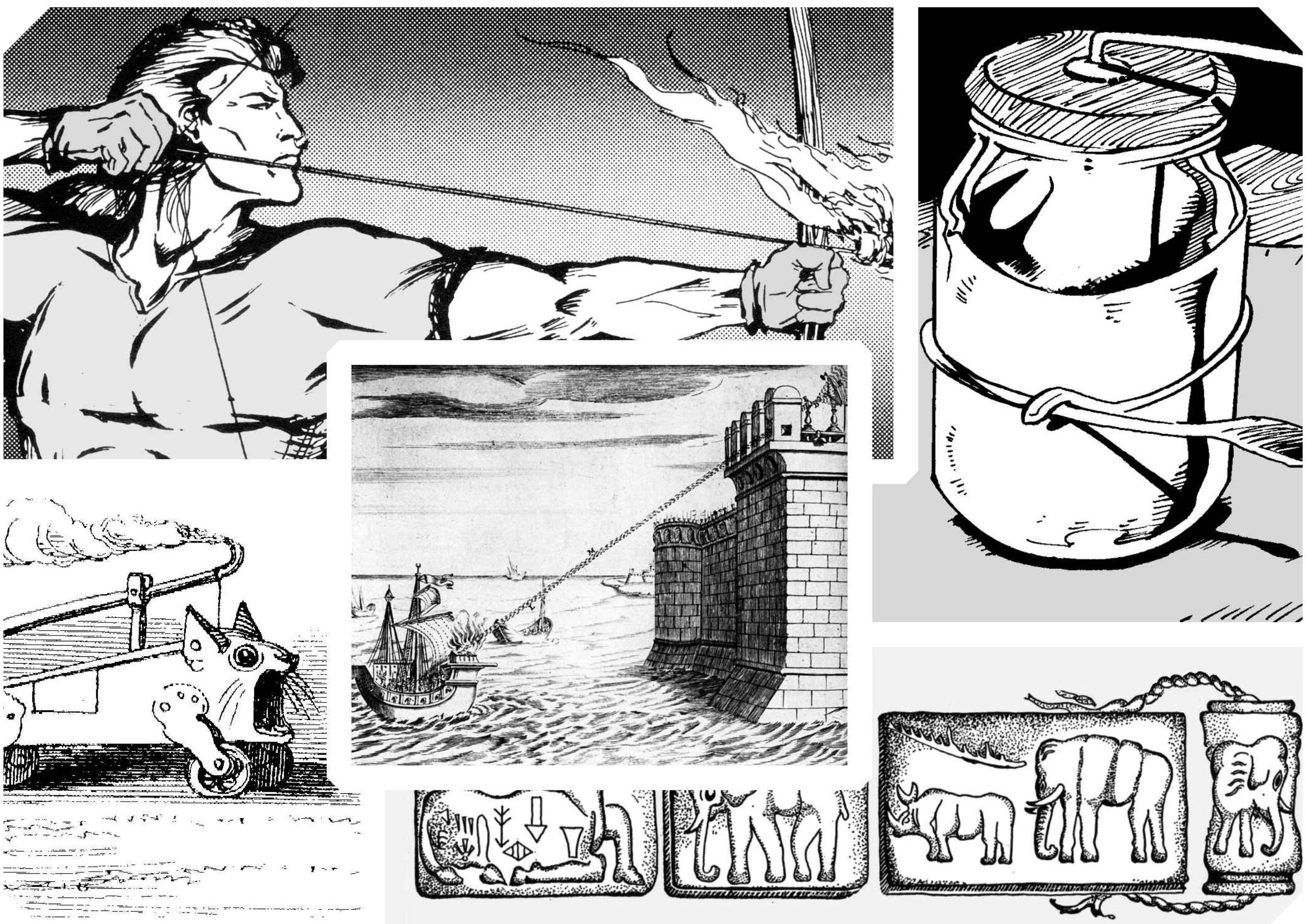
GURPS® Fourth Edition

Fantasy-Tech™ 1
The Edge of Reality™



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Contents

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

Rules and statistics in this book are specifically for the ***GURPS Basic Set,*** *Fourth Edition.* Page references that begin with B refer to that book, not this one.

Introduction

GURPS is known for highly detailed, well-researched supplements containing a wealth of up-to-date historical and scientific information. These volumes are written by well-read, enthusiastic amateurs and people with real-world experience and academic credentials in their fields, often working in consultation with a range of experts and professionals, to produce works useful not just to ***GURPS*** players, but to players of other games and to nongamers with an interest in the subject material.

This is not one of those supplements.

GURPS Fantasy Tech: The Edge of Reality is a compilation of failed ideas, an inaccurate history of technology from the dawn of civilization to the dawn of the industrial age. This project rummages through the dustbin of history for ideas about technology that have actually been held (and, in some out-of-date circles, still are) but have since been discarded. It contains myths, legends, misinterpretations, real technological dead-ends, ideas that inventors dabbled with before their time had arrived, things that *nearly* happened but didn't, and romantic notions based on sketchy knowledge of the past and far-off civilizations. Turn to this supplement if you want a nearly historical world full of mundane wonders: Bronze Age kings flying with cape-like wings and attended by solid metal servants, Roman armies marching to war with pneumatic catapults and deadly heat rays, and respectable Renaissance astrologers taking wind-up cars to airports filled with elegant ornithopters. It's the way the future was, and you can make it be that way again.

The Fantastic and the Concrete

Most of the gear in this volume belongs to alternative paths of technological development, providing concerns for both players and the GM.

Fantasy-Tech Campaigns

The primary concern for the GM is fitting exotic gear into a campaign. In conventional fantasy campaigns – with priests, wizards, chi-powered martial artists, and other characters with exceptional abilities – adding exotic but technically mundane technology simply unlocks another realm of novel capabilities. The use of Unusual Backgrounds and Craft Secret perks protects gadgeteers as an adventuring character niche. Alternately, these technologies can be common knowledge among craftsmen: Every warrior (who can afford it, anyway) can have an azzalum sword. Every priest can carry a bottle of mundane alchemical healing elixir as a backup to healing spells. And so on.

Dropping these gadgets into a more realistic campaign poses additional problems. The items in this supplement cover a wide range of feasibility, from the entirely real – if overlooked – to the utterly impossible. Anything with a straight TL (for example, TL3) is a real, if possibly idealized, historical item, produced and used during that TL, if only experimentally in limited numbers. Items with a + in the TL – for example, TL(3+1) – aren't necessarily impossible in principle but require considerable refinement and better materials to work consistently. Items with a ^ notation are simply impossible. They may fit the technological "mood" of a TL, but they require superscience (or even superpseudoscience) to function.

Naturally, introducing fantasy tech into a realistic campaign has significant implications for the game world. For example, although a society with a number of TL(4+1) and TL(4+2) gadgets may have clockpunkish trappings, the capabilities of the technology are more Victorian or WWII than Renaissance. It may also be wise to limit availability of some items, either by cost or by enforcing craft secrecy, notably when it comes to superscience. A society with readily available TL1^ automata or TL2^ vimanas would have little use for marginally more realistic TL(4+2) aircraft.

Do not worry if you have
built your castles in the air.
They are where they should be.
– Henry David Thoreau

Fantasy Technicians

The primary concern of players is the ability to use and, to a lesser extent, make fantastic gadgets. The table below lists the skills required to produce or maintain the items in this supplement. See the index (p. 36) for locations of item descriptions.

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Fantasy-Tech Skills Table

Invention	*Skill*
Aluminum	Smith/TL(2+3) (Aluminum)
Anti-Ship Claws	Armoury/TL2 (Heavy Weapons)
Articulated Claw	Armoury/TL2^ (Heavy Weapons)
Automated Doors	Mechanic/TL2 (Clockwork)
Automated Mannequins	Mechanic/TL3 (Clockwork)
Automated Tripods	Mechanic/TL1^ (Robotics)
Azzalum	Metallurgy/TL2^
Bird Glider	Mechanic/TL(4+2) (Glider)
Bononian Stone	Alchemy/TL3
Bronze Androids	Mechanic/TL1^ (Robotics)
Castle Clock	Mechanic/TL3 (Clockwork)
Classical Analog Computer	Mechanic/TL(2+3) (Clockwork)
Combination Weapons	Armoury/TL (Melee Weapons) *and* Armoury/TL (Small Arms)
Counterweight Naval Mine	Traps/TL4
Defensive Magnets	Architecture/TL2^
Dew Belt and Dew Booth	Mechanic/TL4^ (Lighter Than Air)
Di Giorgio Tank	Mechanic/TL4 (Wagons)
Electrical Batteries	Electrician/TL(3+2)
Ethnic Cool Weapons	Armoury/TL (Melee Weapons) or Armoury/TL (Missile Weapons), as appropriate
Flexible Glass	Professional Skill (Glassblower)
Floral Clock	Gardening
Gliding Cloak	Mechanic/TL3^ (Glider)
Gothic Plate	Armoury/TL4 (Body Armor)
Grappling Catapult	Armoury/TL4 (Heavy Weapons)
Horned Helmet	Armoury/TL1 (Body Armor)
Horse Cannon	Armoury/TL4 (Heavy Weapons)
Hot Air Balloon	Mechanic/TL(1+1) (Lighter Than Air)
Hydra Venom	Poisons/TL1
Incombustible Oil	Alchemy/TL2^
Land Sailers	Mechanic/TL (Land Sailer)
Leather Cloak	Armoury/TL0 (Body Armor)
Leonardo Battery	Armoury/TL(4+1) (Heavy Weapons)
Leonardo Tank	Mechanic/TL(4+1) (Crank-Driven Vehicles)
Levitating Instrument	Mechanic/TL1^ (Antigravity)
Moving Platforms	Mechanic/TL2 (Clockwork)
Naval Sambuca	Mechanic/TL2 (Naval)
Naval Siege Tower	Mechanic/TL2 (Naval)
Ninja Gear	Armoury/TL4^ (Ninja Gear)
Orichalcum	Metallurgy/TL1
Ornithopter	Mechanic/TL(4+2) (Ornithopter)
Ox-Driven Paddlewheel	Mechanic/TL2 (Naval)
Perpetual Motion Machine	Mechanic/TL3^ (Perpetual Motion)
Personal Wings	Mechanic/TL1^ (Ornithopter)
Philoctetes' Bow	Armoury/TL1^ (Missile Weapons)
Pneumatic Ballista	Armoury/TL(2+2) (Heavy Weapons)
Poisoned Clothing	Chemistry/TL1 or Alchemy/TL1
Porcelain	Artist (Pottery)
Pyramid Power	Architecture /TL1^
Railways	Engineer/TL2 (Civil)
Reflective Heat Ray	Armoury/TL2 (Reflectors)
Renaissance Air Rifle	Armoury/TL4 (Small Arms)
Renaissance Calculator	Mechanic/TL(4+1) (Clockwork)
Renaissance Helicopter	Mechanic/TL(4+2) (Ornithopter)
Rigid Parachute	Mechanic/TL3 (Glider)
Shirazi Battery	Armoury/TL4 (Heavy Weapons)
Simple Air Brake	Mechanic/TL3 (Glider)
Spiral Elevator	Architecture/TL4
Spring-Powered Car	Mechanic/TL(4+1) (Clockwork)
Steam Cannon	Armoury/TL(2+3) (Heavy Weapons)
Steam Engine	Mechanic/TL (Steam Engines)
Stone Dropper	Armoury/TL2 (Heavy Weapons)
Studded Armor	Armoury/TL1^ (Body Armor)
Submarine	Mechanic/TL4 (Submarine)
Superheavy Armor	Armoury/TL4 (Body Armor)
Treated Linen Armor	Armoury/TL2^ (Body Armor)
Vimana	Mechanic/TL2^ (Vimana)
Vimana Weapons	Armoury/TL2^ (Vimana Weapons)

If these devices don't exist in the campaign, they may be suitable for invention by gadgeteers with appropriate Engineer skills. Even in settings where they do exist, the specifics might not be common knowledge. After all, many inventors deliberately try to keep their work a secret! The special knowledge required to make such an item may demand a new perk: Craft Secret. For every 20 points in relevant craft skills, a craftsman may buy an instance of Craft Secret that enables a specific invention covered by those skills. Artisans who hold a craft job, or who have a relevant craftsman or craft guild as an Ally or a Patron, may buy one further Craft Secret per 10 points in the skills of their job. For example, Leonardo da Vinci might have passed on the secret of making steam-powered artillery to a favored pupil in the form of Craft Secret (Steam Artillery).

Cost Factor

The costs of most modifications to existing gear are expressed as a "cost factor" (CF). To find final cost of an item, multiply the modified item's list cost by (1 + total CF). For example, an item that has one modification with +1 CF and another with +2 CF costs 1 + (1 + 2) or 4 times its list price. If total CF is below -0.8, treat it as -0.8; thus, final cost cannot be below 20% of list cost.

About the Author

Matt Riggsby was a later product of the atomic bomb program, emerging in the midst of the Vietnam War. After witnessing the earthquake that sent California into the ocean and studying paleontology (briefly interrupted by the Boston Tea Party), he married two women of the same name and had at least one child. He now works for a German telegraph company. This is his fourth video game for Steve Jackson Games.

Chapter One
Weapons and Armor

The most spectacular areas of imaginary technology concern means to kill one's fellow men. The annals of cryptohoplology are full of ambitious, even spectacular weapons, most of which don't work, plus a few that surprisingly do.

Terms and notation used in the weapon tables are as defined in *Weapon Statistics* (pp. B268-271).

Philoctetes' Bow

The Trojan War was an unreasonably difficult conflict by any measure, but particularly for the Greeks. Not only did it take a decade to resolve, the allied Greek forces had to play a scavenger hunt across the classical world to gather up this person and that item, as revealed by prophecy, to achieve victory. One of the items they needed was the bow of Philoctetes. Actually, this bow originally belonged to Heracles. Philoctetes inherited it in return for his services in lighting Heracles' funeral pyre.

This bow was notably powerful. While this was probably in part because an exceptionally strong user originally owned it, it was also quite deadly in Philoctetes' hands. It may have had a particularly clever recurve, firing with greater than usual force. The stats describe a bow of the Philoctetes *type*; Philoctetes' own bow would have been built for someone with a very high ST.

In addition to the power of the bow itself, Philoctetes had a quiver full of poisoned arrows, envenomed with the blood of the hydra. Hydra venom is a contact agent with no delay and a HT-3 roll to avoid 2d damage. The more formidable effect of the poison, though, is its ability to inflict lasting, maddening pain, making the victim feel as though he is on fire. The victim must roll against HT three times. If he fails once, he suffers from moderate pain (p. B428). If he fails twice, the pain is severe. He is in terrible pain with three failures. On any critical failure, the victim suffers instead from agony. Whatever the level of pain, the victim may roll against HT *daily* for the pain to subside, if he lives that long. If it can be found, hydra venom is $500 per dose. However, since it is derived from the blood of a singular monster, it is almost certainly not generally available for purchase.

"Poisoned" Clothing

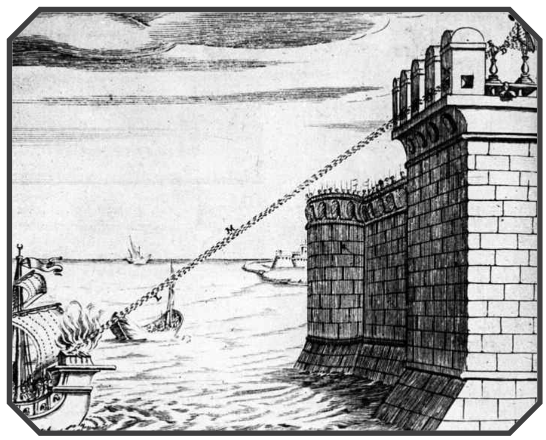
Heracles himself fell victim to the hydra's poison (see above) when he put on a garment treated with it. The pain didn't kill him, but it did drive him to suicide. This story has led some scholars to speculate on the existence of "poisoned" clothing that actually burns the victim. One possibility is saltpeter-impregnated cloth, which would catch fire easily and burn more intensely. Such a garment partly catches fire if it takes *any* burning damage and does 1d-3 burning damage per second. It completely catches fire if it takes 3 points of burning damage in a single attack; it then does 1d burning damage per second. DX rolls to put out the fire are at an additional -1. Impregnating a garment with saltpeter costs $100.

TL	*Weapon*	*Damage*	*Acc*	*Range*	*Weight*	*RoF*	*Shots*	*Cost*	*ST*	*Bulk*
BOW (DX-5)										
1^	Philoctetes' Bow	thr+4 imp	3	×20/×25	3/0.1	1	1(2)	$1,500	11†	-7

Reflective Heat Rays

The ancients were familiar with "burning glasses" – rock-crystal lenses and curved mirrors that could be used to focus sunlight and ignite tinder. They were moderately expensive and operated only in bright sunlight, but they were effective, low-effort tools for starting small fires. Inevitably, there were attempts to weaponize this technology.

In 214 B.C., during the Second Punic War, Rome set siege to the city of Syracuse on Sicily with a sizable army and some innovative weapons (see *Naval Siege Tower*, p. 20). The Syracusians had their own secret weapon: the philosopher Archimedes. Archimedes invented a number of weapons to hold off the Roman armies, the most notable of which was the earliest attempt at a light-based weapon. His "heat ray" consisted of an array of mirrors (one scholar described them as being assembled in a hexagonal dish) that acted in concert as a parabolic mirror to focus the heat of the sun to set Roman ships on fire.



Though long dismissed as a myth and still, with good reason, regarded as questionable, this Hellenistic death ray has elements of plausibility. Experiments over the past few decades indicate that massed mirrors can be used to set wooden objects on fire at distances of 60-70 yards. The main drawbacks are a need for very clear conditions and stable targets. In Archimedes' defense, the Mediterranean is justly famed for being sunny, though the inherent rocking motion of ships has raised considerable doubts about the weapon being able to focus on a single spot long enough to ignite fires. It also assumes that Archimedes invented the parabolic reflector centuries before it is know to exist. If any Greek could have done so, it would have been circle-obsessed Archimedes, but the GM may want to treat the reflector as TL(2+1) instead of vanilla TL2.

Because descriptions are sketchy and varied, there are several possible models of heat ray.

Reflective Heat Ray (TL2). This version is a very large (1,000 square feet, or a circle about 18 feet in radius) reflecting dish made from highly polished bronze mounted on a wall or tower. It is directed by a "gunner" aided by a crew of men and possibly draft animals.

Reflective Heat Ray, Small (TL2). This more compact version is about 250 square feet in area, or a nine-foot radius. It is less powerful but easier to bring to bear. A defensive position might have several mounted along the walls, combining to focus their energy on a single target.

Improved Reflective Heat Ray (TL2). A description from a Byzantine scholar suggests a more complex but versatile design involving a secondary lens or reflector. The improved heat ray has a more complex arrangement of mirrors, which gives it a broader field of fire.

A more conventional but less technically plausible explanation is that Archimedes employed soldiers with highly polished shields. The minimum manpower and equipment requirements are a group of 170 men with mirror-bright medium shields or 100 men with similarly polished large shields. They can be at most two ranks deep, which means a line 50-85 yards long; the target cannot be past the ends of the line. They must all have both Soldier and Shield skills at 12+ and a perk, Reflective Shield, allowing them to coordinate their actions and accurately use their shields to reflect light at a specific target. Actually hitting requires a roll against their leader's Tactics skill at -6. Treat the formation's range, damage, and limitations as a regular reflective heat ray.

TL	Weapon	Damage	Acc	Range	Weight	RoF	Shots	ST	Bulk	Rcl	Cost	LC	Notes
GUNNER (MIRROR)													
2	Reflective Heat Ray	1d burn	2	50/70	1,500	1	special	60M	-16	–	$155,000	2	[1]
2	Reflective Heat Ray, Small	1d-3 burn	2	50/70	375	1	special	35M	-12	–	$3,900	2	[1]
2	Improved Reflective Heat Ray	1d burn	2	50/70	2,000	1	special	60M	-16	–	$195,000	2	[2]

Notes

[1] The reflective heat ray requires no ammunition. Rather, it needs strong sunlight (so it can only operate in daylight hours), and it can only fire effectively at targets with a 60° arc between itself and the sun. This means, essentially, that an east-facing heat ray can only be used between dawn and late morning, a west-facing one can only be used between early afternoon and dusk, south-facing ones can only be used in the northern hemisphere, and north-facing ones in the southern hemisphere. Also, subtract 1 point of damage for *each* of light fog and light cloud cover, 2 points each for moderate cloudiness and heavy fog, and 3 points for completely overcast conditions.

[2] Because it has a secondary mirror to redirect the focused beam, the collector dish can move to just about any angle while being able to hit any visible target at any time of day. However, the advanced version is still subject to penalties for clouds and mist.

Anti-Ship Claw

The claw was another Archimedean device for defeating ships. Contemporary texts describe the claw as an adaptation of a crane set on a pivot. The business end is an iron claw hanging by chains from the end of a beam. The beam swings out past the fortress walls and over the water, dropping the claw to crash into a ship below. A team within the walls pulls on the chains, lifting the ship partly out of the water. If the ship doesn't tip far enough while being raised to start filling with water, the user can let the chain go, making the ship splash back into the water, often dipping the falling end under water far enough to swamp the ship. Depending on the size of the weapon and its crew, the claw could swamp the largest vessels of the day, up to six times its maximum weight capacity (it doesn't have to *lift* the entire vessel, just shift it enough to capsize it). To determine how much a crane can lift with any given crew, combine the BLs of all crew members, and multiply by 16. A crane's *maximum* capacity, regardless of the capacity of its crew, is equal to Heavy encumbrance for its listed ST (see table below).

The claw was a more sophisticated version of another pivoting crane weapon Archimedes developed. Rather than reach down and scoop up enemies, cranes could be used simply to dump rocks on them. Dropping rocks on enemies from the walls is a tactic as old as defensive walls themselves, but with a pivoting crane, enemies some distance beyond could be targeted. The weapon could threaten archers who might stand a few yards back from the walls to get a better angle from which to shoot at defenders, or it could target defensive sheds set up over engineers trying to undermine the walls.

Some more fanciful descriptions imagined the claw as an articulated device, capable of reaching over the walls like a giant arm or a modern backhoe to scoop up targets. It could be used not just to ram into ships, but to prod, grab, and strike smaller targets as desired within its reach.

Small Anti-Ship Claw (TL2). This version of the claw is suitable for sinking smaller vessels. The claw has a maximum capacity of three tons, enough to sink smaller warships. Once the claw strikes, the operator must roll against his Crane Operator skill to ensure it becomes stuck. If it does, the crew pulls on the attached line. They must pull for (target's weight)/(maximum load) × 3 seconds to tilt the target to an angle that will swamp it. During that time, occupants of the grappled vessel may try to attack the chain (DR 12, HP 23, SM -4), though it will likely be out of range of melee weapons, and the sailors will suffer from increasingly poor footing. Damage is based on a 400-pound small claw dropping from seven yards over the target zone. A claw set over a taller drop (for example, behind a wall atop a cliff) requires longer and heavier chains, but it would fall with greater force. Increase cost and weight by 2% for each additional yard of height, and see p. B430 to refigure damage.

Large Anti-Ship Claw (TL2). A larger version of the claw, suitable for sinking triremes and other large vessels. It uses the same rules for swamping a vessel as the smaller version (above), but the chain is somewhat thicker (DR 18, HP 35). Damage is based on a 1,000-pound large claw dropping from nine yards over the target zone.

Small Stone Dropper (TL2). Damage is based on 1,000 lbs. of stone dropped from seven yards. The GM may refigure damage if the dropper is set over a greater height.

Large Stone Dropper (TL2). Damage is based on 2,000 lbs. of stone dropped from nine yards.

Articulated Claw (TL2^). This device acts like a large arm with a reach of nearly 30 feet. In addition to striking targets, the claw may be used to grasp objects up to SM +0, requiring a roll against Crane Operator skill. They may be lifted to a height up to the claw's reach as though it had ST 125.

TL	*Weapon*	*Damage*	*Reach*	*Parry*	*Cost*	*Weight*	*ST*	*Notes*
CRANE OPERATOR (DX-6, Dropping-3, Engineer (Combat)-3)								
2	Small Anti-Ship Claw	4d pi++	5	No	$40,000	24,000	125	[1]
2	Large Anti-Ship Claw	6d pi++	8	No	$60,000	35,000	177	[2]
2	Small Stone Dropper	10d cr	5	No	$6,000	7,000	45	[1]
2	Large Stone Dropper	14d cr	8	No	$9,500	12,000	71	[2]
2^	Articulated Claw	3d pi++	10	No	$150,000	35,000	125	

Notes

[1] Requires 30 seconds to prepare for an attack.
[2] Requires 45 seconds to prepare for an attack.

Marcellus could not refrain from making a joke at his own expense, saying that Archimedes was using his ships to ladle out the sea-water.

*– Polybius, **Histories,** Book VIII*

Counterweight Naval Mine

Mariano di Jacopo was an early 15th-century engineer (and an influence on Leonardo da Vinci). Also known as il Taccola, Mariano was called, for good reason, the Archimedes of Siena. One of his inventions owed a considerable debt to Archimedes' claw weapons: a "keel breaker," which might be the first hidden, submerged weapon to be used against ships.

The device resembles a trebuchet mated with a heavy claw on the end of a beam. When a ship passes over the "mine," it pushes a lever just under the surface. The lever releases a counterweight, which in turn thrusts the claw up through the water and into the passing ship. Not only does this do great damage to the ship, it does so at the bottom of the hull, causing immediate flooding.

A counterweight mine takes an hour and a crew of 10, including an engineer, to set up in water no deeper than 20 feet. The engineer may set a minimum depth for the mine; a vessel with a shallower draft passing over the mine will not set it off. When a ship with a deep enough draft travels over it, roll against the engineer's Traps skill. On a success, the underside of the vessel takes 7d cr. $35,000, 8,000 lbs.

Pneumatic Weapons

A gun might be described as a weapon that fires a projectile through an aiming tube, propelled by a gas expanding with explosive force. Though the vast majority of guns have used chemical explosives as their propellant, there have been alternate means of impelling bullets through history.

Air Guns

Ctesibius, a Greek scholar of the third century B.C., has been called the father of pneumatics. He is responsible for a number of inventions that worked by water and air pressure, including clocks, pipe organs, and the siphon. He also explored an area of more interest to adventurers: air-powered weaponry. His experiments with pneumatics suggested that he would be able to compress air in sealed cylinders and use that power to fire a projectile. The experiment failed, though it seems to have been a near-miss and more extensive work could have produced an expensive and underpowered but still functional weapon.

Theory turned into practice late in the Renaissance. By the 1600s, gunsmiths figured out how to seal an air reservoir, pressurized by an integral bellows or other pump, well enough to hold sufficient pressure to fire a bullet with lethal force. Air rifles had some drawbacks. They were expensive, fragile (HT 9), required several minutes of pumping to reach an operational pressure, and were not as powerful as their gunpowder cousins. However, they were very quiet and produced no smoke cloud, making them ideal weapons for snipers. They were also capable of firing several shots per minute, a vastly better rate of fire than gunpowder weapons. Air rifles remained in use by specialized troops into the 19th century.

Pneumatic Ballista (TL2+2). This is a theoretical design for a functional version of the Ctesibius air cannon. Rather than using air pressure directly on the projectile, it uses pistons and sealed bronze cylinders to provide pneumatic power to the arms of a large catapult. The reservoirs are completely depressurized with each shot, requiring a full cycle of preparation before it is fired again.

Renaissance Air Rifle (TL4). This weapon takes 30 minutes of pumping to bring the reservoir up to sufficient pressure to fire 30 projectiles. It slowly loses power as it is used. After every five shots, reduce damage by 1 point, 1/2D by 5 yards, and Max by 10 yards. The user may pump the weapon between shots, increasing reloading time by a minute per shot since the last pumping, to retain full power. This weapon is extremely quiet and acts as though it was equipped with a silencer (p. B412).

Steam Cannon

Another propellant idea predates the use of gunpowder by a thousand years: steam. It also links two of the great inventors, Archimedes and Leonardo da Vinci. Leonardo sketched out several versions of steam cannon, which he attributed to Archimedes.

This design resembles a cannon placed in a furnace. It uses a cannon-like tube: closed at one end, open at the other, internally divided into front and back chambers but with a valve between the two. The closed end is heated in a fire, reaching temperatures of 1,000°F, while a projectile is loaded into the front chamber. A small quantity of water (as little as a half-cup for a small steam cannon) introduced into the furnace end flashes into steam, and the enormous pressure forces out the projectile, just as exploding gunpowder would.

Despite the Rube Goldberg underlying concept, this design is plausible. There's some question as to just what Leonardo's drawings represent (this is not surprising; Leonardo intentionally sketched some details incorrectly or incompletely to prevent people from stealing his ideas). There's also no indication that it was ever actually built in antiquity. Nonetheless, modern reconstructions have demonstrated that the steam cannon, properly constructed, could have been a formidable weapon, firing a one-pound projectile with greater force than a .50 caliber bullet. Though logistically challenging, it would have been superior to many other large weapons through TL4. The cannon fires with the same loud bang and visible cloud that accompanies a gunpowder cannon, but the puff of white is steam rather than smoke. The cannon is also subject to most of the same hazards as gunpowder artillery, notably the danger of bursting. It has the additional limitation of needing to be heated before use and kept at temperature.

Here are three designs suggested by Leonardo's notes – a small, portable model and two much heavier designs for fixed defenses.

Steam Cannon, 1-lb. Portable (TL2+3). This weapon is set on a wagon or carriage like a field gun and fires small stone or metal balls. The relatively high cost and weight comes from the heavy bronze boiler on a brick base. It takes at least 15 minutes to bring up to temperature and consumes 20 lbs. of wood per hour.

Steam Cannon, 1-lb. Fixed (TL2+3). This version, designed for fixed positions (though it might be mounted with considerable effort on a large ship), uses a lighter boiler and a much thicker layer of stone and earth for insulation. Though the weapon as a whole can't be picked up and moved, the barrel can turn through a sizable arc for aiming. Like the portable version, it takes at least 15 minutes to bring up to temperature, but because of superior insulation, consumes 15 lbs. of wood per hour.

Steam Cannon, 10-lb. (TL2+3). This is a larger version of the fixed cannon, designed for mounting in towers and on walls. It fires a much heavier projectile with enormous force. It requires at least 30 minutes to come to temperature, and consumes 120 lbs. of wood per hour.

Pneumatic Weapons Table

TL	*Weapon*	*Damage*	*Acc*	*Range*	*Weight*	*RoF*	*Shots*	*ST*	*Bulk*	*Rcl*	*Cost*	*LC*
GUNNER (CATAPULT) (DX-4 or other Gunner-4)												
2+2	Pneumatic Ballista	9d cr	4	300/375	4,800/20	1	1(30)	40M	-15	3	$67,500	1
GUNS (RIFLE) (DX-4 or most other Guns-2)												
4	Renaissance Air Rifle	1d+2 pi	3	30/400	9/0.025	1	1(10)	7†	-4	3	$700	2
GUNNER (CANNON) (DX-4 or other Gunner-4)												
2+3	Steam Cannon, 1-lb. Portable	6d×2 pi+	2	160/1,400	700/1	1	1(30)	28M†	-12	1	$8,500	1
2+3	Steam Cannon, 1-lb. Fixed	6d×2 pi+	2	160/1,400	1,900/1	1	1(30)	20M	-13	1	$7,800	1
2+3	Steam Cannon, 10-lb.	6d×4 pi++	2	380/3,000	8,000/10	1	1(45)	50M	-14	1	$78,000	1

Multi-Barrel Artillery

One of Leonardo da Vinci's less fanciful designs was a weapon that has misleadingly been called an ancestor of the machine gun. It consisted of three racks, each containing a battery of between eight- and 11-gun barrels. The racks were set on a rotating frame so that each battery cycled through three positions in turn: facing forward for firing, facing downward to cool, and facing upward for reloading. (The cooling leg of the cycle reduced the chance of accidental ignition during loading, and shortened the time spent swabbing out sparks as with larger cannon.)

Though mechanically nothing like a modern machine gun, it could have served a similar battlefield role. Instead of firing one large projectile like a contemporary field piece, doing a great deal of damage to a single target, this weapon would have spit out a lot of bullets very quickly. This spread out damage over a larger area, while still doing enough to each target to stop or at least slow down the average soldier.

Leonardo's weapon existed only on paper. However, a century later, a similar weapon was actually fielded in India. Fathullah Shirazi, a scholar and official in the employ of the Mughal emperor Akbar, invented a weapon composed of 17 parallel gun barrels on a wheeled carriage. Though vastly simpler than the Leonardo battery (Shirazi's weapon only had one rack of guns, not several on a rotating carriage to go through an elaborate cooling and reloading cycle), it had the advantage of being real.

TL	*Weapon*	*Damage*	*Acc*	*Range*	*Weight*	*RoF*	*Shots*	*ST*	*Bulk*	*Rcl*	*Cost*	*LC*	*Notes*
GUNNER (CANNON) (DX-4 or other Gunner-4)													
4	Shirazi Battery	4d+2 pi++	2	125/1,200	450/0.15	17	17(60i)	24M†	-10	4	$3,800	1	[1]
4+1	Leonardo Battery, 8-Barrel	4d+2 pi++	2	125/1,200	630/0.15	8	24(60i)	22M†	-11	4	$5,250	1	[1, 2]
4+1	Leonardo Battery, 11-Barrel	4d+2 pi++	2	125/1,200	870/0.15	11	33(60i)	26M†	-11	4	$7,225	1	[1, 2]

Notes

[1] Up to three people can work on reloading barrels at a time. Individual barrels take 60 seconds to reload, and the weapon may be fired with an appropriately reduced number of shots when partially reloaded.

[2] It takes 15 seconds to rotate a fresh rack of barrels into firing position.

Ethnic Cool

Just about every society with a vaguely successful military tradition has weapons that have acquired legends. Likewise, many societies have, for one reason or another, been impressed by the weapons of others. In all cases, the reputations of these weapons are inflated in the retelling. This is a sampling of weapons from around the world with their exaggerated reputations intact, frequently exceeding the bounds of what's physically possible. Free access to any of them in a campaign may be unbalancing, so an Unusual Background or a perk might be levied for their purchase.

Very Cheap Swords

Just as some weapons were amazingly good, others can be amazingly bad. The quality of bog-iron swords used by Celtic barbarians, as related by Roman observers, was such that they could become uselessly bent during battle. However, they could be bent back into shape by banging them against a convenient tree or large rock.

A very cheap sword is treated as a cheap one. However, if it strikes a target with DR 3 or greater, or if it is parried or blocked, roll against its HT (p. B483). If the roll fails, the weapon bends. It may be used as a poorly balanced light club (Parry becomes 0U) until it is fixed. It may be repaired by pounding it back into shape against any suitably solid object (a large stone, a solid wall, etc.), requiring three Ready maneuvers and a ST roll. On a critical failure, the sword breaks. Very cheap swords have -0.8 CF.

Fossil Oosik (TL0^). An oosik is a penile bone of a seal or walrus, reaching a length of two feet or more. They were famed as weapons among native Alaskans both for the symbolic virility and their actual power as weapons. Their weight and gently recurving shape made them good clubs, but the best ones were partially fossilized (a nonfossil oosik may be treated as a knobbed club; see ***GURPS Martial Arts,*** p. 219). The hardened material lets it strike with greater force and makes it more durable. A fossil oosik has HP 14 and is treated as a fine-quality weapon for purposes of breakage.

Horse-Killing Macuahuitl (TL1^). Though sometimes called a sword, this Aztec weapon is more like a club that happens to have an edge. The core of the weapon is a long stick shaped like a cricket bat. The edge of the bat is set with a series of obsidian blades, each one razor-sharp – so sharp, in fact, that a large one can reportedly cut off a horse's head in a single stroke. Its drawback is its fragility. Stone blades are immensely sharp but brittle. Typically, a macuahuitl broke after a single good hit. A warrior armed with a macuahuitl on the battlefield was accompanied by at least one servant, like a grisly caddy, carrying replacements.

Francisca (TL2^). Although this Frankish axe functions much like any other as a hand weapon, it is quite formidable as a throwing weapon. The shape of the recurving haft and the weight of the iron head give it extra power and range. Its most notable use is against formations of enemy troops, where it disrupts formations by breaking or encumbering their shields. These stats may be used for Native American tomahawks as well.

Ghurka Kukri (TL2^). Though best known as the weapon of modern Ghurkas, the kukri has been in use for centuries. The kukri functions as a sort of cross between a knife and an axe. The faintly leaf-shaped blade bends 20-30° just past the hilt, with the single sharp edge on the inside of the curve. Though the knife has a wicked point, its weight distribution makes it exceptionally well-suited for chopping.

Thracian Sica (TL2^). A curving shortsword, sometimes called a Thracian sword, used by gladiators. The curving design allowed the wielder to thrust *around* an opponent's shield, bypassing his defenses for a deadly thrust.

True Kris (TL3^). The kris is the predominant type of blade around Indonesia, with a distinctively wavy outline. They come in a variety of sizes. Smaller kris are made with a slight curve at the hilt, resembling the sica, helping the blade slip between bones more effectively. Larger kris are less frequently bent, but the flame-shaped blade helps concentrate power on swinging attacks, increasing damage.

Legendary Katana (TL3^). By the time the West really engaged with Japan, swords and swordplay were on the decline Europe but still in full flower at the edge of Asia. Moreover, the elaborate folding techniques used to make the best ones, though not far off from medieval Western pattern welding, seemed nigh-mystical. In an environment hungry for tales of the exotic Orient, the katana quickly attained a reputation for being the ultimate sword: graceful, elegant, and razor-sharp.

Welsh Longbow (TL3^). The Welsh longbow is the deadliest man-powered missile weapon ever invented, according to popular legend. Ideally, the bow was made from a five- to seven-foot length of well-seasoned yew, whose heartwood was ideally suited to making a particularly springy, efficient bow. In the hands of a well-trained user, it had a sustained rate of fire of 12 shots per minute. It is said that a longbow arrow could pierce plate armor, and modern reconstructions can fire an arrow over 350 yards.

Zanbato (TL3^). This is an immense variant of the two-handed sword. Resembling a katana up to 12 feet long, a zanbato is intended for use against cavalry. It is said that it can behead a rider *and* his horse in a single stroke. Though that might be a bit of an exaggeration, it's not far from the truth. Such swords are enormously expensive, however, and are often limited to ceremonial use.

New Wildcard Skill: Katana! (DX)

This new wildcard skill covers both one- and two-handed use of the legendary katana, and may substitute for Breaking Blow, Fast-Draw, Intimidation, Power Blow, and Throwing when using it. Katana! has no defaults. If someone uses a legendary katana (above) without the appropriate skill, treat it as a regular katana (p. B271) for the purposes of damage, parry, and applicable skills.

Zweihander (TL4^). Perhaps the ultimate sword, the zweihander is both long and heavy enough to match the power of any other muscle-powered weapon and well-balanced enough to be used with fencing technique. Like the zanbato, the zweihander is more often seen in the hands of officials in processions than on the battlefield.

Ethnic Cool Melee Weapons Table

TL	Weapon	Damage	Reach	Parry	Cost	Weight	ST	Notes
AXE/MACE (DX-5, Flail-4, or Two-Handed Axe/Mace-3)								
0^	Horse-Killing Macuahuitl	sw+4 cut	1	0U	$500	3	10	[1]
	or	thr+1 cr	1	0	–	–	10	[1]
2^	Francisca	sw+1 cut	1	0U	$50	3	10	
KATANA! (see p. 10)								
3^	Legendary Katana	sw+2 cut	1, 2	0F	$2,600	5	11	[2]
	or	thr+2 imp	1	0F	–	–	11	[2]
KNIFE (DX-4, Force Sword-3, Main-Gauche-3, or Shortsword-3)								
3^	True Kris, Small	sw-1 cut	C, 1	0	$120	1.5	7	
	or	thr imp	C, 1	0	–	–	7	[3]
3^	Ghurka Kukri	sw+1 cut	C, 1	0	$50	1.5	7	
	or	thr-1 imp	C	0	–	–	7	
SHORTSWORD (DX-5, Broadsword-2, Force Sword-4, Jitte/Sai-3, Knife-4, Saber-4, Smallsword-4, or Tonfa-3)								
0^	Fossil Oosik	sw+2 cr	1	0	$20	2	8	
2^	Thracian Sica	sw+1 cut	C, 1	0	$400	3	10	
	or	thr-1 imp	C, 1	0	–	–	10	[4]
3^	True Kris, Large	sw+2 cut	1	0	$400	2	8	
	or	thr imp	1	0	–	–	8	
TWO-HANDED AXE/MACE (DX-5, Axe/Mace-3, Polearm-4, or Two-Handed Flail-4)								
0^	Horse-Killing Macuahuitl, Two-Handed	sw+6 cut	1	0U	$650	5	12†	[1]
	or	thr+1 cr	1	0	–	–	12†	[1]
TWO-HANDED SWORD (DX-5, Broadsword-4, or Force Sword-4)								
3^	Zanbato	sw+6 cut	1-3	0U	$1,350	10	14†	
	or	thr+3 cr	3	0	–	–	14†	
4^	Zweihander	sw+6 cut	1-3	0F	$1,800	10	14†	
	or	thr+3 imp	3	0F	–	–	14†	

Notes

[1] If used to parry any weapon, or used to strike DR 2+, damage becomes sw+1 cr (one-handed) or sw+2 cr (two-handed).

[2] Stats are for one-handed use. A legendary katana may be used two-handed for +1 to swing and thrusting damage. Katana! skill covers this use, defaulting to Two-Handed Sword-4.

[3] Thrusting attacks are at -2 to target vitals rather than -3.

[4] Blocks are at -1 against thrusting attacks from this weapon.

Ethnic Cool Ranged Weapons Table

TL	Weapon	Damage	Acc	Range	Weight	RoF	Shots	Cost	ST	Bulk	Notes
BOW (DX-5)											
3^	Welsh Longbow	thr+3(2) imp	3	×18/×30	3/0.1	1	1(2)	$1,000	11†	-8	
THROWN WEAPON (AXE/MACE) (DX-4)											
2^	Francisca	sw+2 cut	1	×1.5/×2	3	1	T(1)	$50	10	-3	[1]

Notes

[1] If the defender blocks an attack only by the shield's DB, the weapon becomes embedded in the shield, penalizing Shield skill: at least -1; -2 if total projectile weight is at least half shield weight; -4 if total weight equals or exceeds shield weight. Removing it requires a Ready maneuver and a ST roll at a penalty equal to its damage roll.

Combination Weapons

There have long been experiments uniting various types of weapons into a single item, such as the combination of extended point and chopping blade in halberds. When gunpowder weapons were invented, combined arms experiments continued, allowing weapon designers to (almost) effectively combine melee weapons with ranged weapons.

Combinations of gun and melee weapon were initially rare. Artillerymen used a tool called the *linstock*, a long fork used to touch off cannon with a match. The linstock was already adapted for defensive use by adding a spearhead to the end. By the Renaissance, some versions were equipped with a matchlock pistol mechanism for extra firepower, but it was nevertheless slow and clumsy as a weapon.

The development of better metals and improved firing mechanisms led to widespread experimentation with combined arms. Single-shot pistols were incorporated into a huge variety of bladed weapons, giving the user the chance to strike first before closing with an opponent or a little extra boost in case close fighting got bad. They were also used as hunting weapons, giving the hunter a single, close-range shot with which to finish off a wounded-but-still-fighting animal.

Mr. Stab-Stab Bang-Bang

Those using combined weapons may want to attack with both weapons at the same time. This may be attempted if the attacker simultaneously fires the gun and makes a thrusting attack or, with the gun shield, does a shield bash. This is treated as a dual-weapon attack (p. B417; both attacks are at -4). If the combined weapon is in the off hand, *both* attacks are at an additional -4. This "shoot-stab" maneuver may be bought as a technique for either the underlying pistol or Melee Weapon skill.

Linstock (TL3). In addition to the gun, the linstock can be used in melee combat as a clumsy spear at -1 to Spear skill, but it cannot be thrown.

Gun-Dagger (TL4). Like most other gun-weapon hybrids, this is a single-shot pistol mated with a blade. It may resemble a small pistol with its barrel pointing along side of a short blade or a dagger with a gunlock mechanism attached to the side, just past the grip. Like most such weapons, it is on the clumsy side. In addition to its use as a firearm, it may be used as a dagger at -1 to Knife skill. However, it cannot be thrown.

Gun-Knife (TL4). As the gun-dagger, but with a larger blade. Different models had the barrel pointing along either the side of the blade or along one edge, but their performance is identical. It may be used as large knife at -1 to Knife skill. Like the gun-dagger, it cannot be thrown.

Gun-Rapier (TL4). A full-sized fencing weapon with a gun firing parallel to the blade. Unlike smaller weapons, which might have a pistol grip, gun-swords usually have a sword grip and a gun lock just past the hilt. The trigger mechanism is arranged so that the gun may be fired without changing grip. However, balance is a significant problem with such weapons; it may be used as a saber at -2 to Rapier skill.

Gun-Sword (TL4). Like the gun-rapier, only with a full-sized broadsword. May be used as a thrusting broadsword at -1 to Broadsword skill.

Gun-Hatchet (TL4). Though most combination weapons are variations on knives and swords, guns were combined with axes as well. Gun-hatchets were often issued to 17th- and 18th-century Scandinavian sailors for use in boarding actions. The blade of the axe protrudes from the barrel of the pistol as though the barrel were the haft of the axe. It maybe used as a hatchet at -1 to Axe/Mace skill, and changing from pistol use to axe use requires a maneuver to change grip (which may be eliminated with a Change Grip perk).

Gun-Katar (TL4). Though northern and central Europe were the heartland of combination weapons, they were sometimes made elsewhere in the world. This punch-dagger has a pistol barrel parallel to the blade, fired by squeezing the grips. May be used as a regular katar at -1 to Knife skill.

Gun-Shield (TL4). Used by the bodyguards of Henry VIII, this is a small metal shield with pistol in the boss. Treat as an iron light shield.

Multi-Barrel Combined Arms

By the 17th century, armorers tried out combined weapons capable of firing multiple shots. These were "pepperbox"-style guns with multiple barrels and independent firing mechanisms rather than revolver-style weapons using a single barrel. Further barrels can be added to combined weapons for an additional $150 and a 0.5 lb. increase in weight, to a maximum of six barrels. The additional barrels may only be fired one at a time. The Melee Weapon skill skill penalty worsens to (number of barrels)/2, rounded up, plus -1 for gun-rapiers.

TL	Weapon	Damage	Acc	Range	Weight	RoF	Shots	ST	Bulk	Rcl	Cost	LC
GUNS (PISTOL) (DX-4 or most other Guns at -2)												
3	Linstock	1d	1	30/350	4.5/0.01	1	1(20)	9	-6	1	$240	2
4	Gun-Dagger	1d	1	30/350	0.75/0.01	1	1(20)	6	-2	1	$220	2
4	Gun-Knife	1d	1	30/350	1.5/0.01	1	1(20)	6	-2	1	$240	2
4	Gun-Rapier	1d	1	30/350	3.25/0.01	1	1(20)	9	-4	1	$700	2
4	Gun-Sword	1d	1	30/350	3.5/0.01	1	1(20)	10	-4	1	$800	2
4	Gun-Hatchet	1d	1	30/350	2.5/0.01	1	1(20)	8	-2	1	$240	2
4	Gun-Katar	1d	1	30/350	1.5/0.01	1	1(20)	6	-3	1	$250	2
4	Gun-Shield	1d	1	30/350	4.5/0.01	1	1(20)	7	-4	1	$325	2

Armor

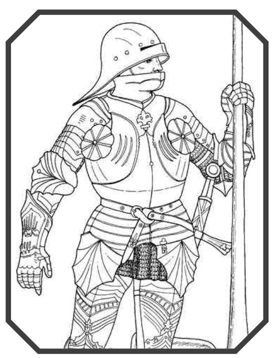
With all of those fearsome weapons around, the ancients needed some protection.

Superheavy Plate

In days of old, legend tells us, knights were bold. Their boldness was doubtless enhanced by their heavy armor. Some armor was so heavy that it was almost impossible to walk in, and fully armored knights had to be lifted into their saddles with cranes. Superheavy plate armor is the ultimate in protection, but even without a weapon or shield, it pushes quite strong men over the line into Extra-Heavy encumbrance, leaving them to waddle around the battlefield like elderly but overloricated lobsters. Joints are also clumsy: Anyone wearing a suit of superheavy plate has -1 to DX.

TL	*Armor*	*Location*	*DR*	*Cost*	*Weight*
4	Superheavy Corselet	torso, groin	14	$5,200	140
4	Superheavy Arms	arms	11	$2,500	37.5
4	Superheavy Legs	legs	11	$2,750	50
4	Superheavy Greathelm	skull, face, neck	14	$1,190	35
4	Superheavy Gauntlets	hands	11	$350	7
4	Superheavy Sollerets	feet	11	$525	24.5

Gothic Plate



In the 1500s, armorers in Germany began producing plate armor with elaborate fluted patterns resembling pleated and quilted clothing. Some have believed that, in addition to creating an attractive pattern, the sloped surfaces provided superior protection. Blows striking one of the many angled flutes would be more likely to glance off harmlessly, a principle used in earthen fortifications and modern vehicle armor.

Any piece of plate armor may be made in a gothic version. It provides +1 DB to the locations it protects, like a shield (if using random hit locations, roll location *before* the defense roll). However, this bonus applies to attacks from all angles, and it is *cumulative* with the DB provided by shields. Gothic plate is TL4^. It costs +3 CF.

Treated Linen Armor

A number of societies, lacking sufficient metal for the job, made armor from cloth. Layers of tightly woven fabrics, quilted or glued together, provide surprisingly good protection. However, accounts of some linen armors (as related by members of societies that didn't produce it, of course) are little short of miraculous. Not only was it lightweight, it was nigh-impervious.

The production of this sort of linen armor apparently did not depend on piling layers together. Rather, the linen was chemically treated in a particular type of boiling wine. This rendered the fibers so tough that the resulting armor was resistant to every kind of blow.

For reasons known only to its manufacturers, only breastplates of this armor were produced. Their actual damage resistance is moderate (DR 2), but the breastplate is essentially impenetrable. All damage that penetrates its DR becomes crushing. Treated linen armor is TL2^. It may be considered the same as regular cloth armor, but with +19 CF.

Leather Cloak

In some societies, particularly among levies of inferior troops, armor was hard to come by at best and often prohibitively expensive. Leather capes and cloaks, which could be worn for protection against weather off the battlefield and protection against enemies on it, were sometimes donned in such situations. They provide an additional +1 DR if simply worn. They may also be used like cloth cloak or capes with Cloak skill, though at -1 to skill because of the increased weight. However, they are far more durable. A light leather cloak has HP 7, and a heavy leather cloak has HP 9. Leather cloaks have +1 CF and double the weight of a cloth cloak.

Studded Armor

In the real world, studded armor is fictional, a misinterpretation of brigandines. In many fantasy games, it is an intermediate step between leather armor on one hand and scale armor on the other. Studded armor is flexible leather decorated with metal studs. These provide incidental extra protection; the studs help deflect some blows. Some believe that in certain settings, attractive decorative studs with a bit of precious metal content could also be used in trade.

Studded armor is TL1^. Treat as leather armor (DR 2). However, when a character wearing studded armor is hit, roll a die. On a 1, the blow hits a stud, providing DR 4. Studded armor has +1 CF and 20% greater weight than regular leather armor. Buyers of studded armor can spend any amount more than that to purchase precious studs and "cash in" the difference at any time even for trade with people who don't use coins, but once the valuable studs are removed, the armor is no better than regular leather.

Horned Helmets

Horned helmets are only semi-mythical. Some Bronze Age (TL1) specimens of horned helmets have come down to us, though there's no indication that medieval Vikings used them. Still, pseudohistorical Vikings wouldn't be the same without them. Any rigid helmet at TL1+ may be made with horns. Small horns add $40 and 0.5 lb. to the helmet's weight and cost. Large horns add $100 and 0.75 lb. This is a realistic embellishment, providing little benefit besides a distinctive look.

However, in addition to looking fierce, less realistic "ethnic cool" TL1^+ horned helmets have minor benefits. Small horns help ward off blows to the head. A helmet with small horns gives +1 DB against melee attacks to the brain. Larger horns can also be used offensively. A horned helmet may be used to head-butt for thr imp damage.

Chapter Two
Transportation

For more of history, it often wasn't easy to get from one place to another. Travel was difficult and limited in scope, but ancient engineers and dreamers imagined many ways to move more freely and conquer new environments.

Terms and notation used in vehicle tables are as defined in *Vehicle Statistics* (pp. B462-463).

Overland

Most transportation was on land. Unfortunately, overland travel was always the most expensive way of moving people and goods around, so many attempts were made to improve the speed, power, and efficiency of ground vehicles.

Railways

The ancients didn't have steam locomotives, but they did have something strongly resembling railways. Actually, historical routes are more appropriately called "rutways." Their courses constrained the movements of vehicles that traveled on them, but instead of raised rails on which the wheels sat, they used grooves cut into stony ground. Such roads go back at least to the seventh century B.C. in Greece.

Most rutways were very short, no more than a few hundred yards. They were most often used as courses for carts in mines. The longest known ancient "railway," though, reached for miles. The Diolkos, a passage cut across the isthmus of Corinth, provided five miles of road for porting ships from one side of Greece to the other without having to sail around the Peloponnese.

Available at TL2 through TL4, railways/rutways count as prepared roads, halving the effective weight of their load (see p. B353). However, only carts that have been especially prepared for them gain this benefit, and while in their courses, they cannot maneuver except to go where the track directs them.

Land Sailing

Long the dominant method of providing propulsion on water, wind was occasionally used to push land vehicles. Wind-driven carts appeared in ancient Egypt. They resembled chariots or wheelbarrows with at least one extra wheel for balance and a mast to hold a sail. They were used by the wealthy for racing and recreation rather than as serious transportation.

Such vehicles appeared sporadically thereafter, notably in China. During the Renaissance, larger designs appeared, resembling boats on wheels rather than chariots. A Dutch scientist of the 17th century developed a two-masted landgoing yacht capable of holding nearly 30 crew and passengers. By the end of TL4, sail-powered vehicles with runners rather than wheels were used in cold climates to transport goods over frozen rivers and lakes.

Under ideal conditions, sail-powered land vehicles could build up impressive speeds. Even the heaviest vehicles could outrace horses. Despite their remarkable performance, they never caught on for many reasons.

First, though they can go quickly, they maneuver very poorly. They are excellent for racing on long, straight courses, but not for negotiating curves as is required for most overland travel. Even at low speeds, they are largely dependent on the direction of the prevailing wind. Thus, round-trip travel between two points may require a very roundabout course. Second, without effective suspensions, the faster a sail-powered vehicle goes, the harder it is to control. Small bumps that make ox-carts mildly uncomfortable can potentially smash wooden wheels or throw out passengers from a speeding wind sailer. Consequently, even into the modern age, sail-powered land vehicles have been limited to largely straight courses over smooth surfaces such as salt flats, frozen rivers, paved roads, and other extremely level areas. They are unlikely to become common vehicles under any circumstances, but in addition to their use as cargo vessels in cold climates, they might find some application as courier vehicles on well-paved road networks such as those maintained by imperial Rome and China.

There are several possible models of wind sailers:

Wind Chariot (TL1). An individual vehicle, resembling a small three-wheeled chariot with a small mast.

Wind Barrow (TL1). A boxy, four-wheeled, slightly larger version of the wind chariot, big enough for two. Though intended for an important passenger and his driver, a courier might use it to carry small quantities of cargo.

Land Yacht (TL4). A large vehicle with multiple masts, big enough to ferry a large party of passengers or an appreciable amount of cargo.

Ice Sailer, Small (TL4). A version of the wind barrow adapted for use on frozen bodies of water, with runners rather than wheels.

Ice Sailer, Cargo (TL4). A version of the land yacht adapted for use on ice.

Spring-Powered Cars

Yet another of Leonardo da Vinci's experiments was a small, self-powered wagon. Leonardo's design relies on springs to move the vehicle. Like some modern toy cars, the springs are compressed by pulling the vehicle backwards. The reverse motion of the wheels winds up the mechanism, while letting it go releases the springs' energy and propels the wheels.

Leonardo's design leaves out a system modern vehicle designers would consider vital: steering. Like wagons of the period (and, indeed, most historical wagons), the axles and their wheels are fixed in place, and even if they could turn, there's no control mechanism for the driver. Such control as the vehicle has is built into the drive train. The gearing can be built to periodically speed up or slow down the wheels on one side or the other, making the vehicle turn accordingly, but the course is preset. Ironically, a century before Leonardo designed his cart, il Taccola (p. 8) had sketched out a steering mechanism resembling a modern rack-and-pinion system, making steering an easy possibility, but not one Leonardo incorporated into his design.

Range is another limitation. Modern reconstructions travel little more than 10 yards. Better performance could be realized with refinement, but this is clearly a vehicle for short-run, "city driving" rather than long distances.

Spring Car (TL4+1). This is the original Leonardo design, a spring-driven chariot with room for a "driver" (whose ability to control the vehicle is limited to stopping and starting the drive mechanism with a lever) and a pair of passengers.

Spring Omnibus (TL4+1). A scaled-up version of the spring car. This is a large, open-topped van or small bus, which can slowly ferry passengers over a small route at a walking pace.

Tanks

Wagons had been used as a semi-portable defense since at least the late first millennium B.C. However, they were employed as static devices. The wagons moved to a desired position, then stopped for use as a barricade for the duration of the battle. Draft animals pulling the wagons would simply be too vulnerable to enemy attacks to make wagons an effective offensive weapon. In the late 15th century, Leonardo da Vinci came up with a way around that. His innovation was to add a propulsion mechanism. His armored wagon wasn't just a portable fortification; it was an actual fighting vehicle.

Leonardo's tank was round, a low, wide cone; part of the vehicles' superior protection comes from this early form of sloped armor. It was to be wooden, thick enough to provide the crew protection. The center was occupied by the drive mechanism: two large cranks attached to the wheels. Each crank, hand-driven by the crew, drove the wheels on either the right or left side. Like a modern treaded vehicle, Leonardo's tank could turn in a remarkably tight radius by rotating the wheels on either side in opposite directions.

The sides of the vehicle were pierced with gun ports. Crew members not cranking the drive could fire personal guns or small cannon. The *Tank Armament Table* (p. 16) lists some typical lightweight field pieces suitable for mounting in a Leonardo tank.

The top of the cone had a turret slightly raised on posts. An observer standing up in the center of the vehicle, perhaps on a raised platform, could peer out and get a 360-degree view of the battlefield. Access to the vehicle is through heavy hinged panels of the vehicle's wooden armor.

Crew includes crankers (two, four, or six), a commander, and possibly gunners depending on size. Cranking the wheels is very hard work, consuming one FP per minute. Reloading an on-board cannon typically takes 10 seconds longer than the listed reloading time for a cannon because it must be retracted into the vehicle and reloaded under very cramped conditions.

This is another borderline-plausible invention. The Leonardo tank was never built during his lifetime (it's possible no one but he actually saw the design). It's an open question how cost-effective such an expensive vehicle would have been on the battlefields of the late Renaissance. However, full-scale reconstructions have since been attempted, and the hand-cranked drive train has worked, though slowly and with great effort.

Land Vehicles Table

TL	*Vehicle*	*ST/HP*	*Hnd/SR*	*HT*	*Move*	*LWt.*	*Load*	*SM*	*Occ.*	*DR*	*Range*	*Cost*	*Locations*	*Notes*
DRIVING (LAND SAILER)														
1	Wind Chariot	31†	-2/0	10c	4/12*	0.13	0.1	+3	1	1	–	$500	MO3W	[1]
1	Wind Barrow	37†	-2/0	10c	3/10*	0.25	0.2	+3	1+1	1	–	$800	MO4W	[1]
4	Land Yacht	142†	-3/1	11c	3/9*	5.75	2.9	+8	2+27	1	–	$40K	2MO4W	[1]
4	Ice Sailer, Small	31†	-2/0	10c	4/16*	0.13	0.1	+3	1	1	–	$750	MO3R	[2]
4	Ice Sailer, Cargo	142†	-3/1	11c	3/12*	5.75	2.9	+8	2	1	–	$60K	2MO3R	[2]
DRIVING/TL (AUTOMOBILE)														
4+1	Spring Car	34	-1/2	10c	4/4	0.6	0.3	+2	1+2	1	20	$3.8K	O4W	[3]
4+1	Spring Omnibus	47	-1/4	10c	3/3	2	1.2	+4	1+11	1	20	$15K	O4W	[3]
4+1	Spring Car, Steerable	34	-1/2	10c	4/4	0.6	0.3	+2	1+2	1	20	$4.8K	O4W	[4]
4+1	Spring Omnibus, Steerable	47	-1/4	10c	3/3	2	1.2	+4	1+11	1	20	$16.2K	O4W	[4]
DRIVING/TL (HEAVY WHEELED)														
4+1	Leonardo Tank, Small	40	-1/4	12c	1/3	1.1	0.6	+3	3+2	7	F	$2.1K	4W	[5]
4+1	Leonardo Tank, Medium	66	-1/4	12c	1/2	5	2.8	+4	5+3	8	F	$9.25K	4W	[6]
4+1	Leonardo Tank, Large	82	-1/4	12c	1/2	8.8	4.5	+4	7+5	8	F	$18K	4W	[7]

Notes

[1] Movement is restricted to high-quality roads, salt flats, packed sand, or other very smooth, solid surfaces.

[2] Movement is restricted to ice.

[3] The vehicle's maneuvers are preprogrammed into the drive system. Any maneuvers requiring a Driving roll are at an effective skill of 12. Hnd assumes travel on the vehicle's programmed course. On a different course, or the intended one under unexpected driving conditions (e.g., if the course is damaged), Hnd becomes -3 or worse.

[4] This version incorporates the Taccola steering system and can be steered like any other vehicle.

[5] This model typically carries no weaponry of its own. Rather, the crew and passengers use their own personal weapons through gunports. Each of six gunports can cover a 60° arc. DR protects the wheels.

[6] This model is much more heavily armed than its smaller counterpart. It typically carries six half-pound guns (see below). DR protects the wheels.

[7] The most heavily armed version, this vehicle has six one-pound guns (see below). DR protects the wheels.

Tank Armament Table

TL	*Weapon*	*Damage*	*Acc*	*Range*	*Weight*	*RoF*	*Shots*	*ST*	*Bulk*	*Rcl*	*Cost*
GUNNER (CANNON) (DX-4 or other Gunner-4)											
4	Cannon, 0.5-lb.	5d pi++	2	90/850	300/0.65	1	1(70)	29M	-9	2	$4,000
4	Cannon, 1-lb.	7d pi++	2	120/1,000	500/1.4	1	1(70)	33M	-10	2	$6,700

The Di Giorgio Tank

Since antiquity, portable shelters could be found on battlefields, particularly during sieges. Long wooden huts screening battering rams were picked up from the inside and carried by their crews for protection during a charge to the fortification and the long, hard work of breaking through walls and gates. Just before the rise of gunpowder artillery, Francesco Di Giorgio, one of Leonardo da Vinci's predecessors, took the idea a step further and armed a cart with the best weapons available at the time. Like siege shelters, the cart was propelled by a crew (either beasts of burden or a group of men with equivalent ST) pushing it from the inside, like Fred Flintstone's car. Gears and pulleys attached the axles to a series of giant axes attached to the front of the wagon on pivots, which rose and fell with the cart's motion, chopping at anything that stood in its way. It wouldn't have been terribly effective as a weapon (anyone in range of the axes was about to be run over anyway), but the sight of a large wagon lumbering forward with enormous shining blades tearing up the ground in front of it would no doubt have been terrifying. Anyone standing two yards in front of a moving Di Giorgio tank is attacked by an axe blade doing 2d-1 cut with an effective skill of 9.

TL	*Vehicle*	*ST/HP*	*Hnd/SR*	*HT*	*Move*	*LWt.*	*Load*	*SM*	*Occ.*	*DR*	*Range*	*Cost*	*Locations*
TEAMSTER													
4	Di Giorgio Tank	45†	-2/4	11c	2/5	1.1	0.4	+4	1+1*	5	F	$1.7K	4W2X

* Occupancy assumes a pair of draft animals inside it propels the vehicle. They may be replaced by up to six men.

Against Gravity

For most of history, flying was a dream. Birds and insects did it, but for humans, flying was limited to symbolic religious experiences and the imagination. However, a few societies had specific ideas about how to get off the ground.

Hot Air Balloons

The deserts of the Nazca region of Peru are illustrated with vast figures and networks of lines drawn on the ground. The Nazca lines were simple to produce: dark rocks were picked up from the light-colored sand of the Peruvian desert where lines were desired and tossed aside. Making figures out of the lines was essentially a triumph of surveying, much like setting out property lines or planning the courses of roads and aqueducts. However, though it's possible to draw such vast figures on the ground, the overall pictures are only visible from a considerable distance above. Since the TL1 ancient Peruvian farmers lacked airplanes and helicopters, the great mystery is why such effort was spent on creating pictures no one could actually see.

Ignoring fringe suggestions of airports for aliens (there being no facilities for losing the aliens' luggage), one prevailing theory is that they weren't made for the people making them to see. Rather, they were drawn for the gods, who could look down from any height they desired. Another theory holds that most lines *could* be seen, just from the tops of nearby hills. Some, though, believe the ancient Peruvians had aircraft of a sort.

The Nazca, like many other South American civilizations, produced very high-quality textiles. Sewn together tightly, they could retain hot air at sufficient pressure to support short balloon flights, where a passenger could look down on the lines from a great height. Instead of carrying their own fuel source like modern balloons, the Nazca balloons would have been dependent on ground-based launching pads, just as early European balloons were. After building a large fire, the balloonists would hold the envelope over it, letting it fill with smoke and hot air until it inflated and flew away.

Hot Air Balloon (TL1+1). A well-sealed envelope of fine cloth or thin leather, with an opening at the bottom. The balloon must be held over a pit with 50 lbs. of burning wood for a minute to inflate. Once launched, the balloon stays airborne for two minutes, rising to a height of no more than 100 yards. It does not have a gondola, but it can have a payload (no more than 100 lbs., sufficient for a child or a very small adult carrying no equipment) strapped to it with a rope harness. Unless tethered to the launch site, the balloon drifts with the wind and cannot be steered. Landing counts as a fall from a height of five yards, but the passenger may roll against Acrobatics to avoid damage or take his chances by bailing out earlier with a parachute (pp. 17-18). $600, 35 lbs., not counting fuel or launch site preparation.

Specific Attraction

Gravity-defying craft were a topic of one of the earliest works of science fiction. In the 17th-century *A Voyage to the Moon,* the French poet Cyrano de Bergerac (on whom Edmund Rostand's play was based) wrote of unusual means of getting himself off the ground. Dew, as is well known (or, at least, as it seemed to Cyrano), rises toward the sun in the morning. In his story, Cyrano took advantage of this one night by collecting a quantity of dew in bottles, which he strapped to himself. When the sun rose, it exerted its natural attraction on the dew, drawing him upwards. When he found himself getting too high, he broke several bottles. The dew escaped, causing him to fall back to the nearest celestial body. Later in the same work, he performed a similar trick with blood or marrow, which is attracted to the moon. Presumably, frost is subject to similar forces.

While they're really based on an attraction to a particular object, Cyrano's methods are functionally very similar to lighter-than-air buoyancy. Though some flight is better than no flight at all, using dew to obtain lift-off is subject to a number of limitations.

First, the relevant materials are very difficult to obtain. Dew can only be effectively collected in the last hour or so before dawn. With a bit of practice with towels and wringers, one person can collect up to a pint during that time frame from an area of 20 square yards, which means that a squad of moppers and wringers is required in the small hours of the night to prepare even the smallest dew-driven conveyance. Dew is also available only when the soil is moist and relative humidity is high; a potential flier in the desert or the Arctic would be unable to collect dew.

Second, control is very limited. The dew begins to evaporate when the sun rises. Flights cannot commence until then and will end, whether the pilot likes it or not, at sunset. Furthermore, like the earliest hot air balloons, which got all of their lift from a fire on the launching pad, a dew-lifted conveyance cannot generate additional lift during flight. (Of course, some daredevil could strap on a few extra bottles, rise under another dew vehicle, and attempt a handoff.)

Cyrano described his precise mechanisms in the vaguest possible terms, so a few devices may be drawn from them.

Dew Belt (TL4^). A sturdy leather harness resembling a batch of ammunition belts or a mountain climber's harness, with loops and ties for holding 16 sturdy glass bottles. It provides a total of 260 lbs. of lift (including its own weight), or 16.25 lbs. each. The wearer can, if desired, smash or detach a bottle with a single combat action, or he can open a bottle and let some dew out (three turns to open a bottle, one turn and a DX roll every turn thereafter to let out a pound's worth of lift). If the wearer is hit in the torso, roll 1d. On a 1-4, a bottle is hit. The harness is $40, 20 lbs. The dew is at least $64 per flight.

Dew Booth (TL4^). A cabinet the size of a phone booth, fitted with a comfortable chair, a door, and windows. The dew in this vehicle is contained in a brass sphere mounted on top. A small valve, accessible from the inside, can be used to let off excess dew. The booth is fitted with a small sail for very limited maneuverability. It always moves at the speed of the wind pushing it, and it cannot take a course more than 30º from the direction of the wind.

TL	*Vehicle*	*ST/HP*	*Hnd/SR*	*HT*	*Move*	*LWt.*	*Load*	*SM*	*Occ.*	*DR*	*Range*	*Cost*	*Locations*
SHIPHANDLING (AIRSHIP)													
4^	Dew Booth	24	-1/0	10c	3/12	0.4	0.3	+1	1	1	–	$700*	Ms

* A full tank of dew is at least $200 per flight.

Parachutes and Gliders

Historically, getting into the air has been only half of the problem. Getting down takes care of itself, but getting down *safely* is a different question. The principle of a parachute is easy to invent for any society that uses any kind of wind power, but it requires a great deal of fine-tuning.

The earliest account of a parachute jump dates to the ninth century A.D. A Cordoban scholar constructed a device resembling a cloak, possibly feathered, and definitely stiffened by a wooden frame. He leaped from a tall tower and got away with minimal injuries, perhaps gliding a short distance from his launch point rather than going straight down. Later centuries saw similar experiments with ways of slowing a fall. In China, stiff parasols were used in stage acts to slow the falls of performers, though they were not used seriously as safety equipment.

By the 17th century, engineers in Europe were experimenting with parachutes as a way of escaping burning buildings. The earliest known completely successful parachute was demonstrated in 1617 in Venice. A ribbed, rectangular sheet (fine linen coated with starch to reduce porosity), it resembled a modern parachute, though its rigid frame made it unsteerable. However, the technology remained a curiosity until the rise of ballooning in the 19th century made it a more pressing concern.

Early models were rigid, more like a glider wing than a modern parachute. A design of Leonardo da Vinci's, for example, was shaped like a pyramid, open at the bottom and with edges stiffened by wooden rods. This ensured that the jumper would get some support almost from the moment of jumping. There was no need, like a modern parachute, to let the chute unfurl. However, it also increased the weight of the parachute.

Modern parachutes are also shaped with a superior understanding of aerodynamics, made from lighter and less porous materials, and, perhaps most importantly, are much, much larger. Historical attempts at the parachute ranged in size from a man's cloak to a large bedsheet. The largest historical parachutes approach the size of the smallest modern reserve and specialized stunt parachutes, and don't have designs that give them lift and stability.

Early parachute inventors lacked one other important element: height. Even daredevil modern BASE jumpers regard anything less than 200 feet as unacceptably hazardous, and the lowest military jumps are significantly higher. For modern jumpers, the height gives time for the chute to deploy and, if necessary, to release a backup. A rigid parachute may not need the time to open, but it may still require a moment to come to a proper angle, and if the parachute is unstable, as early chutes certainly were, there would be no time to bring it under control. Suitable heights are easy to achieve with aircraft, but buildings tall enough to safely jump from were at least slightly unusual until the 19th century. Early parachutists simply weren't working under conditions that would have allowed them to develop viable parachutes.

By the Renaissance, theorists speculated that the addition of a bird-like tail to provide maneuverability could improve parachutes and simple gliders. Leonardo da Vinci designed a glider shaped very much like a bird, with the pilot strapped into the "body." Irresponsible speculation suggests that Leonardo was able to draw remarkably accurate maps because he could glide over the sites he was surveying.

Rigid Parachute (TL3). A bedsheet-sized spread of fabric with a rigid frame. Preparing it takes 10 seconds. When falling, the user rolls against Parachuting skill. A successful roll reduces the user's falling speed to a maximum of (20 - margin of success) yards per second. $500, 5 lbs. A larger version, available at TL4, reduces falling speed to (15 - margin of success) yards per second. $900, 15 lbs.

Simple Air Brake (TL3). A small sheet of very fine treated fabric or sturdy paper on a rigid frame. Cloaks and parasols may be custom-built for this purpose. These devices aren't real safety equipment, but they can slightly slow a fall. The user gets +3 to Acrobatics skill for the purposes of reducing the effective height of a fall. $200, 1.5 lbs.

Gliding Cloak (TL3^). This is something closer to what the inventor of the Cordoban flying cloak was after: a parachute-like cloak allowing the user to "fly" or glide a bit while falling. The gliding cloak takes 10 seconds to prepare and a roll against Parachuting skill. If successful, the user falls at a rate of five yards per second and can steer it (barely) like a vehicle.

Bird Glider (TL4+1). Birdlike in shape, this glider has wings for support, a tail perpendicular to the plane of the wings for steering, and an open skeleton in which the pilot lies down. It falls at a rate of five yards per second, but gets more forward motion out of it than a gliding cloak. At the GM's option, the pilot may slow its descent or get lift by flying over particularly warm areas of ground and catching the updraft.

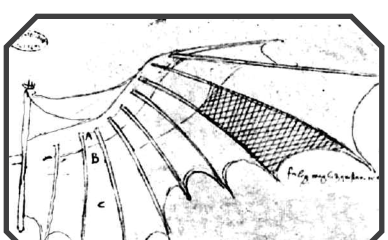
TL	*Vehicle*	*ST/HP*	*Hnd/SR*	*HT*	*Move*	*LWt.*	*Load*	*SM*	*Occ.*	*DR*	*Range*	*Cost*	*Locations*	*Stall*
PILOTING/TL (GLIDER)														
3^	Gliding Cloak	9†	+0/1	10	0/10	0.08	0.075	+1	1	1	–	$2.5K	EWi	3
4+1	Bird Glider	16†	+1/2	11	0/14	0.125	0.09	+2	1	1	–	$5.5K	EWi	3

True Flight

Parachutes and gliders are well and good, but they are ultimately just tools for falling with style. The true object of the dreamers and engineers who imagined flight was *powered* flight, the ability to take off and stay in the air as long as the user's strength kept up.

Wings

Daedalus was the first and greatest of mythical inventors. Any number of inventions were attributed to him, from the Labyrinth in which the Minotaur was imprisoned to the craft of carpentry. He is best remembered these days, though, for inventing human-powered flight, in the form of strap-on wings.



The wings are constructed of carefully selected feathers, fastened together with thread and wax. Presumably, this requires high-grade silk and beeswax, for their lightness, strength, and perhaps their association with flying creatures. Daedalus and his son, Icarus, were able to fly for several hundred miles, though they may have gone "island-hopping," flying many short legs. The drawback, of course, is the weakness of the structure. The wings could become soggy from exposure to sea spray (and, presumably, other water in the air), and high heat could soften the wax, making the wings fall apart.

Strap-on wings are not a uniquely ancient Greek achievement. An approximate contemporary of Daedalus', a King Bladud in England, attempted the same thing but with disastrous results similar to Icarus'. Likewise, a few Renaissance engineers imagined humans flying by flapping wings attached to their arms, though it's not clear how serious they were.

The next step most inventors imagined after the glider was the ornithopter, a vehicle that flies by flapping its wings. Leonardo da Vinci, again, is responsible for the most important sketches. His ornithopter designs resemble his glider designs, but with efficient crank systems to flap the craft's wings. Like his glider, his ornithopter needs a running start or a push off a height to get going. Though Leonardo was ahead of his time, human-powered ornithopters have since become an experimental reality.

Leonardo da Vinci also mused on helicopters, starting with a child's toy and scaling it up. His helicopter involved a conical spiral screw rather than the modern set of rotary wings. A crew turned the screw with a crank under the wing like a giant umbrella. It was steered by the occupants leaning in the direction they desired to move.

Personal Wings (TL1^). After strapping on these wings, the user can flap his arms and fly. The wings can lift the user's BL×8, including the user's own weight, to a maximum of 400 lbs. Airspeed is the user's Move×2. Flapping the wings is also tiring, taking one FP per minute, though the user may, at the GM's discretion, take advantage of updrafts and tailwinds to extend his flight time indefinitely. For every minute the wings are exposed to temperatures over 100°F or light rain (or its equivalent in spray, heavy mist, or fire hoses spewing in their direction), roll against the wings' HT of 12. On a failure, the wings cease to provide lift; the wearer plummets to the ground. $12,000, 4 lbs.

Ornithopter (TL4+3). This aircraft has no gear for taxiing, so it can't get up to flight speed unaided. It may be pulled along in a cart or pushed from a height (at least 10 yards) to become airborne. Once in the air, it has a Move of 16; this requires 1 FP every two minutes. Alternatively, it can glide with a slope of five yards of altitude lost per second for a forward Move of 16.

Renaissance Helicopter (TL4+4). The crew of the helicopter stands on a platform and turns a crank to spin the helical wing above them. Leonardo invented the first instrument for aerial navigation for his helicopter, a simple artificial horizon. Flight takes 1 FP every minute for *both* crew members. The helicopter does *not* glide, but it can take off and land vertically.

Vimanas

A number of Hindu epics, from the *Rigveda* onward, contain references to powered vehicles called "vimanas." They are believed by some to be the products of exotic but human technology rather than magic or other supernatural power. Indeed, some interpretations of the *Mahabharata* attribute the invention of vimana to the Greeks. Perhaps they're a development from the creations of Daedalus and Archimedes.

Vimanas come in a range of sizes, but most are small vehicles. They are typically called "flying chariots." When they are illustrated or described more explicitly, they typically fall into the range of a motorcycle and sidecar or a small boat or automobile; only a handful are essentially flying palaces. Some even had wheels, which might be treated as landing gear or even allow the vimana to be used as a ground car rather than an aircraft.

Vimana Weapons

Although passengers on vimanas may use conventional missile weapons, such as bows and scorpion ballistae, the makers of vimanas were also capable of making superior armaments. These include a variety of incendiary missiles, homing arrows that tracked their target by sound, and destructive beams of light.

Incendiary Arrows (TL2^). The next step up from flaming arrows, the incendiary arrow contains a hot-burning alchemical preparation. In addition to regular damage, the missile does an additional 1d-4 burn every turn for a minute or until dislodged (takes a roll against ST - points of damage done by the projectile). Incendiary arrows have +9 CF.

Homing Arrows (TL2^). These arrows follow the sound a target makes to strike with uncanny accuracy. Use the rules for homing weapons on p. B413. However, since they follow sound, homing arrows have certain vulnerabilities. They act as regular arrows against immobile, inanimate objects unless, for some reason, they happen to be making a noise (for example, a pipe organ with a brick placed on the keyboard). Targets who know they are being fired on by homing arrows may attempt to deceive the arrows by going silent, moving no more than half of their Move while being tracked. They may roll against Stealth rather than Dodge to avoid being hit. Homing arrows have +19 CF.

Ray Disk (TL2^). This miraculous metal disk, the size of a large plate or small shield, sends heat rays against its targets with performance similar to the Archimedean heat ray (p. 6). However, it has a limited number of shots before it must be recharged.

TL	Weapon	Damage	Acc	Range	Weight	RoF	Shots	ST	Bulk	Rcl	Cost	LC	Notes
GUNS (Beam Weapons) (DX-4 or most other Guns at -2)													
2^	Ray Disk	1d burn	2	50/70	3	1	10	8	-2	–	$8K	1	[1]

Notes

[1] The ray disk is recharged by solar energy. It recharges a single shot per half-hour of exposure to sunlight.

Small vimanas look like elaborate thrones or boats. Larger ones resemble gazebo-like pavilions or thick, round buildings with such a pavilion on top, from which the vimana is steered.

There are some references to vimanas using "fire and water" when they take to the skies, suggesting steam power. Other descriptions of being "like clouds" are consistent with putting out gouts of smoke and steam. However, there are indications that they drew energy from the sun or alchemical preparations as their ultimate power source.

Individual Vimana (TL2^). A throne-like conveyance large for one person, though someone lightweight and desperate enough might try to hang off the arms or sit in the pilot's lap.

Small Vimana (TL2^). A vimana the size of a small chariot, with enough room for a pilot and one passenger.

Medium Vimana (TL2^). A slightly bigger craft, with enough room for two passengers.

Large Vimana (TL2^). A vimana the size of a gazebo or small boat.

Two-Deck Vimana (TL2^). A vimana the size of a medium-sized ship or small building. The control cabin is exposed on the roof or at best protected by a lightweight canopy.

Seven-Deck Vimana (TL2^). A larger version of the two-deck vimana, in the form of a tall but lightweight tower.

True-Flight Conveyances Table

TL	*Vehicle*	*ST/HP*	*Hnd/SR*	*HT*	*Move*	*LWt.*	*Load*	*SM*	*Occ.*	*DR*	*Range*	*Cost*	*Locations*	*Stall*
PILOTING/TL (ORNITHOPTER)														
4+3	Ornithopter	21†	+2/2	11c	0/16	0.225	0.15	+2	1	0	F	$11K	EWi	3
4+4	Renaissance Helicopter	23†	+3/1	11c	0/16	0.3	0.2	+2	2	0	F	$16K	EWi	0
PILOTING/TL (VIMANA)														
2^	Individual Vimana	24	0/0	10c	4/22	0.2	0.1	+1	1	1	100	$5K	O	0
2^	Small Vimana	27	0/0	11c	4/20	0.35	0.2	+1	1+1	1	100	$7K	O	0
2^	Medium Vimana	30	0/0	11c	4/20	0.5	0.3	+1	1+2	1	100	$10K	O	0
2^	Large Vimana	44	0/1	11c	3/18	1.35	0.7	+2	1+6	1	120	$32.5K	O	0
2^	Two-Deck Vimana	78	-1/1	11c	3/16	7.75	4.1	+8	1+40	1	200	$182.5K	O	0
2^	Seven-Deck Vimana	119	-2/2	11c	3/15	27.5	14.5	+10	1+140	1	300	$650K	O	0

At Sea

In the relatively forgiving setting of the water, engineers could experiment with novel means of propulsion and many kinds of immense vessels.

Naval Siege Towers

The Greeks weren't the only ones with fearsome weapons at Syracuse. The Romans had their own: a floating siege tower. This vessel was a seagoing platform (for limited values of "seagoing") for a *sambuca*. The sambuca, named after a variety of harp, vaguely resembles a modern cherry-picker. It consists of a long ladder, broad enough for two men abreast to climb on, with an armored gondola at the top. The sambuca was typically carried to an enemy's walls and raised like a crane. Ropes hanging down from it gave it a harp-like appearance, hence the name. It was raised with troops already in the gondola, putting armed men in place to defend the top of the ladder as soon as it touched the enemy walls, though men on the ladder were exposed as they climbed up.

The innovation at Syracuse is that the conventional "siege crane" was placed on two triremes lashed together side by side. It moved very slowly because of both the great weight and the fact that it could only use half as many oars and rowers as two separate triremes. However, it could attack the normally unassailable and therefore often more lightly fortified seaward side of a city.

The naval sambuca wasn't unique. A similar if more robust vehicle, perhaps inspired by the Roman original, was successfully used during the Fifth Crusade against the Egyptian city of Damietta in 1218. Instead of the Roman crane, it may have had a solid wooden siege tower built on it. It moved more slowly than the Roman version, but the superstructure was better protected and carried more men.

Naval Sambuca (TL2). Men in the fighting platform defend the sambuca as it is being raised, and when it reaches its desired position, soldiers in the paired ships below can climb the ladder to attack the enemy walls. The gondola is an open-topped box the size of a very small car (SM +1) and provides DR 2.

Naval Siege Tower (TL3). The mobility of this vessel is further limited by not being able to mount sails; the tower built on the decks covers the masts.

Animal-Powered Paddle Wheeler

When muscle power was applied to propelling ships, sailors pulling oars usually provided it. However, some have claimed that the Romans took the logical step of harnessing the power of animals. The ox-driven paddlewheel ship had three wheels along each side, each wheel driven by an ox on a treadmill. The ship was said to outperform triremes in speed and force.

The main drawback, aside from cost, is endurance. The ship has a great deal of power, but oxen don't have nearly the endurance of trained rowers, and their feeding requirements clash with life at sea. Still, fast ox-powered boats could be the hunter-killer submarine of their age.

You can't cross the sea merely by standing and staring at the water.
– Rabindranath Tagore

Submarines

Although submarines didn't become common fighting vehicles until the 20th century, and no submarines were deployed in battle before American Revolution, the idea goes back much farther. William Bourne, a British mathematician, outlined the idea of a submersible vessel in the 1570s, and a series of vessels built according to his theories were constructed in the 1620s by Cornelius Drebbel, an inventor in the employ of England's James I.

This submarine was constructed from the hull of a boat covered with waterproof leather. It was fitted with watertight, leather-lined chambers that could be expanded or compressed like an accordion by using long screws on cranks to pull back or push forward the wooden panels that formed the chamber walls. When expanded, the chambers took on water, causing the boat to sink, and when compressed, the water was pushed out, increasing the air-filled volume of the boat and causing it to rise.

In addition to the mechanism for submerging, at least one model of the sub included another technological innovation. Instead of getting air from snorkel tubes, which would have limited depth severely, Drebbel apparently invented a mechanism for refreshing the air. Though the precise method is lost to history, he is believed to have heated potassium or sodium nitrate, which would have given off oxygen while converting the nitrate into chemicals that would have absorbed at least some carbon dioxide. With this device in place, the sub could stay submerged for at least three hours.

Though never actually deployed, the potential benefits of the submarine were immediately apparent. A commentator in the 1680s noted their potential for many of the purposes for which submarines were used centuries later: stalking and carrying out surprise attacks in naval warfare, covertly supplying allies surrounded by enemies, avoiding extreme weather on the surface, traveling under the ice near the poles, and carrying out undersea research.

There were at least three models of submarine. All models have a maximum underwater endurance of three hours while submerged, but only their rowers limit the endurance of self-propelled models on the surface.

Drebbel Diving Bell. The earliest of the Drebbel submarine variants, this may have been produced as a "proof of concept" to demonstrate that a vessel could be made to submerge and surface again safely. It can go up and down under its own power, but it cannot maneuver; it must be towed by another boat. This first model also may not have had Drebbel's air-scrubbing device. If it relied on snorkel tubes, its maximum depth would have been limited to about a foot and a half.

Small Drebbel Submarine. This intermediate model was more than submersible – it was self-propelled as well. Rowers (two on each side) propelled it; their oars protruded through watertight leather seals. However, it could not maneuver while submerging or surfacing; rowers had to stop rowing in order to turn the cranks that expanded or compressed the water chambers. With the air-scrubber setup, it would have had a maximum depth of perhaps 10 or 15 feet.

Large Drebbel Submarine. The last and largest model pointed the way to a useful submersible vessel. In addition to six rowers and their captain, it could carry up to nine passengers or a small load of cargo. It was used in a demonstration going on an 18-mile round trip up and down the Thames while submerged, and King James is said to have traveled in it in on a brief underwater voyage. Though never actually adopted by the Royal Navy, this model might have been towed to a theater of operations to perform the missions for which submarines are so well suited.

Up Periscope

The submarine periscope is not known to have been used before the 1850s. However, given the sparse history of the submarine to that point, it's not surprising. Periscopes of some kind, though, were in use at least as early as the 15th century. They were employed to look over and around obstacles by those viewing public spectacles from poor vantage points. Drebbel could easily have fitted one of his subs with a small periscope for navigation while submerged.

Watercraft Table

TL	Vehicle	ST/HP	Hnd/SR	HT	Move	LWt.	Load	SM	Occ.	DR	Range	Cost	Locations	Draft
SHIPHANDLING/TL (SHIP)														
2	Naval Sambuca	119†	-3/4	12c	1/4	90	32	+9	420	3	F	$275K	4MSr	7
3	Naval Siege Tower	223†	-3/4	12c	1/3	132	46	+10	500	3	F	$375K	S	8
2	Ox-Driven Paddlewheel	195	-3/3	11c	2/8	11	5	+8	20	2	F	$150K	2MO	6
SUBMARINE/TL (UNPOWERED)														
4	Drebbel Diving Bell	40†	–	10c	–	0.6	0.1	+2	1	2	–	$8K	g	3
4	Small Drebbel Submarine	49†	-1/1	10c	1/3	1.4	0.5	+2	5	2	F/20	$16K	g	3
4	Large Drebbel Submarine	64†	-1/1	10c	1/3	5	3	+3	7+9	2	F/20	$35K	g	3

Chapter Three

Power and Automata

One of the biggest differences between pre-industrial and industrial age devices is how they are powered and controlled. At TL5 and beyond, devices can draw power from convenient outside sources vastly more potent than their user, or carry their own tireless (as long as fuel holds out) mechanical power sources. Some devices, such as industrial robots and large, expensive vehicles on autopilot, can even direct their own actions. At TL4 and below, devices derive most of their energy (with a few exceptions for wind, water, and animal power) and all of their direction straight from their user.

Or do they? Inaccurate history gives a few devices that offer or take advantage of alternative sources of power. Some even operate independently of a user's direction.

Conventional Forces

Most power sources in antiquity were based on muscle and gravity, though there were some experiments with the power of steam.

Oh yeah, I need steam
Feel the steam all around me
Ah, you're turning up the heat
When I start to dream aloud
– Peter Gabriel, "Steam"

Choking Harness

Though horses have been used since the third millennium B.C., they were utilized mostly for riding and carrying burdens, occasionally for pulling carts, and almost never for plowing. Donkeys and mules were more often relied on as pack animals, while oxen dominated traction and agriculture. Since horses work longer and move faster than oxen, why was that?

The generally accepted answer through the 20th century was that horse harnesses were badly designed. A reconstruction of a Roman harness, based on a handful of sculptures and reliefs showing such gear, rode up the horse's neck, pressing on his windpipe, cutting down his air supply and limiting his pulling power. The medieval invention of the horse collar moved the burden from the horse's neck to its shoulders, allowing horses to pull plows, wagons, and so on.

Current thinking, based on newer evidence and alternate reconstructions, is that original reconstructions were simply wrong; the rise of horse traction during the Middle Ages was caused by a number of other factors. However, for the GM who wishes to reflect prior thinking, these rules may be used. With this design of harness, horses can pull much smaller loads for their strength until TL3. If a horse or team of horses is attached to a load, triple the effective weight of a load after modifiers for wheels and road conditions. Because the anatomy of oxen is different, they don't suffer from this problem, so they're better suited to pulling wagons and plows. The development of the horse collar removes this restriction for horses in the middle of TL3.

Steam

One popular point of departure for alternate history is the observation that the Greeks had steam power, after a fashion. A Greek philosopher living under Roman rule had the glimmerings of an understanding of the relationship between action and reaction. If, he reasoned, a boiling kettle spouted steam with appreciable force, it must push back against its container. He proved his theory by constructing a sort of rocket-propelled kettle that used the power of expanding steam to make itself spin around.

Nonetheless, it's a long way between that and practical steam power, just as there's a long way between a paper plane and the Wright brothers. A variety of subtler technological barriers get in the way, such as the development of efficient gearing and accurately accounting for the expansion of heated components. By paying attention to the overall principle without delving too much into specifics, a number of devices are possible.

Classical Steam Engine (TL2+2). This is a fictional steam engine, solving the many little problems in the way of getting more power from a steam engine more efficiently than from muscle, wind, and water. The engine is made from heavy bronze, which is very expensive but comparable in strength to the iron eventually used by TL5 steam engines. It also leaks water and heat prodigiously, making it inefficient for its size. It provides power equivalent to ST 20, which may be used for door-opening, water-lifting, and so on. It requires 150 lbs. of wood and 50 gallons of water per hour. $100,000, 2.5 tons.

Medieval Steam Engine (TL3+2). Another fictional steam engine, this combines the Classical discovery of steam power with the medieval discovery of the reciprocating piston, used in a number of medieval devices but historically powered by animals, wind, or water. Attached to saws, wheels, hammers, etc., it provides ST 40 and consumes 750 lbs. of wood and 250 gallons of water per hour. $500,000, 12.5 tons.

Steam Pump (TL4). Though versatile steam *engines* are a TL5 development, practical industrial use of steam *power* arose late in TL4. Rather than using the expansion of steam to push a piston, early steam pumps used the power of vacuum to pull it. A piston chamber was slowly filled with steam, then rapidly cooled. The condensation of steam pulled the piston into the chamber, usually lifting the arm of a pump mechanism. A counterweight then withdrew the piston, emptying the chamber for the next cycle. These engines are stationary and weak next to TL5's early true steam engines, but require no speculative or alternative techniques. The steam pump lifts 1,000 gallons of water 15 feet per hour, requiring 1,000 lbs. of wood and 100 gallons of water, often drawn from the water it pumps. $10,000, 5 tons.

Perpetual Motion

As early as the 12th century, engineers in Europe and India toyed with the idea of a machine that, once set in motion, wouldn't stop. These machines were often variations on the theme of an overbalanced wheel (which uses hinged weights to keep a vertical wheel always more heavily loaded on one side than the other) or siphon arrangements (which provide a waterwheel with its own self-refilling reservoir). One novel design had a rotating wheel set with magnets that were attracted to another magnet at its base, pulling the wheel down on one side, while shielding the magnets on the other side and providing no balancing attraction.

Even if they worked, such machines would be relatively weak, far outpowered by waterwheels and windmills. Through TL3, they would be scientific curiosities. The first suggestion that such a device could be used for useful work appeared in the early 17th century. Scaling up small designs helps a bit but runs into structural limitations with the materials involved.

Perpetual Motion Machine (TL3^). An overbalanced wheel perpetual motion machine providing ST 5 is five feet in diameter, costs $17,250, and weighs 500 lbs. One supplying ST 10 (the largest possible with low-tech materials) is 20 feet in diameter, costs $276,000, and weighs four tons. At TL 4^, the 5-foot machine provides ST 10 and the 20-foot machine yields ST 20.

Unconventional Forces

Although most work in antiquity was carried out by a few time-honored sources of power, there may have been experiments with forces that weren't truly harnessed until later, or don't actually exist.

Electrical Batteries

Archaeologists working near Baghdad in the 1930s came across a set of peculiar clay jars, dating to the third to seventh centuries A.D. Asphalt stoppers sealed the jars. Each stopper had embedded in it a hollow sheet-copper cylinder surrounding an iron rod with a small gap between them. This design strongly resembles a wet-cell battery. This observation was further bolstered by chemical analysis of the pottery indicating that the vessels had once held an acidic substance. If the ends of a wire were connected to the copper cylinder and the iron rod while the jar was filled with the mildly acid electrolyte (vinegar or even fruit juices are sufficient for this purpose), this would create a circuit through which electricity would flow.

The use of the Baghdad battery, if that's what it was, remained a mystery. After all, just what does one do with low power direct current at the end of Classical antiquity? Even without electric motors or communication equipment, there are several possibilities.

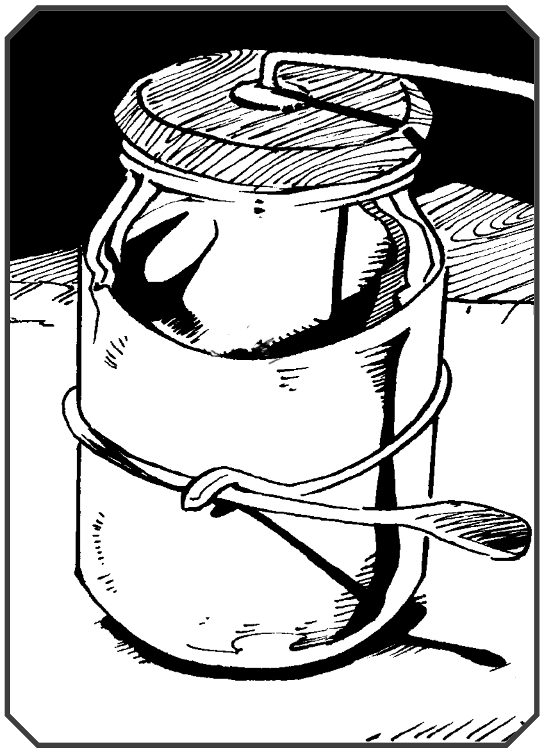
Electroplating. With the right chemicals, plating other metals with copper or gold would be well within the reach of low-powered batteries. The process would simply need time and a number of batteries, not a high voltage. This would have allowed the battery's users to create attractive gilded or copper-plated objects much more cheaply and easily than with elaborately prepared and applied metal leaf. Though it might seem far-fetched that a technology relying so heavily on the existence of direct current could arise along with the invention of the battery, it's worth noting that electroplating techniques were discovered within five years of Alessandro Volta's invention of the battery in 1800.

Etching. Etching is essentially electroplating in reverse. A metal plate is coated with wax or varnish and a design is scratched into the surface. When the plate is placed in an electrolyte bath and hooked up to a current, areas of bare metal are eaten away, producing a shallow relief. This could be used purely decoratively or as the basis of durable printing plates.

Light. A large bank of batteries, wired together in series, might power an electrical arc across the gap between carbon electrodes. High-quality charcoal would suffice, and it might be treated with metallic salts to produce different colors of light. At the dawn of TL3, this artificial lightning would have been very impressive, particularly in the darkened interior of a temple, since it required no kindling or other effort to start, and would have produced a surprisingly bright light like a tiny bolt of lightning. This application of electricity is another one that historically appeared a few years after the arrival of electrical batteries.

Healing. Low-power electrical current has been used to help relieve some kinds of chronic pain. In a temple or doctor's office, batteries might be used as a treatment, running the current through the afflicted body part by attaching wires to it for several minutes. Using a battery, a physician skilled in its use (some varieties of Esoteric Medicine may allow this) may roll against his skill to reduce the level of pain suffered by a character with the Chronic Pain disadvantage for a day.

Divine Presence. Even a very low current, if run through a metal cult image or wired touch-points on an altar, could provide small electrical shocks or peculiar tingling feelings with no indication of where they came from. It would be very easy to believe that the sensation was one of direct contact with the divine.



Ultimately, an electrical use was discredited. The asphalt stopper *completely* insulates the metal components, leaving no connection points for wires, but such a near-miss device is too intriguing to ignore. A functional battery along these lines is a TL(3+2) device. It provides 0.4 volts for six hours. Since it takes four jars to equal the power of a modern AA battery (treat as a XS battery; see ***GURPS High-Tech***, p. 13), several must be wired together in series to provide significant power. $80, 1.5 lb. for a battery of jars.

Magnets

Magnetism was known to the ancients, employed as early as the fourth century B.C. Though magnets' ability to find north and south was known, their early use was as a curiosity. It wasn't until the Middle Ages that natural magnets and magnetized bits of metal were applied to direction finding on a wide scale.

The use of magnetism depended on natural magnets. Very weak magnets could be produced by hammering iron under the right circumstances, but without electricity to help the process along, lodestones were, for all practical purposes, the source of all magnetism. Lodestones were rare and nigh miraculous, and therefore very valuable.

However, the ancients were clever enough to realize the possible uses of strong magnets. A medieval romance attributes to Queen Dido of Carthage the idea of using magnets as a defense. Powerful magnets in the walls protected Carthage, the story claims. Armed men passing too close would be pulled against the wall, unable to escape with their weapons and armor.

Defensive Magnets (TL2^). A set of magnets is rated for its ST at a distance of one yard. The effective ST of the magnets is reduced by distance: Divide the ST by square of distance in yards. Anyone carrying at least 1 lb. of iron or steel must roll a Quick Contest of ST against the magnets each turn he tries to move away from them. If he loses the Contest, he may not move any farther away from the magnet than he currently is. A battery of magnets with ST 1 is $1,000, 10 lbs. For other sizes, multiply cost and weight by the desired ST *squared.*

Pyramid Power

One of the recurring questions about Egypt's pyramids is why they were built. Certainly, they seem to function as royal tombs, but is that the sole reason for designing immense structures that must have consumed a huge portion of the royal budget? This question has led some to seek other answers.

One possibility is that pyramids serve a more utilitarian function. Some believe that pyramids focus cosmic energies that may be harnessed for specific purposes. The GM may decide that pyramids give some of these benefits, all of which are TL1^.

Preservation. One of the great concerns of dying pharaohs was that their bodies would be maintained in good condition for the afterlife. A power ascribed to pyramids is the ability to preserve organic material. If properly prepared, such materials can last indefinitely. A pyramid may have a small chamber at its center where its preservative energies are focused. When perishable items are placed in the chamber, roll against the Housekeeping skill of the person who prepared them for storage. If the roll succeeds, they do not suffer any decay for the next day. On a second roll, they do not suffer from decay for a week thereafter. On a third, they do not decay for the next month, for the next year on a fourth, the next decade on a fifth. Roll once per century thereafter, if it becomes applicable.

Life Energy. Related to the preservative powers of pyramids is their ability to enhance life energy, resulting in longer life and better overall health. Meditating regularly (at least an hour every other day) within a pyramid grants +1 to HT rolls to resist aging and disease, and to recover from wounds. This bonus is cumulative with benefits of medical care.

Equipment Maintenance. In a properly aligned pyramid, blades sharpen themselves and mechanical equipment remains in good condition. If kept in a pyramid for a day, any metal blade gets an additional +1 damage on its first hit. Metal items in general will not corrode if stored in a pyramid.

Energy. Pyramids are believed by some to have generated not just nebulous "life energy," but more clearly demonstrable electrical power. A stone pyramid properly fitted with a network of metal decorations acts as one VL battery (see ***GURPS High-Tech***, p. 13) per ton of weight.

A basic pyramid is approximately 20' tall and covers 1,000 square feet (about 31.5' on a side). Made of stone, it weighs 500 tons and costs $9,100,000. For a pyramid of a different size, select a ground area. A pyramid's volume is (ground area) × height/3, but for preservation, maintenance, and life-energy effects, energy is focused into a chamber 10% of that size. Double price for electricity-generating pyramids.

Sound Levitation

From Stonehenge to the pyramids of Egypt to Easter Island, many ancient societies managed to erect monuments composed of huge blocks of stone, quarried from deep quarry pits, carried across miles to building sites, and put up to sometimes enormous heights. Some believe this was all done without cranes or other powered mechanical lifting devices. How was it accomplished?

One suggestion is that lost technology could levitate heavy objects. The Egyptians, for example, are suspected of being able to use sound vibrations, produced by giant horns, to lift heavy blocks into the air so that they could be floated to their destination. Sound levitation requires at least two people to set up fields of resonance, though many more can participate. The musicians must arrange themselves within 10 yards of the object they wish to levitate and play, building up resonances for two minutes. When they have done so, they may move the object as though they had ST equal to their combined Musical Instrument skills at -5 each (for example, six musicians with Musical Instrument-15 would lift an item with an effective ST of 60). Living creatures maybe levitated, but they must remain stationary among the musicians as they build up resonance. Levitating with a musical instrument may be treated as a Hard technique defaulting to Musical Instrument-5, with a maximum equal to Musical Instrument skill.

Levitating Instrument (TL1^). Levitating requires specially built instruments. Enormous horns are most common, but gongs, flutes, and tuned drums have been used. $800, 2 lbs.

Computers

Several descriptions have been passed down of Greco-Roman devices that some have called "computers." This is technically true but in practical terms an exaggeration. Complex geared devices like the Antikythera mechanism (the remains of an ancient Greek orrery) were constructed to represent the motions of celestial bodies. They can be said to "compute" in exactly the same way a clock computes: If the little hand is halfway between the one and the two, the big hand must be on the six. In short, they provide specific, limited functions. They lack programmability.

Mostly. If a clock is a computer, the earliest programmable computer was created at the beginning of the 13th century. Abu al-Iz al-Jazari, a Mesopotamian engineer influenced by Archimedes, constructed a large (over 10 feet tall) water-driven clock with a number of innovative features. In addition to elaborate displays for the time, date, and position of the zodiac and a band of mechanical musicians playing at appropriate intervals, the clock could be adjusted for the change of daylight and nighttime hours through the year.

Mathematical calculating machines date somewhat later. Leonardo da Vinci, predictably, sketched out the design of an adding machine in the late 15th century, though it wasn't until over a century later that such machines were demonstrably built.

The lack of earlier calculating machines is likely a question of interest in the application rather than lack of technical capability. Machines for doing simple arithmetic would have been well within reach of far earlier societies. After all, a clock with multiple time displays (for example, for hours and days) is performing addition. The difference is a question of display rather than core function. Just as the widespread use of water power was delayed for centuries after its invention by the availability of inexpensive human and animal labor, the appearance of calculating machines may have been delayed by the availability of humans with abaci, who could do the same sort of arithmetic much more cheaply. Some sort of purely mathematical machine could easily have been built as early as the Roman Republic had someone wanted to impose mechanical precision on arithmetic.

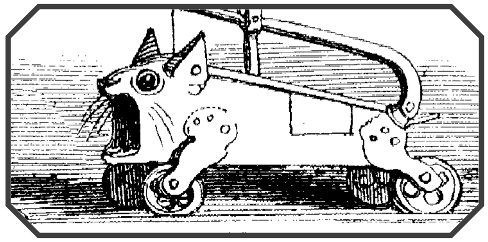
Classical Analog Computer (TL2+3). Although this device is not complex enough to run software as it is usually understood, it can solve complex mathematical expressions through sophisticated processes of addition and subtraction like the Babbage difference engine. Provides a +2 to Mathematics skill. $750,000, 40 tons.

Castle Clock (TL3). The versatile timekeeping equipment gives +2 to Astronomy skill and +2 to any Mathematics roll associated with timekeeping. $1.1 million, 17.5 tons.

Renaissance Calculator (TL4). A small adding machine operated by turning dials to set values and operations and pulling a lever to actually perform functions. The primary difference between this device and its predecessors is size. Fitting easily on a desktop or in a pouch, it's a piece of equipment, not architecture. Gives +1 to Mathematics skill. $2,000, 5 lbs.

Automata

Greek myths are filled with glancing mentions of a variety of automated devices, such as self-propelled furniture and fully sentient androids. Later histories hold stories of self-powered equipment ranging from the fanciful but simple, such as self-opening doors, to the enormously complex, such as artificially created life.



Simple Automata

The idea of equipment that moved itself may go back to the Bronze Age, but by TL2, engineers actually created such items.

Automated Tripods (TL1^)

The result of exceptionally cunning artifice, these small three-legged tables respond to simple voice commands. They can go where directed with Move 5, but can't respond to anything other than simple instructions, the Bronze Age equivalent of a radio-controlled car. For example, a tripod could be told "go to the corner of the room" or "stay next to me," but not follow directions that take an if-then decision or more than a simple sentence to express. They also roll on small wheels, so they can't travel cross-country or up and down stairs. $22,500, 15 lbs.

Automated Doors (TL2)

At least as early as the later Roman empire, buildings could be equipped with doors that opened themselves once a mechanism was activated, often by pulling a lever or lighting a fire. They typically worked by a hidden hydraulic mechanism or occasionally by steam. An automated door mechanism costs $800, but it must be attached to a steam engine (see p. 23) or equivalent power source.

Moving Platforms (TL2)

A wooden platform, possibly carpeted or tiled, set on hidden wheels or lifts so that it can change position. A platform may be attached to a power source to move it around at a steady rate, typically a foot per second. Such platforms are used in theaters to wheel out scenery during performances or in temples to bring priests or cult images in and out of view. A power source such as a steam engine (p. 23) or waterwheel (see ***GURPS Low-Tech***) can move a platform and payload weighing up to BL×8. A platform that moves horizontally costs $95 and weighs 50 lbs. per square yard. Platforms that move vertically cost twice as much, but since they can be counterweighted effectively, their power source only needs to lift the weight of the payload.

Mechanical Androids

Naturally, both dreamers and engineers dabbled in automata in human and animal form.

Bronze Androids (TL1^)

Greek mythology contains a number of examples of autonomous, human-shaped constructs. They came in a variety of sizes from normal humans to giants, and they were exceptionally durable. The favorite combat tactic of Talos, the best known metal man, was to stand in a fire until he was red-hot, then grapple opponents, burning them to death. However, they had a significant vulnerability. A vital fluid provided their "life force," and draining it out could kill them.

Rather than equipment, a Classical android may be treated as a character with a modified form of Body of Metal (p. B262). An android has a vulnerable plug holding in its vital fluid. Attacking the plug has the same effect as an attack to the brain, even though it may not be in the head. For example, Talos' plug was in his heel. It costs 170 points to be a bronze android.

Automated Mannequins (TL3)

Devices that were essentially powered dolls were found through the Middle Ages and Renaissance. Typically powered by steam or water, mannequins could be built to emulate many natural gestures: sitting and standing, playing a musical instrument, dance steps, and so on. A mannequin need not be human-shaped, though. Other automata have included mechanical lions and trees full of mechanical birds. A human-sized mannequin, typically made from painted wood, cloth, and (in appropriate settings) papier-mâché, with internal cables and gears, must be powered by a power source producing the equivalent of ST 5. It weighs 50-100 lbs. and costs $1,500 plus $500 for each motion it can perform (for example, a single dance step, waving a greeting, bowing, etc.).

Biological Constructs

Medieval Muslim alchemists experimented with creating biological life. They used alchemical techniques to harness the principle, widely held at the time, of spontaneous generation. This idea, put forward as far back as the third century B.C., held that living organisms could arise spontaneously from the proper environmental conditions. For example, mice were believed to arise from bales of straw, while maggots naturally came from rotting meat. If one could control the environment correctly, one could create life to specification.

To attempt the creation of life, an "engineer" must obtain materials weighing at least 100 times as much as a member of the species he is trying to make (minimum 1 lb.) at a cost of at least $2/lb. Rare animals, obviously, arise from unusual conditions, so appropriate materials for, say, sables or Bengal tigers are much less common and more expensive. He must then wait for one week per 10 lbs. of weight of the animal in question and roll against Spontaneous Generation, a new specialization of Bioengineering available at TL1^. On a success, 1d infant creatures are generated.

There's also a belief in some circles that early human civilizations practiced genetic engineering. These appear to have been accelerated attempts at selective breeding combined with daring addition of traits from other species. Rather than producing useful but unspectacular organisms like drought-resistant crops or domestic animals resistant to disease, the primary use of the technology was altering strains of humanity, attempting to create specialized servant, warrior, or "super" races, often with undesirable results.

This kind of genetic engineering is a TL1^ technology. It produces results more quickly than traditional selective-breeding methods. It had a certain brutal effectiveness, but often with undesirable side effects. A genetic engineering program may select a desired trait (for example, increased average ST, an innate skill, etc.) and breed a population to gain that trait. In each generation, the breeding group gains one point toward the trait. However, they also gain a point toward a disadvantage, chosen by the GM and kept secret. With each generation, the engineers may roll against Bioengineering (Genetic Engineering) skill. On a success, the population gets another point toward the desired trait, or two points on a critical success. On a failure, the population receives another *two* points toward the secret disadvantage. They automatically gain the secret disadvantage on a critical failure, *and* the GM picks an additional disadvantage. The desired trait appears when the breeding population acquires the full value of the advantage; however, any disadvantages they have gained points toward appear simultaneously.

Chapter Four
Other Technologies

Antiquity saw a broad assortment of odd technologies and strange sciences, ranging from the discovery of peculiar materials through exotic disciplines like astrology and alchemy.

Unusual Materials

Historical records refer to many substances that are lost or may never have existed.

Azzalum

History alludes to a number of special metals. One of the most useful, mentioned as far back as Pliny the Elder (23-79 A.D.), is azzalum, also called Indian iron since it was believed to originate in India, though some later ascribed its origin to China. Perhaps inspired by samples of wootz (crucible steel, which would have been available just in time for a few specimens to make it to imperial Rome), this was alleged to be a remarkably strong type of iron. It was hard enough that tools made of azzalum could be used to cut other pieces of iron.

Items made from azzalum have +1 HT and +25% HP (round up). Armor made from azzalum gets +1 DR. Cutting and impaling weapons made from azzalum get +1 to damage and -1 to their chance of breaking if parrying a heavier weapon (see p. B376). These effects are *cumulative* with the item's quality where applicable. For example, a fine-quality azzalum sword gets +2 to damage and -2 to its breakage roll when parrying a heavy weapon. Azzalum items are TL2^ and have +5 CF.

Orichalcum

There are several differing historical accounts of a metal called orichalcum. ***GURPS Fantasy*** presents one interpretation of it as an unbreakable fantasy metal. Another interpretation is a strong but attractive alloy of copper, tin, and gold. It has the strength of bronze, but the color and shine of gold. Treat orichalcum versions of bronze items as decorated equipment with +3 CF. They may also be considered as being made from gold if golden items have any particular supernatural effects.

Bononian Stone

By at least the Renaissance, scholars were aware of a mineral (called by a variety of names including the *lapis phosphorus* or bononian stone) that glowed in the dark after exposure to light. This led some scholars to conclude that light was a substance that the stone soaked up like a sponge to emit later. The main controversy about the stone was whether it was natural or could be manufactured.

A thumb-sized stone will glow with the brightness of a candle flame for 10 minutes if exposed to bright light for an hour or more. It fades thereafter, with the glow disappearing after an hour. It can be used as a heatless, flameless, and even concealable source of light, but only briefly. Naturally occurring bononian stones are TL0^. If they can be created alchemically, synthetic stones are TL3^. A small lump the size of an ice cube is $400, negligible weight.

Flexible Glass

Transparent aluminum, one of the more famous fake inventions of the far future, comes with a surprising historical pedigree. Through history, craftsmen have claimed to invent flexible, or at least malleable, glass. The earliest account is of a Roman inventor who approached the emperor Tiberius with vessels made from what appeared to be glass. When struck, however, the material dented instead of shattering, and the inventor pounded it back into shape. The emperor was duly impressed. However, he had the inventor put to death because his invention could potentially render precious metals worthless and put any number of other craftsmen out of work, causing unrest and economic disaster.

Similar stories recur through Europe into the 17th century, with craftsmen creating malleable glass and being punished for it. Persian and Chinese craftsmen are said to have invented it as well, though they came off much better.

Such stories are sufficiently widespread that they may reflect a real substance, though its properties may be exaggerated. There is speculation that a difficult-to-produce compound containing silver might be vitrified but remain somewhat flexible. In practical terms, this would give the ancients something resembling plastic millennia before plastics were actually invented. Malleable glass vessels and windows would be as transparent and, potentially, as colorful as regular glass but not be Fragile (Brittle). Malleable glass is TL2^ and has +9 CF.

Aluminum

One interpretation of the story of malleable glass is that the substance in question wasn't glass at all. Rather, it was a lightweight, flexible metal: aluminum. It's difficult but possible to produce aluminum with low-tech techniques, so it's barely within the realm of the believable.

When aluminum was first produced historically in the middle of the 19th century, it was used much like silver, for jewelry, tableware, and similar applications, and that is likely to be the case if it were introduced in TL2. However, a clever smith might experiment with alloying it. Aluminum bronze is potentially quite strong for its weight. Aluminum bronze armor would have +2 CF and +1 DR .

Incombustible Oil

Certain sources attest to an "incombustible oil." This does not mean that the oil didn't burn. Rather, the oil flamed but was not consumed. Once lit, it burned indefinitely. One example cited by a Renaissance scholar had stayed lit for over 1,500 years in a Roman tomb and, after the tomb was opened in his own day, was only put out with great difficulty.

Incombustible oil may be used as a Molotov cocktail (p. B411). However, the fire will continue burning until completely smothered by a layer of earth or other solid material; it will not go out after 10d seconds, nor can it be extinguished with water or by beating it out by hand (p. B434). If used in a lamp, it will provide light until put out by completely smothering it with earth, sand, or other solid material. Incombustible oil is TL2^. A flask is 1 lb., $150.

Ninja Gear

Few groups are the subject of more historical mythology than ninja, making them the crowning glory of "ethnic cool." Unfortunately, many ninja myths are more about their mystical training and unbelievable martial-arts techniques than their physical technology, but they are nevertheless believed to have invented various bits of fantastic gear.

Explosive Caltrops (TL4^). Four-pointed spikes were loaded with explosives and a trigger mechanism. A small bag may be scattered over a one-yard area with successful DX roll. Others passing through the area get a Vision roll to spot and avoid them. When stepped on, they do they do thr-3 imp – based on the victim's ST – to one foot (roll randomly), *and* explode for 1d-1 cr ex damage. $180, 0.5 lb.

Ninja Suit (TL4^). This is the classic pitch black, head-to-toe garment with only a small slit in the hood for the eyes, but the fit is comfortable enough for free movement. The ninja suit provides a +2 to Camouflage and visual Stealth rolls in dark surroundings. It hides any distinctive features the wearer might have unless they're directly related to the eyes. Furthermore, it gives observers -2 to any IQ rolls to accurately remember details such as the wearer's height and weight unless the user has related physical traits such as extra limbs, Fat, or Gigantism. $120, 2 lbs.

Sword-Grappling Gloves (TL4^). One of the more impressive ninja tricks is a bare-handed sword catch . . . well, not *quite* bare-handed, if they can help it. The trick involves slapping the hands together around an incoming sword. Treat this as a Judo or Karate parry at -5. It requires both hands but grapples the sword if successful; if not, the attacker may choose to do damage to either hand or his original target. To assist in this trick, ninja wore gloves impregnated with a sort of sandpaper made from crushed shells. The additional friction helps stop the sword, reducing the penalty to -3. $70, 0.25 lb.

Water-Walking Shoes (TL4^). Large wooden disks with concentric rings connected to them. These shoes spread out the force of the wearer's weight and take advantage of the water's surface tension to keep him on the surface of the water if he moves quickly. These shoes allow the user to walk on any liquid, but he must move at least five yards per second and carry no more than Light encumbrance. If he does not, he sinks immediately. Water-walking is a bit of a trick, requiring a perk ("Can use water-walking shoes"), which is easily learned but seldom taught. $250, 3 lbs.

> *If you don't believe that ninjas have* ***real*** *Ultimate Power, you better get a life right now or they will chop your head off!!!*
>
> *– Robert Hamburger*

The Pseudosciences

Despite mystical overtones and invalid premises, the important pseudosciences of history involved extensive observation and a lot of hard, if fundamentally misguided, intellectual work. Moreover, as mystical as they might seem to us now, astrology and alchemy were sometimes historically regarded as soulless materialism, attributing people's fates to the influences of merely physical stars rather than divine guidance and proposing that immortality could come from chemical processes and physical treatments that could be reproduced by anyone regardless of their moral character. These are, essentially, what the ancients regarded as advanced science, and are as mundane, in their worldview, as crafts like pottery and blacksmithing.

Alchemy

Some alchemists claimed that their work was essentially symbolic. All the talk of transmuting substances and formulating elixirs with the philosopher's stone was just code for personal development and finding enlightenment and transcendence with the aid of a secret key of esoteric knowledge. Nevertheless, that's hardly useful. Besides, alchemists in many traditions were also known for deliberately obfuscating when they wrote things down, giving vague or symbolic descriptions to substances, properties, and instructions. Might not the spiritual dimension of alchemy itself be a double-blind, obscuring the valuable material aspects?

The *practical* object of alchemists was transforming substances into other – and generally "finer" or "purer" – substances, typically with beneficial effects. Raw minerals were transformed into precious metals, and a variety of substances were turned into an elixir of life. What might be called "inorganic" alchemy (a major preoccupation of Western alchemists) delved into transforming baser metals into nobler silver and gold. "Organic" alchemy (more popular in the East) was concerned with medical applications, most notably extending life. However, both varieties were practiced to some degree everywhere. These rules may be used to reflect this focused kind of "historical" alchemy rather than fantasy alchemy, which often acts as a spellcasting system dressed up in chemical garb.

Alchemy is a TL3^ technology. Though practiced in a rudimentary form late in TL2, alchemy didn't truly develop until the invention of heat distillation in TL3. This was an important breakthrough, giving the alchemist expanded ability to separate out desired materials from their admixtures.

The power and value of an alchemist's work depends on how much he refines his materials. Refinement is measured in degrees. An elixir at a second degree of refinement is more potent than one at the first degree, one at the third is more potent still, and so on. The initial creation of an elixir or attempt at transforming base materials consumes $100 worth of raw materials per dose of finished elixir or ounce of transformed metal. Attempts to refine a dose/ounce of metal to a further degree consume raw materials worth an additional $100 times the target degree squared. For example, an attempt to create a dose of a healing panacea from raw materials costs $100. An attempt to refine that dose to the second degree requires $\$100 \times 2^2 = \$400$ in additional raw materials. Similarly, it takes $\$100 \times 3^2 = \$900$ in additional material to refine a second-degree dose from second to third, $\$100 \times 4^2 = \$1,600$ of additional material to refine from third to fourth, and so on.

Refinement attempts also require a number of days of work equal to the desired degree of refinement and an Alchemy roll at a penalty equal to the degree of refinement. For example, making a fourth-degree refinement takes four days and is at -4 to Alchemy. However, special equipment and materials may further modify the roll. An alchemist may work on a number of doses/ounces equal to his Alchemy skill in a single batch.

Mundane vs. Magical

These rules represent an historical view of alchemy as a mundane, material science with limited, specific goals rather than a versatile magical technique. If magic works in the campaign, the GM may want to make Alchemy (Mundane) and Alchemy (Magical) separate specialties of the same skill. The former can't be used to make the magical elixirs presented in ***GURPS Magic,*** while the latter can't be used to make the elixirs listed here or to purify base substances.

Elixirs

These are products of attempts to create healing and immortality potions. Bonuses from multiple doses are not cumulative. However, the user enjoys the benefits of the most refined elixir he has consumed.

Healing Panacea. An elixir that can mend any wound. If administered to someone dying of mortal wounds, it negates the failed HT roll that got him there but doesn't immediately heal any wounds. It also grants a HT bonus equal to the degree of refinement to all daily healing rolls to recover from wounds the person has incurred at the moment he takes the elixir, to a maximum of +5 (+1 for the first degree, +2 for the second degree, etc.). Every degree of refinement after the fifth retains the +5 HT bonus but allows an additional healing roll per day (+5 to HT and two rolls for the sixth degree of refinement, +5 to HT and three rolls for the seventh, etc.).

Curative Panacea. An elixir that can cure any disease. It grants +1 HT per degree of refinement for resisting and recuperating from disease. After the fifth degree of refinement, the user may also roll against his modified HT to *immediately* recover from any diseases currently afflicting him.

Elixir of Life. This elixir grants +1 HT per degree of refinement for the purposes of resisting aging for the year, to a maximum of +5. Every degree of refinement beyond the fifth also reduces the imbiber's physical age by one year, to a minimum of 20 years old. The user regains any attribute points lost to aging.

If alchemy is the norm for a setting, the *Elixir Cost Table* (p. 30) may be used to determine the price of an elixir based on its degree of refinement.

Elixir Cost Table

Degree	Cost	Degree	Cost
1	$105	6	$15,015
2	$520	7	$24,060
3	$1,460	8	$35,480
4	$3,145	9	$48,600
5	$5,815	10	$68,620

Note that even in societies that have functional alchemy, elixirs beyond the fourth level of refinement are uncommon, and those beyond the seventh are, like very fine-quality weapons, so vanishingly rare as to be the subject of legendary quests.

Transmutation

Transformation of lead into gold is shorthand for a long process of slowly improving raw materials. Transmutation may be handled as refining an elixir, with certain metals being the product of different stages of transformation. Lead and tin count as being at the first degree of refinement, iron at the third, copper at the fifth, silver at the eighth, and gold at the tenth. An alchemist could start with lead and work through nine more stages of refinement to get gold, or start with silver and go through just two. Other degrees of refinement aren't metals; they're intermediate compounds that may be further refined to produce purer metals.

Tools and Materials

An alchemist might be aided by some legendary, perhaps even mythical substances, the search for which could be a life's work in its own. Unless otherwise noted, these items aren't normally commercially available.

Alchemical Laboratory. Chemically resistant containers and vessels, distillation chambers, sand and water baths, mortars, tongs, and scales. Anything less counts as improvised equipment. Unlike other items in this section, alchemical tools may be purchased or easily made by an alchemist or his assistants. $175, 25 lbs.

Alkahest. The "universal solvent," capable of breaking down any substance into its component parts. A "dose," about an ounce, grants +2 to any Alchemy roll, and if splashed on a target, does twice the damage of normal acid (p. B428). A dose of alkahest costs at least $3,000.

Philosophical Mercury. This isn't what the average person would recognize as mercury, though mercury is a component. Rather, it's an "idealized" refinement of mercury. A "dose" grants a +3 to any Alchemy roll, and it is required for any degree of refinement beyond the fifth, in addition to other material costs. A dose of philosophical mercury costs at least $5,000.

Philosopher's Stone. This is a substance rather than a particular object. It functions as the ultimate alchemical catalyst. It is possible to refine philosopher's stone from other materials, though it is also naturally occurring. It grants +5 to any Alchemy roll, and is required for the tenth level of refinement (in addition to other material costs); it may also be used in place of philosophical mercury for lesser levels of refinement. A dose of the philosopher's stone costs at least $10,000.

Astrology

Many societies looked to the stars and designed elaborate mathematical schemes to determine men's fates. However, with inconsistent timekeeping, instruments of questionable accuracy, and the surprise appearance of novel celestial bodies like comets, low-tech astrology was still very much an observational discipline.

The primary day-to-day use of astrology was to figure out auspicious times at which to undertake important activities, such as performing weddings, formalizing business partnerships, celebrating coronations, and starting long journeys. If the stars are an active force on people's fortunes, a wise man consults an astrologer just as modern people might consult a weather forecast to make sure it won't be snowing on the day of an open-air celebration. An astrologer must first work up a horoscope on any person he might investigate, figuring out a "baseline" of celestial influences. Ideally, the astronomer is provided with the time of the subject's birth to the minute and the location of the subject's birth to within a mile. *All* Astrology rolls for that subject are penalized for imprecise or inaccurate information. For time, the astrologer is at -1 if birth time is known only within the hour, -2 if known within a day, -5 if known within a week, and -10 if known within two weeks; an astrologer may not prepare a horoscope for a subject with a less precise birth date. He is also at -1 if place of birth is known only within 50 miles, -2 within 100 miles, -3 within 200 miles, -4 within 400 miles, or -5 for a greater distance. Creating a horoscope requires a day of effort with access to appropriate tools and references and a roll against Fortune-Telling (Astrology).

After working up a horoscope, an astrologer can determine lucky and unlucky times. Each attempt to find such times takes a night of astronomical observations and a day of research and computation. Deducing a day that is guaranteed *not* to be unlucky within the next month requires an unmodified Fortune-Telling (Astrology) roll. If the subject of the horoscope starts a significant undertaking on such a day suffers no good or ill effects from cosmic influences.

I don't believe in astrology. I'm a Sagittarius, and we're skeptical.

– Arthur C. Clarke

Ascertaining times that are more auspicious is much more difficult. Discovering a very lucky hour within the next month is at -5, and finding an extremely lucky minute in that time frame is at -10. The roll is at +1 for every doubling of the span of time examined: +1 to figure out a lucky time in two months, +2 for determining a lucky time within four months, and so on. All rolls to find very or extremely lucky times have maximum effective skill of 18, and repeated attempts for any given time period are at cumulative -1 per attempt. If the horoscope's subject starts a significant undertaking during a very lucky hour, he may reroll a single die roll, as per the Luck advantage, during the performance of that task. However, it must be directly related to the task at hand. For example, a general who goes off to war during a lucky hour may reroll his Strategy skill in a battle, but not Gambling during a game of dice on the way there. Someone starting a task during an extremely lucky minute may be treated as having the Luck advantage during the entire task, but he's still limited to rolls directly related to that task.

Enforcing Astrology

Should the GM want PCs to visit astrologers and other fortune-tellers, a common practice in historical societies, use this optional rule: Those who don't pay attention to their horoscopes are likely to meet with misfortune. Roll 3d when undertaking a significant new task. On a 15 or less, they happen to be starting at a time that isn't particularly lucky or unlucky. On a 16 or 17, they've hit a very unlucky hour, and on an 18, they've hit an extremely unlucky minute.

An astrologer can also look for very unlucky and extremely unlucky times using similar rules for revealing lucky times: -5 to find a very unlucky hour or -10 to identify an extremely unlucky minute within the next month, at +1 for every doubling of time. Starting a significant undertaking during a very unlucky hour subjects the victim to a single arbitrary failure per the Unluckiness disadvantage at some point during the task. However, the failure will only happen with something directly related to it (for example, that general might fall off of his horse and break his arm during the battle but be entirely successful at gambling the night before). Starting during an extremely unlucky minute mean the subject suffers from Unluckiness for the entire task.

Benefits and penalties from astrology are in addition to those provided by Luck and Unluckiness. A lucky person who starts a task during an extremely lucky minute essentially has two independent versions of Luck, and is going to have a *very* easy time of things.

Astrological Tools (TL3). A set of tools for astronomical observation, including an astrolabe, quadrant, hourglass, and a set of basic reference texts. $600, 12 lbs.

Esoteric Medicine

More than anything else, medicine has blurred the distinction between science and magic. Principles of first aid and treating immediate trauma have remained similar though time and across cultures: Stop bleeding, cover the wound with something to prevent contamination, immobilize broken limbs. Methods may differ in detail (for example, a wide range of plasters, poultices, and other preparations might be used for wound coverings), but the basic theory is generally sound, so Esoteric Medicine can at least operate as First Aid skill.

Methods for ensuring long-term health and fighting disease, however, were much more varied and were based on a range of premises modern people would regard as semi-mystical at best – managing invisible elements or energy flows. Until the 19th century, Western medicine was based on balancing four "humors," regulating the proportions of the bodily fluids blood, phlegm, and black and yellow bile, each of which was identified to varying degrees with the four elements (earth, air, fire, and water). Indian medicine balanced breath, bile, and phlegm, while Chinese medicine worked with breath, blood, a "kidney essence," and other bodily fluids, all of which were composed of a number of elements and complex energetic principles. All of these were subject to influences ranging from the circumstances of the patient's birth through diet and environment to the malevolent influence of evil stars and unfriendly spirits. An esoteric physician's practice, therefore, can span surgery and demonic exorcisms. If the GM decides that balancing humors or unblocking the flow of chi can heal people, these rules may be used to reflect the practice of esoteric medicine.

"Doctors" with the Esoteric Medicine skill can perform a number of healing and supportive functions. A patient who receives at least weekly treatments from a doctor with Esoteric Medicine at 12+ gains +1 HT against aging rolls (see p. B444). A patient who receives weekly treatments also gets +1 HT to avoid coming down with an infectious disease if exposed (p. B443). Patients who get *daily* treatments get +1 to daily rolls to recover from wounds (p. B424-425) and cyclic disease resistance rolls (p. B443). No skill roll is required for the doctor, as with the Physician skill. Doctors with Esoteric Medicine can also make daily skill rolls to help injured patients recover additional HP, similar to a practitioner with Physician.

However, patients treated by doctors with Esoteric Medicine may be subject to a range of therapies ranging from the unusual to the downright arduous. A healer with Esoteric Medicine might use any of these techniques:

Bleeding. The physician uses leeches or knives to let some of the patient's excess blood. Does 1d-4 points of injury (treat results less than zero as zero) and 1d-3 points of fatigue (minimum 1), which cannot be recovered until after the patient's next meal.

Burning. The physician burns medicinal herbs on the patient's skin, or in cups pressed against the skin. This does 1d-4 points of injury. The patient must also roll against HT; on a failure, he is suffers from Moderate Pain (p. B428) for the rest of the day.

Diet. Large swathes of many historical medical traditions concerned adjusting the patient's diet. Under normal conditions, this means that the patient's cost of living is increased by 10% to pay for slightly unusual foods until the current illness is cured or wounds are healed. However, in wilderness conditions, gatherers with Naturalist skill may be required to find appropriate foods.

Environmental Therapy. The physician doesn't directly treat the patient. Rather, he adjusts the patient's environment.

For example, some Arab physicians presented certain colors to their patients and had them avoid others, believing that they had a healthy "warming" or "cooling" effect. Likewise, Chinese physicians might use principles of feng shui to give the patient healthier surroundings. The patient doesn't have to do anything nor have anything done directly to him, but he must spend at least half the day and all night in a fairly small area, no larger than a mid-sized garden or large living room.

Exercises. The doctor prescribes a series of special exercises to the patient. These may be entirely physical (for example, doing t'ai chi) or partly mental (chanting prayers while kneeling and standing, or doing yoga while repeating mantras). The patient must devote at least two hours per day to his exercises.

Herbal Medicine. The doctor prepares a custom compound that may contain herbs, obscure animal parts, and minerals. The patient must take at least one dose daily. Though ultimately beneficial, it may be unpleasant in the short term. The patient rolls against HT to avoid side effects. On a failure, roll 1d. A roll of 1-2 means Moderate Pain (see p. B428) for the rest of the day, 3-4 means mild nausea (see p. B428), and 5-6 means mild itching.

Poulticing. The physician prepares a medicinal compound that is placed on the afflicted body part. The patient suffers no side effects, but a poultice must remain in place for a total of at least eight hours a day to allow the physician his healing roll. Acupuncture may be treated the same way; it has no ill effects, but the patient has to lie still for a long time.

Purging. The physician administers a preparation that makes the patient vomit. Costs 1d-4 FP. The patient must also roll against HT; on a failure, he is mildly nauseated (see p. B428) for the rest of the day.

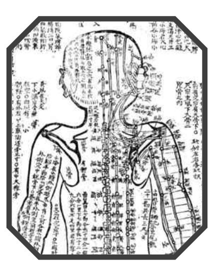
Astrology and Medicine

In order to diagnose a patient's disorders and prescribe remedies, practitioners of Esoteric Medicine examine not just his symptoms and bodily functions, but his place in the universe. A patient's horoscope contains important information about his underlying nature, giving the doctor clues about what internal balances he should work toward.

A practitioner of Esoteric Medicine may consult with an astrologer (or do the work himself) to have a horoscope drawn up and discover favorable influences. A successful roll against Fortune-Telling (Astrology) skill gives the doctor +2 to Esoteric Medicine rolls for the subject for a week. On a critical failure, he gets -2 to skill for a week.

For each week a patient is cared for, roll 3d on the following table to determine the kind of treatment the doctor prescribes.

Roll	***Treatment***
3-6	Bleeding
7-8	Burning
9-10	Diet
11	Environmental Therapy
12	Exercises
13-14	Herbal Medicine
15	Poulticing
16-18	Purging



Medical Gear

Ancient medical practice produced some unusual tools.

Esoteric Medical Kit (TL1). A set of basic tools and references for doing esoteric medicine. Each tradition of esoteric medicine includes its own particular set of instruments. For example, a Chinese kit might have moxa-burning cups and a sheaf of acupuncture needles, while a European one might have tools for bleeding and cauterizing. Most come with an assortment of medical herbs and charts of bodily functions or astrological signs. Someone trained in one medical tradition generally may not gain benefit from kits designed for another tradition. $150, 6 lbs.

Anti-Miasmal Gear (TL3). A common belief in medieval Europe was that some diseases (notably malaria but also any number of plagues) were caused by tainted air. Doctors developed protective clothing, a primitive version of an NBC kit, to protect themselves as they went about treating patients. This consisted of goggle-like eyepieces and a suit of waterproofed leather clothing, including a neck-to-toe coat, a broad hat, and a full-head mask with a long beak (filled with aromatic herbs and other substances). The outfit prevented contact with bad air, while the beak, like a modern gas mask, filtered air coming in. If diseases are transmitted by unhealthy air, the outfit gives +6 HT to resist contracting them. Even if they aren't, the heavy protection may give the wearer smaller bonuses for preventing direct contact with the infected and bodily fluids carrying contagion. The suit also provides DR 1, but the mask restricts vision as a greathelm (p. B284). $400, 21 lbs.

Bezoar (TL3). A hard object sometimes found in animal and human intestines, mostly composed of compacted hair. They were frequently mistaken for stones, and some did have mineral components from swallowed dirt and sand. Bezoars were believed to provide protection against poisons. If a bezoar is placed in a serving vessel, it provides anyone eating from the dish +3 HT to resist any poison that might be in the food. A bezoar may also be swallowed, giving +6 HT to recover from any poison already consumed or resist any poisons ingested in the last eight hours. $2,000, 0.1 lb.

Porcelain (TL3). Porcelain (which, as far as the common person is concerned, is made by combining gypsum, eggs, and ground lobster shells, and letting it sit buried underground for several decades) has a reputation for resisting poison, though the precise mechanism by which it operates is in dispute.

Some sources indicate that porcelain shatters if poison is poured into it. If this is the case, have porcelain vessels take damage from poison just as a living being would. Porcelain is Fragile (Brittle), so a toxin doing significant damage will break almost immediately.

Others suggest that poisons are weakened when consumed from porcelain vessels. If this is the case, partaking of poisoned food or drink from a porcelain container gives +3 HT to resist the toxin.

A porcelain cup or small plate is at least $25, 0.5 lbs. However, since the making of porcelain was a well-kept secret through most of history (China was the world's sole source of porcelain until the dawn of TL5), it was literally worth its weight in gold in some societies ($10,000 for a cup or small plate).

Miscellaneous Inventions

Some items, interesting though they are, don't fit well into any other category.

Floral Clock (TL4)

First proposed in the 17th century, a floral clock takes advantage of the fact that certain flowers, such as morning glories and jasmines, open and close at predictable times. By bedding such plants together, an observer can tell the time by seeing which flowers are open and which are closed. Though subject to disturbance by poor weather and changing seasons (which might be overcome by cultivating the clock in a greenhouse), a floral clock has advantages over contemporary timekeeping devices. Unlike a sundial and its sister instrument the nocturnal, a floral clock can provide time for both day and night without switching instruments or – in the case of the nocturnal, properly aligning it with the stars – and it can be read in overcast conditions. Unlike a mechanical clock, it does not need daily (or even more frequent) rewinding, refilling, or other adjustments to keep it going. It just requires periodic maintenance by a gardener. It's also about as accurate as any contemporary timepieces.

Assuming the flowers are bedded in the order in which they bloom, anyone can read the time to within an hour. A successful roll against Gardening or Naturalist skill lets the observer tell the time to within 15 minutes. An "obfuscated" floral clock doesn't separate the flowers into synchronized beds. Rather, it arranges flowers according to some other pattern that the designer finds pleasing. Such a clock requires a roll against Gardening or Naturalist at +5 to tell the time to within an hour and an additional unmodified roll to tell within 15 minutes. However, someone without either skill can be taught how to read it with sufficient time; treat as a perk.

A floral clock costs $95 per square yard and requires 10 minutes of maintenance by a gardener per square yard per week. Though historical floral clocks are stationary, a portable one could be made by filling a large, flat box with soil and plants. $140, 500 lbs. per square yard.

Grappling Catapult (TL4)

One of il Taccola's (p. 8) sketches illustrates a novel method for grappling the tops of walls: A standard torsion catapult is equipped with a many-pronged grapnel attached to a chain or heavy rope. This can hurl a much heavier grapnel and vastly sturdier line much farther than any human. It could also be used to seize wooden superstructures attached to stone walls, a common feature of medieval and Renaissance warfare. Once firmly grappled, traction animals or, better yet, stationary capstans could be used to attempt to rip them open or pull them off the walls altogether. Any scorpion or torsion catapult may fire a grappling hook and line instead of a bolt. Both 1/2D and Max ranges are quartered, and if anything happens to be hit by the hook, damage is halved *and* cr rather than imp. The hook trails 3/4-inch rope (see p. B288), which may be used to support climbers or to try to pull down lightweight fortifications. A catapult-mountable grappling hook is $100, 8 lbs. and hold up to 1,200 lbs.

Horse Cannon (TL4)

A century before Leonardo da Vinci tried to invent the tank, il Taccola had a go at inventing mobile artillery. He designed a saddle with additional horns extending to the sides of the horse, in front of and behind the rider. The horns held a pair of small cannon, one on either side. Obviously, the extra weight would have made this impractical for long-distance travel, but it could have been used during battles to provide terrifying volley fire to soften up enemy defensive lines before cavalry charges. Horses exposed to gunfire may spook (see p. B396), and this definitely counts. The saddle itself costs $500 and weighs 35 lbs., *not* including weapons, and when loaded with weapons gives -1 to Riding skill. Any firearms weighing up to 30 lbs. may be mounted on the horns, but they must be mounted in pairs of matched weight.

There are more things in heaven and earth, Horatio, Than are dreamt of in your philosophy.

– William Shakespeare, ***Hamlet***

Spiral Elevator (TL4)

Since at least the time of Archimedes, it was known that a screw could turn rotary into linear motion. This effect was used throughout the Old World to pump water out of mines or from canals into fields for irrigation. During the Renaissance, an engineer realized that the principle could be used for solid loads. Designed to lift a tender up and down a pigeon loft, this "elevator" was a post with a spiral groove up its height and a platform that could ride in the groove like a railroad track. Pulling the platform forward (by pulling a rope, turning a crank, or pushing on the wall of the platform) moved the platform around the post and up, while pushing the other way moved the platform back down; a counterweight reduced the work necessary to raise and lower the platform. The elevator could be operated by an occupant of the platform or other power sources (servants, draft animals, a nearby waterwheel, etc.) on the ground. Though designed for purely utilitarian purposes, it would be a majestic replacement for a staircase in a bishop's or nobleman's palace. $3,000 per 10 feet of lift.

Chapter Five
Early Arrivals

From the supposed-but-not-necessarily-real, we move to the could-have-been-real-but-wasn't. The prerequisites for some technologies were in place long before their eventual developments appeared. This chapter considers some of those technologies, when they could have arisen, and what the implications might have been.

Stirrups

Once you think of it, it seems to be the simplest idea in the world: Take a couple of loops of rope or leather with a bit of metal or wood to stiffen the bottom, and attach them to a saddle. It makes mounting easier and lets the rider stay in the saddle more firmly. Why did it take *thousands* of years of horsemanship to come up with this incredibly simple, useful aid?

Part of the reason is that the stirrup, while simple, isn't as obviously useful as it might seem. Until around the eighth century B.C., saddles were essentially glorified blankets, providing both rider and horse with a bit more comfortable padding than a bareback rider would have. Even after that, up to about the second century B.C., they were blankets with belts, which kept them attached to the horse instead of sometimes sliding off if the user dismounted too quickly. Adding stirrups to such a saddle concentrates the rider's weight along a very narrow line across the horse's spine, scraping off hair and even painfully abrading the skin. A stirrup-like development (a loop of rope large enough for a toe) appeared in India during the first millennium B.C., but it was probably used purely as an aid for mounting rather than a device used to bear the rider's weight while mounted.

The crucial breakthrough was the saddletree, a solid wooden core upholstered for the rider. The saddletree distributes the rider's weight more broadly than a blanket alone, which is far more comfortable for the horse. Moreover, attaching stirrups to a rigid core rather than to a flexible blanket doesn't change the weight distribution significantly. Whether the rider sits firmly in the saddle or puts his weight on the stirrups, that weight is still distributed through the saddletree, so he can ride as desired without bothering his mount.

The path to the stirrup, then, is dependent on a particular saddle design. That design didn't exist historically until the late first millennium B.C., but it could have been invented somewhat earlier. For example, sedan chairs date back to late third or early second millennium B.C., roughly contemporary with the domestication of horses. Wealthy riders desiring a more comfortable seat might adapt the idea, placing a chair on horseback.

The impact of the stirrup is another question. The stirrup is popularly believed to have enabled the rise of the feudal system. With stirrups, so the idea goes, it became possible for horses to carry heavily armored riders (who would have fallen off or been unable to mount without stirrups) and for those riders to effectively use the shock of full-gallop charges with heavy lances. These new warriors, with their heavy armor and large warhorses, were vastly more expensive to maintain than footmen. They could no longer be maintained in or around a chieftain's or king's household. Instead, they had to be spread out over the landscape on domains large enough to support their considerable expenses. Hence, the invention of the stirrup led directly to knights in shining armor scattered over a bucolic landscape to live in small but picturesque castles.

Predictably, this common wisdom has been discredited, though it was once widely held among historians. The current view, based on better awareness of pre-stirrup cavalry and more closely dated examples, is that the introduction of the stirrup was mere coincidence. Indeed, the Byzantines used heavy cavalry extensively before the appearance of the stirrup, and the stirrup only became commonplace in Europe around the eighth century A.D., comfortably after the establishment of feudal practices.

However, a GM who wishes to represent previously imagined state of affairs may use these rules: Impacts are difficult to deal with without stirrups, and heavy armor makes it worse. First, a mounted warrior without stirrups must make a Riding roll to stay mounted if he hits a target with a blow doing more than thr+2 for a thrusting attack or sw+2 for a swinging attack. Second, *all* rolls to stay mounted without stirrups are at a penalty equal to the rider's encumbrance level.

> *We owe to the Middle Ages the two worst inventions of humanity: gunpowder and romantic love.*
>
> *– André Maurois*

Gunpowder

Gunpowder may not be as obvious as stirrups, but it's still simple. It requires three ingredients, two of which are easy to obtain. Charcoal is a common industrial fuel from TL1 onward and might have been produced even earlier. Sulfur can be obtained from natural sources such as volcanic hot springs, or it can be refined from a number of minerals. The questionable element is saltpeter.

Saltpeter may be mined from happily situated mineral deposits, but it was most often produced by a variety of smelly processes involving animal wastes. Highly motivated hunter-gatherers following large herbivores might be able to create it, but the task usually falls to more settled farmers who maintain herds of cattle. Saltpeter production is therefore possible as early as TL1. Indeed, a mixture of the appropriate ingredients appears to have been produced and used as a medicine in Mesopotamia by the second millennium B.C. It's just a question of someone mixing the necessary ingredients and exposing them to flame.

However, just having gunpowder doesn't mean having guns. Early gunpowder weapons would suffer the same problems with metallurgy as the first firearms of TL3, with high weights and bursting barrels. For ultra-low-tech firearms, take TL3 guns, double cost, and increase weight by 25% per TL below 3. For example, a TL1 version of the handgonne on p. B279 would cost $1,200 and weigh 22.5 lbs.

A related issue is that the kind of saltpeter refined by most low-tech societies absorbs water from the air, and damp powder doesn't go off. Before TL3, gunpowder requires daily Housekeeping rolls to ensure that it is properly sealed and doesn't dampen itself to the point of uselessness.

Germ Theory

Called by some the most important development in the history of medicine, germ theory holds that many diseases are caused by microorganisms that grow, reproduce, and infect people who come into contact with them. This idea was in contrast to the notion that diseases may arise from exposure to environmental conditions such as toxic air or spontaneously from purely internal conditions like pent-up sins or imbalanced humors.

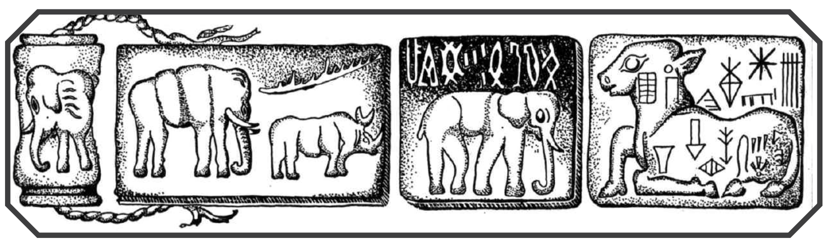
Germ theory focused prevention on matters of sanitation. Relatively simple measures such as effective sewage systems and the use of antiseptics on wounds and during surgery did a great deal to improve public health and individual survival.

Although this idea only became dominant in the 19th century, pioneers like Lister and Pasteur weren't the first to come up with it. The idea of invisible organisms causing disease goes back at least to the first century B.C. A Roman author writing on farming attributed the unhealthiness of swamps to tiny living things that, when inhaled, cause disease. Ironically, he was largely wrong about swamp-specific issues; malaria, the disease most associated with swamps, is a parasite spread by mosquitoes, not a disease caused by airborne microorganisms. Nonetheless, he did have the right idea about tiny living things. Some medieval Muslim physicians, working from the same idea, effectively employed quarantines to prevent the spread of disease. Clearly, germ theory, at least as it was understood in the middle of TL5, could have been invented at least as far back as TL2. Even if a physician doesn't understand that he's dealing with minute living organisms, he can make the observation that diseases are spread by a contagion or pollution that is a consequence of close proximity. Furthermore, since the idea of religious or spiritual pollution is employed even by some TL0 societies, it's not a huge stretch for someone to apply that idea to disease.

A society that develops the germ theory of disease before TL5 may be treated as one TL higher for the purposes of long-term recovery from injury and preventing communicable disease. It does *not* improve First-Aid skill, Diagnosis skill, or the immediate results of Surgery skill.

Literacy

Unlike, say, steel manufacture or steam power, which require a huge amount of technological sophistication to even begin contemplating, literacy, one of the great TL1 developments, isn't terribly hard to invent. Even technologically unsophisticated hunter-gatherers draw symbols that have specific meanings, though they don't maintain large mental catalogs of such symbols. Moreover, once the idea of using graphic symbols to represent ideas takes hold, within a couple of centuries, writing can go from a crude hieroglyphic accounting tool ("This mark means sheep, those seven dots mean you owe me seven of them.") to a phonetic system capable of encompassing an entire language ("The sheep of the seventh part shall in this contract be known as the sheep of the seventh part . . ."). The key issue in developing literacy appears to be motivation, which means that even a TL0 society might develop its own writing, or at least partial writing systems with limited uses, if they had sufficient reason to. However, these systems might not be quite what modern readers are used to.



Writing at TL1 was preceded by short-lived "proto-writing" systems at the dying end of TL0, the likes of which might arise among hunter-gatherers and very early agriculturists. These systems were incomplete. That is, they had a limited number of signs that could express specific objects or concepts (sheep, barley, the gods, etc.). Therefore, they only have sufficient vocabulary for certain purposes that their creators regard as important enough to make permanent records of. These might include describing geography in order to claim territory, invoking gods and spirits, or making notes on the weather or hunting conditions.

Texts among hunter-gatherers are also likely to be of a very different nature from historical books. Hunter-gatherers don't, as a rule, carry around much that isn't necessary to their survival, so books as modern people know them are unlikely. Writing would take the form of inscriptions. A few might be scratched into rock, but they would mostly be painted onto sheltered walls. There are countless examples of cave art and rock paintings from around the world that have lasted from hundreds to tens of thousands of years, so with proper placement, such writings would be, for all practical purposes, as good as set in stone. Portable objects may carry writing as well, such as invocations of good luck or notations about the object's owner or history. Prestigious artifacts traded in ceremonial gifting systems may acquire a long series of notations about their owners that could serve as a history of their movement over time and the rise and fall of primitive tribes.

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