	4	16	0.5	40	2	[5]
Siege Tower, 20'	$24,700	18,970 lbs.	–	18	3 cf	16 oxen	20	1,200	4	0.5	15	2	[1] [2]
Farm Wagon	$760	680 lbs.	1	–	40 cf	2 draft horses	2	22	8	0.5	30	3	[5]
Hussite War Wagon	$10,600	21,300 lbs.	2	20	–	8 draft horses	10	760	4	0.5	10	3	[5]

Notes: [1] Driver walks alongside. [2] Oxen can only work half a day. [3] Armor nonrigid; DR 2 on bottom/wheels. [4] DR 1 protects vehicle only. [5] Wheels unarmored. [6] Vehicle "crew" are two ST 12 bearers carrying vehicle.

Water Vehicles

SHIPS

Vehicle	Cost	EW	Crew	Psgrs.	Cargo	Flotation	DR	HP	Move	MR	Daily Travel	TL	Notes
Egyptian Merchant Ship, 90’	$17,900	20,950	36	–	4,500 cf	323,532	2	713	2 5	0.02	50 137.5	1	Rowed Sailed
Egyptian Riverboat, 35’	$2,537	3,560	14	–	350 cf	31,200	1	65	2 6	0.1	62.5 150	1	Paddled Sailed
Eicoseres, 50’	$5,900	4,288	22	–	75 cf	38,400	3	188	4 7	0.1	112.5 187.5	1	Rowed Sailed
Obelisk Barge, 200’	$34,700	174,000	36	–	Spcl.	4,375,000	2	7,500	1	0.01	37.5	1	Towed
Penteconter, 125’	$13,600	10,272	55	–	750 cf	128,544	3	435	4 7	0.02	112.5 175	1	Rowed Sailed
Ancient Merchant Galley, 75’	$9,570	11,190	35	–	1,350 cf	162,240	2	480	3 6	0.02	75 150	2	Rowed Sailed
Chinese River Boat, 43’	$6,200	9,500	18	–	800 cf	57,408	4	480	3	0.02	75	2	
Da Yichuan, 79’	$13,475	19,000	50	50	360 cf	131,664	5	881	4	0.02	100	2	
Hellenistic Quinquereme, 120’	$80,800	59,200	310	27	180 cf	253,344	10	1,350	6 5	0.02	150 137.5	2	Rowed Sailed
Hippagogos, 120’	$28,400	37,000	122	–	Spcl.	202,800	10	1,178	4 6	0.02	100 162.5	2	Rowed Sailed
Karve, 76’	$8,100	10,900	32	–	400 cf	62,073	4	476	3 6	0.05	75 150	2	Rowed Sailed
Lembos/Liburnian, 60’	$13,390	12,075	60	–	100 cf	56,160	5	473	4 6	0.02	100 150	2	Rowed Sailed
Louchuan, 179’	$69,500	102,000	150	800	6,000 cf	2,156,880	5	5,070	2	0.01	62.5	2	
Ploion, 65’	$31,500	36,390	10	9	2,000 cf	203,775	2	1,050	5	0.02	125	2	
Roman Quinquereme, 135’	$135,000	81,000	286	100	1,000 cf	544,128	10	2,125	5 6	0.01	125 162.5	2	Rowed Sailed
Trireme, 120’	$56,700	48,000	186	14	180 cf	202,800	10	1,178	5 6	0.02	137.5 150	2	Rowed Sailed
Xiao Yichuan, 59’	$9,800	13,000	38	25	227 cf	73,776	5	600	4	0.02	100	2	
Baghlah, 120’	$27,000	34,100	10	2	9,000 cf	620,730	2	1,088	6	0.05	288	3	
Baochuan, 465’	$1,300,000	1,710,000	43	101	1 mil. cf	62,700,000	10	96,000	5	0.005	264	3	
Boum, 90’	$25,300	67,600	12	–	9,300 cf	1,297,890	2	975	6	0.05	162.5	3	
Caravel, 80’	$20,500	38,500	23	–	2,240 cf	277,056	5	1,350	8	0.05	408	3	
Carrack, 128’	$78,700	201,500	25	–	22,400 cf	1,479,720	10	7,450	5	0.02	240	3	
Cog, 77’	$22.700	50,400	18	–	5,800 cf	501,600	5	1,950	4	0.05	216	3	
Crusader Ship, 118’	$106,000	190,000	72	50	50,000 cf	3,704,316	5	7,275	1 5	0.02	37.5 264	3	Rowed Sailed
Drakkar, 150’	$67,200	72,230	70	70	2,000 cf	517,920	10	2,100	3 5	0.05	75 240	3	Rowed Sailed
Dromon, 130’	$111,500	81,350	160	50	600 cf	315,744	5	1,575	5 6	0.05	125 150	3	Rowed Sailed
Fuchuan, 98’	$33,700	60,000	10	–	1,000 cf	776,256	5	2,700	5	0.02	240	3	
Hulk, 58’	$6,900	16,000	10	–	1,000 cf	125,400	5	750	4	0.05	216	3	
Knarr, 82’	$10,850	19,300	16	16	5,400 cf	205,656	5	1,050	1 4	0.05	37.5 192	3	Rowed Sailed
Ousiakos, 130’	$77,200	46,800	108	–	600 cf	234,624	5	1,275	5 6	0.05	125 162.5	3	Rowed Sailed
Shachuan, 48’	$27,300	32,500	9	–	1,800 cf	195,510	5	2,048	6	0.05	150	3	
Venetian Galley, 125’	$67,300	81,000	190	–	6,000 cf	617,448	10	2,325	3 7	0.02	87.5 360	3	Rowed Sailed

Vehicle	Cost	EW	Crew	Psgrs.	Cargo	Flotation	DR	HP	Move	MR	Daily Travel	TL	Notes
BOATS													
Bark Canoe, 15’	$270	195	2	–	20 cf	3,120	1	14	2	0.25	62.5	0	
Bark Canoe, 35’	$650	460	6	–	40 cf	9,984	1	32	3	0.05	75	0	
Clay Tub, 6’	$32	225	1	–	–	1,254	2	0	2	0.25	50	0	
Coracle, 5’	$290	150	1	–	20 cf	1,875	2	9	1	0.25	20	0	
Currach, 17’	$700	339	3	–	30 cf	4,680	2	18	2	0.25	40	0	
Dugout Canoe, 15’	$410	320	3	–	15 cf	4,212	3	32	2	0.25	62.5	0	
Kayak, 15’	$207	30	1	–	5 cf	960	1	3	3	0.25	75	0	
Maori War Canoe, 60’	$4,900	2,636	25	–	60 cf	43,689	4	210	3	0.05	87.5	0	
Papyrus Boat, 20’	$1,390	1,177	8	–	50 cf	13,167	1	34	2	0.05	50	0	
Quppu, 13’	$1,300	860	12	–	400 cf	31,250	2	284	1	0.05	25	0	
Umiak, 25’	$1,350	458	6	–	30 cf	9,360	2	29	3	0.05	75	0	
Outrigger Canoe, 25’	$754	590	5	–	50 cf	10,128	3	32	3	0.05	75	0	
Double Canoe, 50’	$3,750	2,825	10	10	100 cf	18,720	3	2×30	2	0.05	62.5	1	Paddled
									6		312		Sailed
Fowling boat, 15’	$106	535	2	1	–	1,135	9	5	3	0.25	75	1	Poled
Sampan, 21’	$150	490	2	–	20 cf	1,872	2	24	3	0.25	75	1	Poled
Shashah, 10’	$112	120	1	–	20 cf	1,254	2	3	5	0.25	125	3	
RAFTS													
Raft, 4” logs	$90	369	1	–	–	584	6	28	1	1 yd.	25	0	
Raft, 7” logs	$140	559	2	–	–	974	6	42	1	1 yd.	25	0	
Raft, 10” logs	$190	768	3	–	–	1392	6	58	1	1 yd.	25	0	
Raft, 12” logs	$240	952	4	–	–	1767	6	71	1	1 yd.	25	0	
Raft, 6 1/2” reeds	$50	377	4	–	–	1219	3	28	1	1 yd.	37.5	0	

Notes: The log raft designs assume a square top deck area of either 72” × 72” or 70” × 70”, whichever makes up an even number of logs. The reed raft is 72” × 72”. Larger rafts can be built with multiple sections of the same size; multiply cost, EW, crew, flotation, and HP by the number of sections. Up to half the crew can be replaced with cargo of the same weight (200 lbs. per crewman). This burden has the raft all but submerged, with water washing over the top. Reducing the burden 50% gives freeboard equal to 1/4 the raft’s thickness.

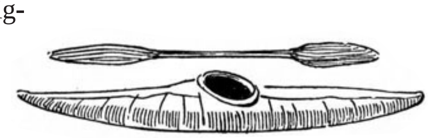
The following ships normally carry bulk cargo (50 lbs./cf): the ploion; the louchuan, fuchuan, and shachuan; the boum and baghlah; the Venetian galley; and the cog, hulk, caravel, and carrack. The obelisk barge does not have a cargo capacity in the conventional sense; it is designed to carry 1,500,000 lbs. of stone on its deck. The hippagogos has space to carry 30 horses below decks.

Watercraft Sizes

Certain of the watercraft listed above are built in a standard size, especially the warcraft, such as the trireme, the yichuan, or the dromon. For other craft, every new craft is a new design. Ambitious GMs will build their own boats and ships using ***GURPS Vehicles***. But what if you want one of the designs presented above, only a bit bigger or smaller – more or less the way orders have been presented to shipwrights for several millennia, in fact?

Attribute	Boat	Canoe
Cost	LF squared	LF
Weight	LF squared	LF
Crew, rowing	LF	LF
Crew, sailing	(√ of LF)	Cube root of (√ of LF)
Passengers/cargo	LF cubed	LF
Flotation	LF cubed	LF
DR	no change	no change
HP	LF squared	LF
Move/range, rowing	no change	Cube root of (√ of LF)
Move/range, sailing	Cube root of LF	no change
MR	no change	no change

Decide what percentage the length should be increased or decreased by. Express it as a factor; for example, a 20% increase would be a factor of 1.2, a 20% decrease a factor of 0.8. Then adjust the other attributes as specified in the following table, where LF stands for “length factor.” The table has two columns because scaled-up canoes simply get longer, but scaled-up boats get bigger in all three dimensions. (Rafts are scaled up by adding sections as described in the Notes.)



For example, suppose we want to design an extremely large crusader ship, with length increased to 201’ (a 70% increase). This would multiply its cost by 2.89 ($306,000), empty weight by 2.89 (549,000 lbs.), crew by 1.7 (121), passengers by 4.9 (245), cargo by 4.9 (245,000 cf), flotation by 4.9 (18,151,148 lbs.), HP by 2.89 (21,025), rowing move by 1(10), and its sailing move by 1.19 (6). These figures amount to a reasonable guess at the performance of such a scaled-up ship design.

Glossary

Acupuncture: A Chinese medical treatment based on inserting needles into specific points on the body.

Age-Grade: An organized group made up of all the men, or women, in a certain age range in a tribe.

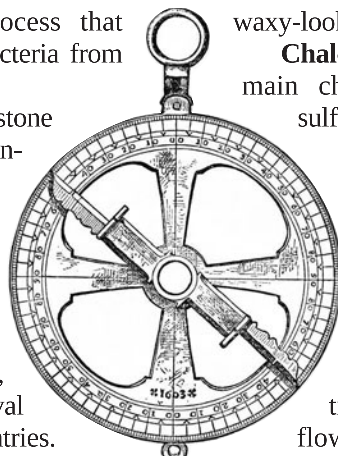
Alluvial: Deposited by running water; used to describe soil or minerals.

Alphabet: A system of writing in which each symbol represents a specific phoneme.

Anatolia: The geographic region that now makes up the Asiatic part of Turkey.

Antisepsis: Any process that cleans away infectious bacteria from an injury.

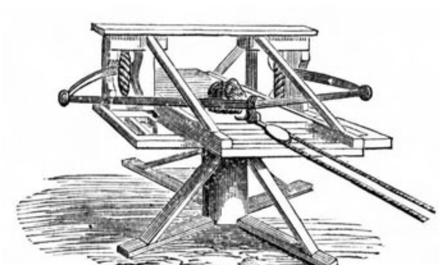
Ashlar: Squared-off stone blocks to be used in construction.



Astrolabe: A compact device used to perform a variety of astronomical observations and calculation. Apparently invented in ancient Rome, but mainly used in medieval Christian and Muslim countries.

Atlatl: A Mesoamerican device used to hurl javelins to greater range than by hand.

Ballista: Before the third or fourth century, a catapult projecting heavy stones; later, a catapult firing bolts. Includes such types as the *arcuballista* (a heavy crossbow) and the *carroballista* (a vehicle-mounted bolt thrower).



Barrel Helm: A type of head armor in the shape of a cylinder, protecting the skull, face, and neck.

Betel: The leaf of *Piper betle,* chewed in India and Indonesia with lime and the seeds of *Areca catechu*, a kind of palm. Mildly addictive.

Big Man: An informal leader in a tribal society, who gains his position by collecting and giving away large amounts of material wealth.

Bloom: A mass of soft metal formed from the ore in a furnace, to be shaped, hardened, and purified by hammering.

Burin: A prehistoric stone tool with a sharp point used to bore holes through another object.

Chalcedony: A translucent, waxy-looking quartz.

Chalcophile: A metal whose main chemical affinity is for sulfur.

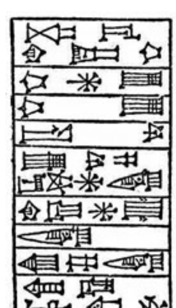
Circumcision: Surgical removal of the foreskin. Also used for usually more drastic modification of the female genitals.

Clepsydra: A water clock, in which time was measured by the flow of water through an opening at a controlled rate.

Cochineal: An insect, *Dactylopius coccus*, that is the source of carmine dye.

Conchoidal: A type of fracture in crystalline material that leaves behind a piece shaped like a cone.

Corpus Juris Civilis: Emperor Justinian's compilation of the laws of Rome, taken as a basis for legal codes in medieval Europe.



Cuneiform: Ancient Mesopotamian writing, done by pressing a wedge into clay or wax.

Deadfall: A heavy weight on a fragile support, designed to fall and trap any animal that disturbs the support.

Dhow: A generic name for Arabian ships.

Epsilon Axe: An ancient Egyptian weapon with a long metal blade shaped like an orange slice attached to a wooden hilt at three points.

Feudalism: A political system based on the exchange of personal commitments between ruler and subject, with the subject being granted the use of an area of land and performing services in return.

Fish Wheel: A large, rotating mechanism designed to trap fish and drop them into baskets. Used in the Pacific Northwest.

Flint: A hard quartz that produces sparks when struck, especially by iron or iron pyrites.

Flux: A substance that is added to solid raw materials in a furnace to cause them to melt at a lower temperature.

Gastraphetes: An ancient weapon resembling a large crossbow, but with a semicircular belly brace to help cock the bow, rather than a stock.

Geophagy: The practice of eating earth or clay.

Gladius: The classic shortsword, used as a military weapon by the legions of the early Roman Empire.

Greek Fire: A flammable substance of unknown composition that would burn on water, used as a weapon by the Byzantine Empire.

Haft: The handle of a tool or weapon, providing leverage when it is swung.

Hand Axe: A tool made from an oblong flat piece of stone, chipped to a sharp edge except on one side which is used as a grip.

Hypocaust: A hollow space under the floor of a house, through which hot air could be circulated to provide warmth.

Jadeite: A very dense, typically green stone, one of two forms of jade (the other is *nephrite*).

Junk: A generic name for late medieval Chinese ships, from the Portuguese *junco*.

Jurisconsult: An ancient Roman legal scholar called in to advise a judge about the law.

Kelek: A Mesopotamian raft made of leather floats supporting a wooden framework that held them together.

Khopesh: An early form of sword used in ancient Egypt; bronze-bladed, with a circular arc of metal sharpened on the outer edge providing the cutting surface.

Kiln: An oven designed for firing pottery.

Knapping: Working (usually stone) by breaking or chipping off pieces.

Kumiss: An alcoholic beverage made from fermented milk.

Lancet: A small, sharp knife used for *venesection*.

Lintel: A horizontal beam of stone or wood laid over posts or pillars that support it.

Lithophile: A metal whose main chemical affinity is for oxygen.

Loess: A loamy yellow or brown soil deposited by the action of streams or wind. Typically found in the northern hemisphere.

Logogram: A standardized graphic design that represents a word.

Macauitl: A swordlike weapon used in Mesoamerica, made by placing numerous obsidian blades along the edges of a wooden blade.

Machicolation: A small hole in the ceiling of a castle passageway through which intruders could be attacked, typically with bows.

Maggot: The larva of any of various species of fly.

Maize: American cereal grain *Zea mays* or Indian corn. Usually simply called corn; anthropologists and archaeologists prefer the more precise name to distinguish it from Old World grains such as wheat and barley, since in traditional British usage "corn" could mean any grain.

Microlith: A stone blade less than two inches long, typically designed to be set in a wood or bone haft.

Millet: A cereal grain, *Punicum millaceum*, widely used in African and Asian cultures.

Moldboard: A curved iron plate attached to a plow to lift and turn over the soil after it is cut, making the plow suitable for heavy soils.

Mordant: A substance that combines with a dye to make it insoluble, so that it will not wash out of cloth; for example, alum.

Motte and Bailey: A style of fortification based on a ditch, the motte or moat, surrounding a courtyard, the bailey, in which a defensible building was placed. A wall of earth, timber, or stone normally surrounded the bailey.

Mud Brick: Construction material made by baking square chunks of mud in the sun.

Murex: A sea snail, *Murex brandaris*, native to the Mediterranean, that is the source of royal purple dye.

Naphtha: Petroleum, from the Near Eastern name *naft*.

Necropolis: A large elaborate burial area containing many tombs.

Nock: A notched section at the end of a bow designed as a place to attach a bowstring. Also, to ready an arrow for firing.

Numerology: Any system in which numbers are assigned magical or other symbolic meanings in addition to their mathematical meaning.

Obsidian: A volcanic glass, usually black, that fractures to form a very sharp edge, making it a valuable trade good in prehistoric societies.

Outrigger: A log or other long piece of wood, parallel to the body of a canoe and linked to it to provide added flotation and better stability in the water.

Papyrus: A tall sedge, *Cyperus papyrus*, native to the Nile valley, used to make writing material, rope, and rafts.

Pattern Welding: A metalworking technique in which parts of a piece of iron were treated with charcoal to manufacture steel edges or bands, giving improved strength and durability.

Pavise: A late medieval version of a wall shield.

Peat: Partly carbonized vegetable matter dug up from boggy areas and used as fuel.

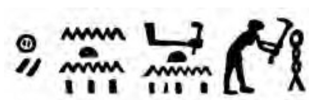
Pebble Tool: A chopping tool made by chipping one end of a stone to a jagged edge.

Petard: A small gunpowder bomb used to break open fortified doors.

Pewter: A gray, moderately hard alloy of tin and lead. (Because of health concerns, modern pewter replaces lead with another metal, such as antimony.)

Phalanx: A Greek infantry unit made up of spearmen in close formation to gain protection from each other's shields.

Pictogram: A standardized graphic design that represents an object or idea but not a specific word.



Pozzolana: A volcanic ash used in making cement and concrete.

Quern: A slab of stone on which grain is spread to be ground by crushing it under a round stone.

Rubble: Irregular stone used without shaping in construction.

Sariam: An armored garment developed in ancient Sumer, effectively a scale armor leather robe extending to the ankles.

Shaduf: An Egyptian device for raising water, with a bucket on one end of a pole that is lowered into the water and a counterweight on the other end that pulls it back up.

Siderophile: A metal with low chemical affinity for either oxygen or sulfur, which tends to go into solution in iron during planetary formation.

Soapstone: A soft stone, composed mainly of talc, with a soapy feel.

Stick Noose: A pole 1-2 yards long with a noose at the far end that can be used to snare an animal.

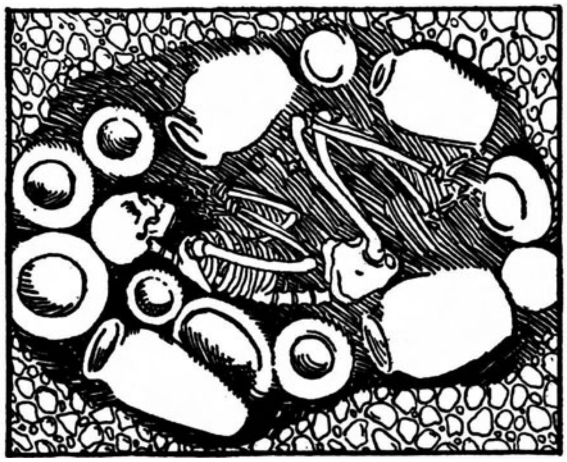
Syllabary: A system of writing in which each symbol represents a specific syllable.

Tannin: Various substances extracted from plants and used in tanning.

Tawing: Tanning of hides by a dry process such as treatment with alum.

Terbutje: A swordlike weapon used in New Caledonia, made by placing shark's teeth along the edges of a wooden blade.

Transhumance: A form of herding in which animals spend the winter in lowland pastures near farms and the summer in upland pastures.



Travois: A framework of two trailing poles supporting a platform or net to carry a load.

Trepanation: Surgical removal of disk-shaped pieces of the skull.

Trireme: The standard warship of the Athenian Empire, designed to destroy other ships by ramming them, and propelled by banks of oars powered by three rows of oarsmen at different levels along each side of the ship.

Tundra: The treeless plains of the arctic regions. In this region, the subsoil is permanently frozen.

Variolation: A precursor to smallpox vaccination, in which pus from people with mild cases of smallpox was used for immunization.

Venesection: Medical treatment of opening a patient's veins to reduce his blood volume.

Wicker: Basketry-like material woven from twigs, especially of the willow tree.

Woad: A blue dye derived from a European herb, *Isatus tinctoria*. Used by the British in Roman times to stain their skins before battle.

Woomera: A device of aboriginal Australian origin that is used to hurl full-sized spears to greater range than by hand.

Bibliography

The list below is not exhaustive; a complete bibliography of just the texts consulted during this project would require many pages. These texts discuss technologies in a fashion useful to the historical gamer, as well as a handful of books on subjects that are less commonly discussed in print at all.

Encyclopedia Britannica. A good encyclopedia can provide further information on many of the topics discussed in ***GURPS Low-Tech***. The *Britannica* is the most comprehensive and the most scholarly. Its articles also provide a tremendous amount of the sort of information that makes good sidebars for ***GURPS*** books. No one reference book is infallible, but there's no better place to start.

Adkins, Lesley and Roy, *Handbook to Life in Ancient Rome*, Oxford University Press, 1994, and *Handbook to Life in Ancient Greece*, Oxford University Press, 1998. Ready reference books that provide a solid level of detail about the culture, weapons, armor, and other equipment of ancient Greece and Rome.

Balent, Matthew, *Weapons and Castles* and *Weapons and Armor*, Palladium Books, 1982. Exhaustive surveys of weapons and armor used worldwide, with generic game statistics.

Barber, Elizabeth Wayland, *Women's Work: The First 20,000 Years*, Norton, 1994. A survey of fiber and clothing from Paleolithic string skirts to Egyptian court robes.

Burenhalt, Goren, General Editor, American Museum of National History, *Illustrated History of Mankind*, Harper SF, 1994. Five-volume set of handsomely illustrated surveys of ancient cultures, including *People of the Stone Age* (Vol. 1), *Old World Civilizations* (Vol. 3), *New World and Pacific Civilizations* (Vol. 4), and *Traditional Peoples Today* (Vol. 5).

Cantor, Norman, Ed., *The Encyclopedia of the Middle Ages*, Viking Penguin, 1999. The 600 individual entries include many that focus on particular items of technological interest, although the primary focus is on key persons, places, and events of the period.

Casson, Lionel, *The Ancient Mariners – Seafarers and Sea Fighters of the Mediterranean in Ancient Times*, 2nd Ed., Princeton University Press, 1991. Still the most comprehensive history of the evolution of sailing vessels and naval warfare, from earliest recorded history to the 15th century.

Casson, Lionel, *Ships and Seamanship in the Ancient World*, Johns Hopkins, 1995. A recently updated history of ancient Mediterranean seafaring.

Coles, John, *Archaeology by Experiment*, Scribners, 1973. How to do serious reality testing of archaeological theories; full of actual, tested numerical results about prehistoric and ancient technologies. Requires critical reading, though, as some experiments do not perfectly replicate the original technologies.

Connolly, Peter, *Greece and Rome at War*, Greenhill Books, London, 1998. A comprehensive look at the weapons, armor, strategies, and tactics used by ancient Greece and Rome. Contains a large amount of physical detail (lengths, weights) on various arms and armor, as well as subsections on naval warfare and siegecraft.

Cotterell, Brian, and Kamminga, Johan, *Mechanics of Pre-industrial Technology*, Cambridge University Press, 1990. In effect, this is freshman physics, with all the examples taken from anthropology and archaeology.

Daniels, Peter T., and Bright, William, Eds., *The World's Writing Systems*. A very detailed scholarly handbook on writing throughout history and throughout the world. The quality of the graphic reproduction is superb; this book shows what the text really looked like.

David, A. Rosalie, *Handbook to Life in Ancient Egypt*, Oxford University Press, 1999. The latest entry in this ready reference series surveys all aspects of daily life in one of the original cradles of civilization.

de Camp, L. Sprague, *The Ancient Engineers*, Ballantine Books (reprinted 1998). An entertaining summary of the great engineering feats of the human race up until the Renaissance. Individual chapters detail Egyptian, Greek, Roman, Arab, and Chinese contributions.

Deng, Gang, *Maritime Sector, Institutions, and Sea Power of Premodern China*, Greenwood Press, 1999. Information on a number of Chinese ships less familiar than the junk, and on the economic impact of their construction and operation.

Diamond, Jared, *Guns, Germs, and Steel*, W.W. Norton & Co., 1997. A highly readable study of how and why some cultures advanced more than others in various technologies, and what the historical consequences were.

Diehl, Daniel, and Donnelly, Mark P., *Siege – Castles at War*, Taylor Publishing Co., 1999. Based on a Discovery Channel documentary, this volume employs over 150 photos of re-enactors to illustrate the aspects of a late medieval siege.

Drews, Robert, *The End of the Bronze Age*, Princeton University Press, 1993. Excellent description of armies during the age of chariot warfare, and the factors that led to the passing of that age, set within a larger discussion of why the major Bronze Age civilizations almost simultaneously faltered around 1200 B.C.

Engels, Donald W., *Alexander the Great and the Logistics of the Macedonian Army*, University of California Press, 1978. A case study of one historical period illuminates problems of supply and mobility that shaped many earlier and later wars.

Farb, Peter, *Man's Rise to Civilization: The Cultural Ascent of the Indians of North America*, 2nd Ed., Dutton, 1978. A classic anthropological work, still worth reading as an overview of Stone Age societies and cultures.

Favier, Jean, *Gold and Spices: The Rise of Commerce in the Middle Ages*, 1998. Excellent source outlining the developments that influenced merchants, trade, banking, etc., during medieval times.

Ffoulkes, Charles, *The Armourer and His Craft From the XIth to the XVIth Century*, Dover Publications, Inc., reprinted 1988. This book, originally published in 1912, provides a comprehensive description of the European armorer's trade: the tools he used, the types of goods he made, and the manner in which they were produced.

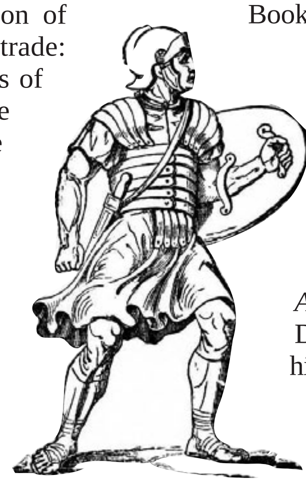
Fliegel, Stephen N., *Arms and Armor: The Cleveland Museum of Art*, Harry N. Abrams, Inc., 1998. Solid discussion of the history and development of medieval weaponry, with many illustrations drawn from the museum's collection.

Gamble, Clive, *Timewalkers: The Prehistory of Global Colonization*, Harvard University Press, 1994. A survey of human colonization throughout the world and its effects on the environment. Useful for questions of subsistence and survival.

George, James L., *History of Warships: From Ancient Times to the Twenty-First Century*, Naval Institute Press, 1998. Most of this book is post-TL3, but the discussion of early warships is well researched and lucid and includes excellent treatments of naval tactics.

Gernet, Jacques, *A History of Chinese Civilization*, 2nd Ed., translated by J. R. Fisher and Charles Hartman, Cambridge University Press, 1982. Seminal French work on Chinese history from the Shang dynasty to the Mongol invasions. Devotes serious attention to documenting the course of technological developments.

Gies, Frances and Joseph, *Cathedral, Forge, and Water Wheel*, Harper Perennial, 1994, and *Daily Life in Medieval Times*, Black Dog and Leventhal Publishers, 1999. The former book focuses on medieval developments in technology and documents the influences of non-European (Chinese, Indian, Islam) sources of change. The latter book is a new illustrated compilation of three popular previous works by the same authors: – *Life in a Medieval City* (1970), *Life in a Medieval Castle* (1974), and *Life in a Medieval Village* (1991).



Gimpel, Jean, *The Medieval Machine: The Industrial Revolution of the Middle Ages*, Penguin Books, 1976. This book on medieval inventions and innovations provides some of the best data available about the effects of various technologies on production yields.

Grant, Michael, *The Ancient Mediterranean*, Dutton/Plume, 1988. This history devotes some attention to Mediterranean civilizations that often command less attention, like the Phoenicians and Carthaginians.

Greenhill, Basil, *The Evolution of the Wooden Ship*, Batsford, 1988. Detailed plans for the construction of a number of historical ships.

Hawkes, Jacquetta, *The Atlas of Early Man*, St. Martin's Press, 1976. Compares the course of cultural, technological, and artistic development in every region of the world from 10,000 B.C. to 1000 A.D., focusing on eight periods ranging in length from 500 to 2,000 years.

Heer, Friedrich, *The Medieval World: Europe 1100-1350*, 1962. Focuses on non-military developments in business and the sciences.

Hooper, Nicholas, and Bennett, Matthew, *The Cambridge Illustrated Atlas: Warfare – The Middle Ages 768-1487*. Though the primary focus of this volume is a review of the strategies of medieval warfare, the appendices provide a very useful summary of technological trends in arms, armor, army composition, and siegecraft.

Hourani, George F., *Arab Seafaring*, Princeton University Press, 1995. A seminal work on naval innovation, focusing solely on the vessels, technologies, and trade routes used by the Arabs.

Hope, Lt. Col. C.E.G., *Encyclopedia of the Horse*, Viking Press, 1973; and Hyland, Ann, *The Horse in the Middle Ages*, Sutton Publishing, Ltd., 1999. Two sources that discuss the invention and spread of riding equipment, a subject provoking intense debate due to the lack of period sources.

Irwin, Geoffrey, *The Prehistoric Exploration and Colonization of the Pacific*, Cambridge University Press, 1992. An analysis of seafaring by the Polynesians and their predecessors, based on anthropology, practical sailing experience, and computer models.

James, Peter, and Thorpe, Nick, *Ancient Inventions*, Ballantine Books, 1994. Discussion of ancient technological developments, with particular focus on the bizarre.

Keegan, John, *A History of Warfare*, Knopf Books, 1993. A noted military historian dissects the history of warfare to identify the seminal events that changed the nature of battle forever.

Kern, Paul Bentley, *Ancient Siege Warfare*, Indiana University Press, 1999. A recent study of siege warfare from Mesopotamia to Rome. Excellent use of ancient sources.

Landels, J. G., *Engineering in the Ancient World*, University of California Press, 1978. A survey of major technological achievements of the Greeks and Romans.

Levathes, Louise E., *When China Ruled the Seas*, Simon & Schuster, 1994. An account of Zheng He's voyages of 1405-1433 and of Chinese seafaring in general.

MacQuen, J. G., *The Hittites – And Their Contemporaries in Asia Minor*, Thames and Hudson, 1975 (revised 1986). This general history contains some intriguing details on Hittite military equipment and chariot units, which were very unlike those of other lands.

Manley, John, *The Atlas of Past Worlds – A Comparative Chronology of Human History 2000 B.C.-A.D. 1500*, Cassell Publishers Ltd., 1993. This book uses archaeological evidence to compare cultures and civilizations in five areas of the world at each of four years in history.

Marsden, E.W., *Greek and Roman Artillery: Historical Development*, Clarendon, 1969. This comprehensive review of all the documentary evidence on Greek and Roman heavy weapons is a classic.

McClellan, James E., III, and Dorn, Harold, *Science and Technology in World History*, Johns Hopkins, 1999. A comprehensive survey of the development of technology, with especially good coverage of prehistory and non-Western cultures. The perfect one-volume overview.

McEvedy, Colin, *The Penguin Atlas of Ancient History*, Penguin Books, 1967. This text, recently reprinted, provides insights into the growth of populations, trade routes, etc., during the Classical Age.

McGrail, Sean, *Ancient Boats in N.W. Europe*, Longman, 1987. Despite the title, this book is actually a survey of boatbuilding traditions throughout the world, as revealed by anthropology and archaeology. Many tables provide rich quantitative information on watercraft.

Messadie, Gerald, *Great Inventions Through History*, W. and R. Chambers, Ltd., 1991. An attempt to pinpoint dates of historical introduction of many important innovations from the Stone Age to the 1900s.

Needham, Joseph (and others), *Science and Civilisation in China*, Cambridge University Press, 1956-1998. This monumental, definitive multi-volume study is also available in an abridged form, *The Shorter Science and Civilisation in China.*

Oakeshott, R. Ewart, *The Archaeology of Weapons: Arms and Armour From Prehistory to the Age of Chivalry*, Dover Publications, Inc., 1996. Republication of a 1962 work that chronicles the development and use of weapons over 30 centuries, based on both archaeological finds and evidence from contemporary art and literature.

Sawyer, Mei-Chun (Ed.), and Ralph D. (translator), *The Seven Military Classics of Ancient China: Wu Ching Chi Su (History and Warfare)*, Westview Press, 1993. Translations of Sun Tzu's *Art of War* and six other ancient works that dispense guidance on how to build armies, plan battles, and wage war.

Sherratt, Andrew, *Economy and Society in Prehistoric Europe*, Princeton University Press, 1997. A collection of innovative essays on widely diverse aspects of European prehistory, from the distribution of trade goods to Scythian pot parties. Equally worthwhile as serious scholarship and as entertaining reading.

Smil, Vaclav, *Energy in World History*, Westview Press, 1994. A survey of the worldwide evolution of technology, with statistical information on many topics.

Unger, Richard W., *The Ship in the Medieval Economy: 600-1600*. Describes major ship types of the Byzantine, Viking, and medieval European traditions.

Warry, John, *Warfare in the Classical World*, University of Oklahoma Press, 1995. Superbly illustrated volume that traces the evolution of warfare from 1600 B.C. to 800 A.D. Filled with many sidebars detailing the attire and weapons of representative men at arms, ship types, and siege engine designs.

Webster, Graham, *The Roman Imperial Army*, A & C Black, 1985. Less concerned with strategy and tactics than with logistics and administration, this volume describes the unglamorous details behind Rome's defense of its empire.

Welsh, Frank, *Building the Trireme*, Constable, 1988. Describes the reconstruction of an ancient Greek warship in a modern boatyard; entertainingly written and a good guide to the intellectual controversies that surround this aspect of naval history.

Yadin, Yigael, *The Art of Warfare in Biblical Lands in the Light of Archaeological Study*, McGraw-Hill, 1963 (2 volumes). Beautifully illustrated with images of ancient art and artifacts. This survey of the development of warfare in Israel and neighboring lands is especially valuable for its discussion of the technological limits on military action and the competing evolution of weapons and defenses.

INDEX