



FARM, FORGE AND STEAM

A NUTS AND BOLTS GUIDE TO CIVILISATIONS

BY PHILLIP MCGREGOR



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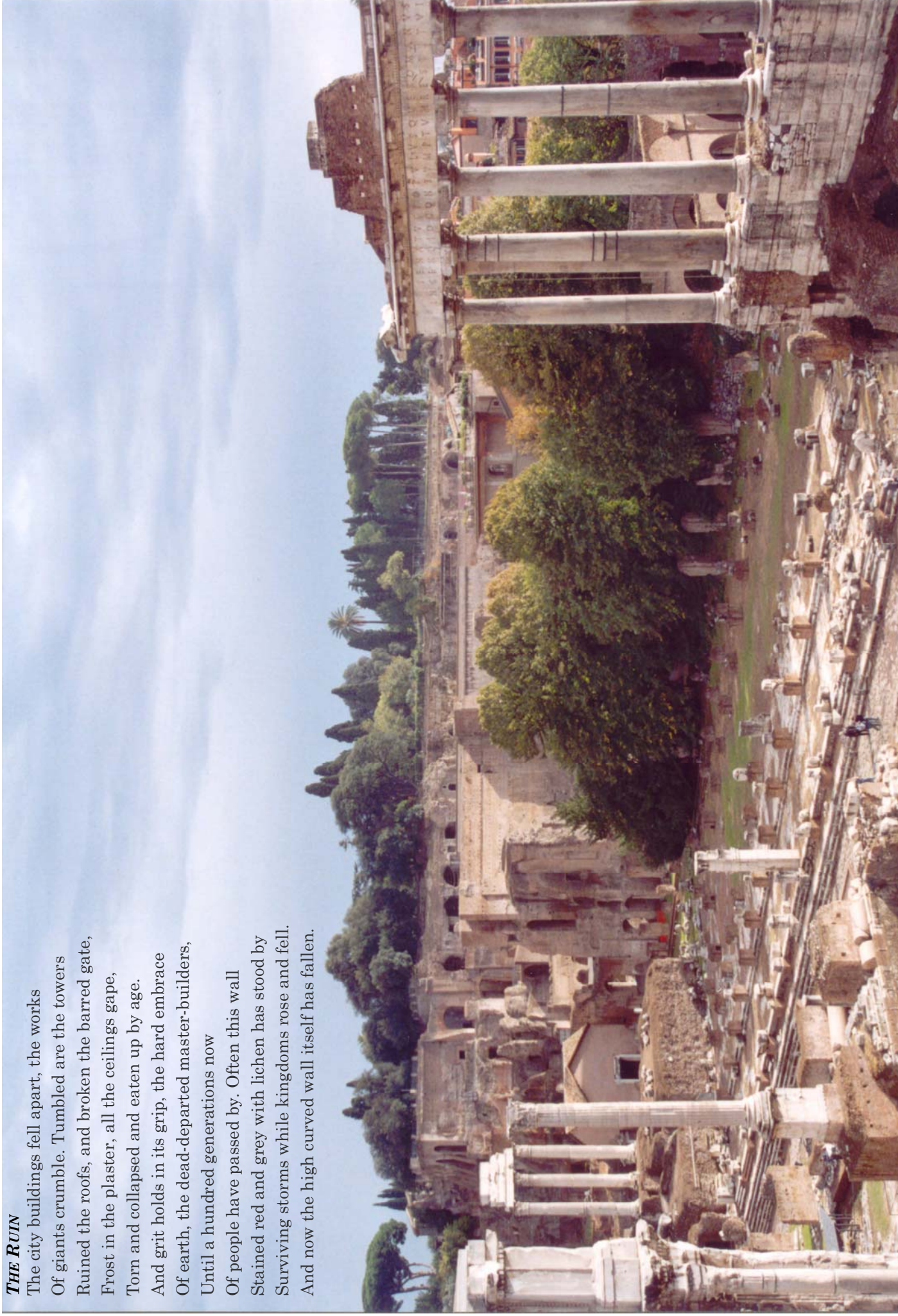
Kibitzing and Advice: The gang at the NSW Wargamers

DEDICATION:

This game supplement is dedicated to the memory of my father, Bevan George McGregor (1913-1999) who never really understood what it was I did on my weekends and in much of my spare time (a lot of it sitting before a computer screen, which he didn't really understand, either) for the last 30 years or so, but was always supportive of whatever it was I did. A great father and a really nice guy. I miss you a lot.

THE RUIN

The city buildings fell apart, the works
Of giants crumble. Tumbled are the towers
Ruined the roofs, and broken the barred gate,
Frost in the plaster, all the ceilings gape,
Torn and collapsed and eaten up by age.
And grit holds in its grip, the hard embrace
Of earth, the dead-departed master-builders,
Until a hundred generations now
Of people have passed by. Often this wall
Stained red and grey with lichen has stood by
Surviving storms while kingdoms rose and fell.
And now the high curved wall itself has fallen.



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THE LIMITS OF POSSIBILITY

If you've been playing Role Playing Games for any length of time you've almost certainly picked up some historical knowledge – most RPGs are, after all, set either in earth's past history or borrow elements of that history as the basis for much of their setting.

Having at least a passing knowledge of pre-modern societies and cultures, or some aspects of them, is a handy thing – it gives the player an *edge* and enables the GM to make the game more *interesting* and *believable*.

POSSIBILITIES?

The problem is that most commercially available RPG campaign backgrounds are poorly conceived *pastiches* – a hodge-podge of disparate elements borrowed from a variety of cultures from different places and times.

What, at first, seems “cool”, often ends up gratingly annoying for all involved.

Just think of one common example – the “typical” fantasy RPG campaign background is based on a pseudo-medieval society (there is nothing *inherently* wrong with that!), but one that has remained *completely* static for many hundreds or, often, *thousands* of years.

Historically, european “medievalism” lasted for about 600 years, from c. AD 800 (and the crowning of Charlemagne) to c. AD 1450 (Gutenberg's Printing Press) – but even a cursory examination of the period shows that society and technology was *anything* but static.

So *why* would anyone believe that a fantasy background would be any different? There *are* some reasons – it's just that they aren't very believable!

SOME (IM)POSSIBILITIES

Are the humans (and other races) in such game backgrounds *stupider* than those of the “real world”? Not unless humans in your game world are *radically* different from the “real world!”

Is there some *physical limit* that makes progress impossible – and *what is it*?

If *that's* your excuse you better make it inherently *believable* rather than merely claiming, for example, “*the existence of magic and the Gods makes it so*”.

If that *is* the case only the *way* in which things change will be different – because *change is the natural state of human societies*.

CIVILISATION 101

FF&S attempts to define the limits (“rules”, if you will) that define pre-modern societies and civilisations ... the constraints under which they operate, knowingly or unknowingly.

This will allow GMs to design *believable* campaigns That are no less fun, “cool”, or different for being realistic.

It also makes an attempt to look at *how* and *why* those limitations were eventually overcome (or, at least, *redefined*), and why it didn't happen *faster* or spread more quickly, and how the changes impacted on existing societies.

This is obviously a *huge* area, which is why **FF&S** claims only to *attempt* to define the parameters.

The basic information and guidelines provided in this volume will provide you with useful tools for campaign design and civilisation construction as well as the starting point for any more detailed research you may wish to do.

THE PROBLEM WITH TIME

The key reason for researching and writing **FF&S** arose from the development of what will eventually be the *Displaced* series – a time travel-parallel history background into which modern characters can be dumped.

This was a natural outgrowth of **PGDs** first product, *Road to Armageddon*, and is, of course, one of the more popular tropes of late 20th and early 21st century Science Fiction.

Like standard Fantasy campaign back-grounds, such books are equally (if not *more*) likely to be completely unbelievable in their premises.

After all, who could really believe that *one man* could institute an Industrial Revolution in around ten years, as one such series assumes. Other novels, allowing a whole community to be sent backwards or sideways in time are only slightly less unbelievable.

It's not inherently impossible, but it *does* require more thought and explanation than the typical SF author puts into it.

I'd like to think that I have done that in *Road to Arnageddon*, but you need to be aware of the potential pitfalls that litter most fictional treatments of this popular genre.

What do I mean? Well, consider such a background from *your* point of view as a GM – and the likely reaction(s) of your players.

WHAT'S IN IT FOR THE PLAYERS?

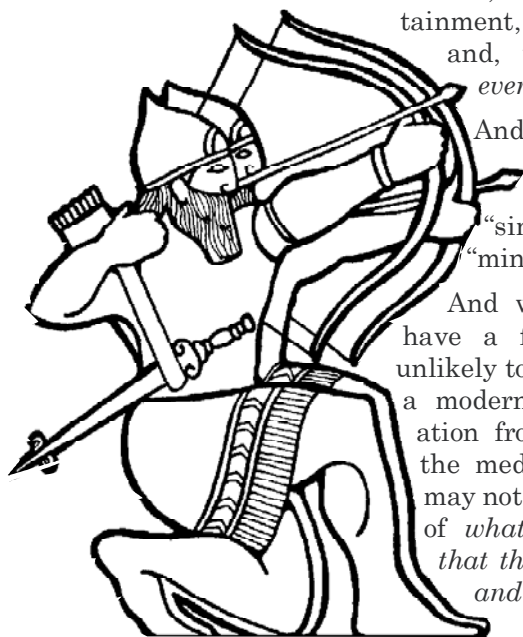
One of the first things that the player(s) will want to try their hand at is to, *somehow*, use knowledge of the technology of *their* time to *change things*.

And they won't be satisfied with *minor* changes, they'll want to change things in *major* ways. To *their* advantage, of course. What else would you expect – *altruism*?

They'll want *more* and *better* than the locals can provide – more and better communications, transport, food, entertainment, accommodation and, well, pretty much *everything*.

And you, as the GM, will have to deal with all these “simple” ideas and “minor” changes.

And while you *probably* have a fair idea that it's unlikely to be easy to recreate a modern industrial civilisation from scratch in, say, the medieval period – you may not have any idea at all of *what the problems are that they will have to face and overcome*.



SO WHAT'S THE DEAL?

Never assume that the inhabitants of the past are *stupid* – or even that they haven't already *thought* of some of the simpler “solutions” to those problems that the players (through their characters) wish to solve.

It's more likely that those in power *either* don't see the need (or believe the costs or risks outweigh the benefits) *or* that resources needed to institute the changes simply don't exist.

As for the more complex technology that the players will want – well, the problem that they will face is that the further they go back in time the more they will lack the tools (or raw materials) to construct the tools to construct the tools to construct whatever it is they want (and probably several iterations beyond that!).

FF&S will have a look at the basics – the *limits of the possible* – as they are likely to apply to anything the players want to do, from the most basic and all encompassing to the more esoteric and specific.

Hopefully, when all is said and done, you will find the concepts and information presented in this book of use in creating believable and fun campaigns for yourself and your players!

– Phillip McGregor
(Sydney, 2004-2005)

HISTORICAL NOTE

While every attempt has been made to ensure the accuracy of the materials presented herein, a large part of the topics covered are in a state of flux.

The theories that the author believes best fit the facts as we know them have been chosen over those that seem, at present, to be less likely – but there *are* alternative theories.

Similarly, the assessment of historical and other “fact” made in this monograph are based on research that often raises conflicting assessments, the author has chosen those that he feels are the most likely.

Any errors are, therefore, entirely his.

IN THE BEGINNING



SECTION

1

“And God said, Let us make man in our image, after our likeness: and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth upon the earth.

So God created man in his own image, in the image of God created he him; male and female created he them.

And God blessed them, and God said unto them, Be fruitful, and multiply, and replenish the earth, and subdue it: and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth.

And God said, Behold, I have given you every herb bearing seed, which is upon the face of all the earth, and every tree, in the which is the fruit of a tree yielding seed; to you it shall be for meat.

And to every beast of the earth, and to every fowl of the air, and to every thing that creepeth upon the earth, wherein there is life, I have given every green herb for meat: and it was so.”

Genesis, 1, Verses 24-30, (King James Version)

“Life in an unregulated state of nature is nasty, brutish, solitary and short.”

Thomas Hobbes (1688-1779)

AN OVERVIEW OF HISTORY

HOW IT ALL BEGAN

The line of evolution from African proto-apes to modern humans began around seven million years ago (though estimates range from five to nine million years) – but it was not until around four million years ago that our lineal ancestors had achieved an upright posture, though they remained physically small (and had small brains).

These proto-humans started using stone tools about 2.5 million down to 1.7 million years ago – though the likelihood of tools made from less durable materials (wood and bone, most likely) predating these is considered likely.

The spread from from their African “Eden” was slow – they only reached South East Asia between 1.8 million and 1 million years ago; but they did not reach the less hospitable climes of Europe (the last Ice Age didn’t end till between 50,000 and 15,000 BC) until half a million years ago.

This was around the time Neanderthals appeared in Europe – and their 450,000 year heyday only ended in 50,000 BC when Cro-Magnon man appeared (only displaced the Neanderthals in Europe around 40,000 BC).

Australia was only reached around 60-40,000 BC, Papua-New Guinea around 35,000 BC, Siberia not until 20,000 BC, and North America *probably* not till 12-15,000 BC (and the tip of South America may not have been reached until around 10000 BC).

The Pacific Islands were only settled between 1200 BC and AD 1000 – and, of course, the Antarctic continent was never settled by human beings at all.

AGRICULTURE

For most of their existence, human beings and their ancestral proto-humans have been hunter-gatherers ... and only began to develop the precursor skills and technologies of agriculture and stock raising around 10-9000 BC.

The first place where proto-agriculture developed was the Fertile Crescent (Iraq plus parts of Turkey Syria and Lebanon), where something recognisable as a settled proto-agricultural life-style developed as early as 8500 BC.

These developments were really sedentary hunter-gatherer societies rather than true agricultural societies because the Fertile Crescent was both fertile *and* well provided with precursor species to the most important modern food animals and crops.

Even in their ancestral forms these “wild” foods (various species of wheat, peas, olives, sheep and goats) were so productive that gathering them provided a large enough surplus for a group to become sedentary and develop proto-villages and even proto-cities.

The date of adoption of something recognisable as proto-agriculture is directly linked to the number and suitability of potential food crops and domesticable animals in a given region.

The Fertile Crescent had the best varieties, other regions had less favourable situations – the last to develop agriculture *independently* (Eastern US, c. 2500 BC) completely abandoned *local* species as soon as climate tolerant Maize was available.

AREA OF ORIGIN	TIME PERIOD	PLANT SPECIES
Fertile Crescent	8500 BC	Barley, Wheat, Lentils
East Asia (China)	7500 BC	Rice (South), Millet, Soybeans (North China)
Mesoamerica	3500 BC	Squash, Maize, Beans; Turkey
South America	3500 BC	Manioc, Sweet Potato, Potato, Quinoa
Eastern USA (Woodlands)	2500 BC	Squash, Sunflower, Marsh Elder

Agriculture is superior to a hunter-gatherer lifestyle *only in retrospect*. Early hunter-gatherers were generally healthier and better fed than early farmers – and had a much *easier* time feeding themselves.

Pre-mechanised agriculture was hard, grinding, work – and risky, to boot (modern farmers occupy the *best* land, and modern nomads the most *marginal* whereas in pre-farming times *hunter-gatherers* occupied *everywhere*).

WHY AGRICULTURE?

So why *was* agriculture “invented?” The easy answer is *because no-one knew where it was leading*.

Once it *had* been invented, then it was not always adopted by those who came into contact with the idea of it.

The main advantage was that it enabled farmers to space children closer together (nomadic mothers need to space children 4-5 years apart) so farmers have faster population growth and a greater population *density*.

These larger, denser, populations support non-farming specialists – an advantage in developing technology and better social organisation.

This, in turn, a given population to support increasingly large numbers of people from the same amount of land.

High population density thus gives farmers an unbeatable edge over low population density hunter gatherers.

HOW DID IT START?

The *Fertile Crescent* developed agriculture c. 8500 BC, followed by *China* (rice, millet, pigs, silkworms) c. 7500 BC, then *Mesoamerica* (corn, beans, squash, turkeys) and the *Andes* (potato, manioc, llama, guinea pig); and finally the *Eastern US* (sunflower, goosefoot) c. 2500 BC.

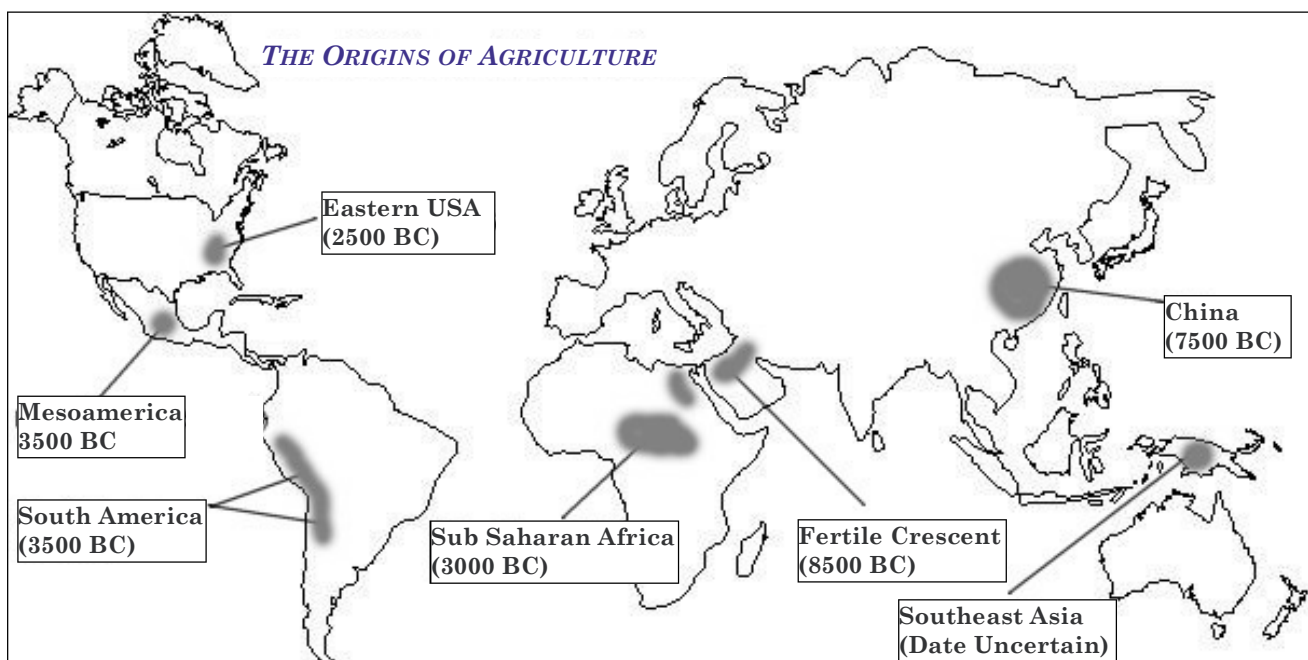
Egypt (sycamore fig, chufa, donkey, cat) got the *idea* from the Fertile Crescent c. 6000 BC; the Sahel (sorghum, african rice, guinea fowl) from Egypt c. 5000 BC; as did Ethiopia (coffee, leff) and Tropical West Africa (african yams, oil palm) c. 3000 BC; *New Guinea* (banana, sugar cane) and the *Indus Valley* (sesame, eggplant, cattle) probably got the *idea* China c. 7000 BC.

Everywhere else the idea *and* the plants came, directly or indirectly, from one of these five precursors.

The level of technology and complex social organisation a civilisation has achieved is directly related to how early they developed or adopted farming.

Humans aren't stupid, but that doesn't mean they have 20:20 hindsight, either!

Many of the “obvious” inventions and social developments since the invention of agriculture (c. 8500 BC) are *only* obvious *with* 20:20 hindsight!



AN (A)MAIZING PROBLEM

The wild form of Maize (the main Mesoamerican food crop), *Amaranth*, looks *nothing at all* like modern maize and even DNA typing has not convinced some scientists that it was.

They are *equally* unsure *how* it was selectively bred into Maize – the best guess is *thousands* of years.

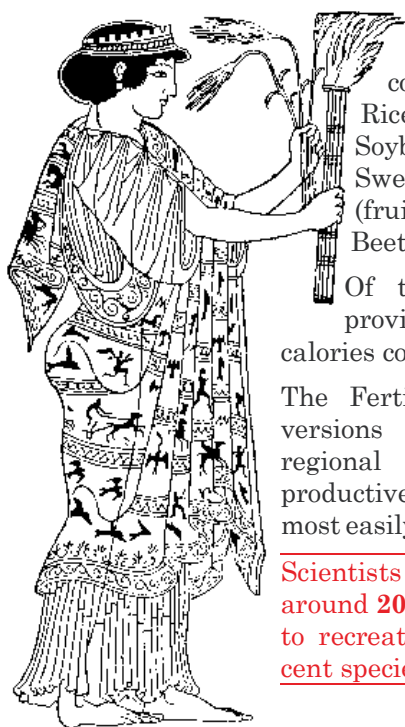
STARTING EX NIHILO

The first domesticated crops were those easiest to domesticate – with a single gene mutation that changed them into a variety suited for cultivation.

Natural selection (early proto-farmers knew nothing of plant genetics!) of useful characteristics took a *long* time.

There are 200,000 species of wild flowering plants but only a few hundred have been domesticated – and most of those are of minor importance and usually *very* recent domesticates (most berries, for example).

The bulk of our modern agricultural crops are limited to a dozen species –



Wheat (several varieties, many of which are no longer commercially grown), Maize, Rice, Barley, Sorghum (cereals); Soybeans (pulse); Potato, Manioc, Sweet Potato (tuber); Banana (fruit); Sugar Cane and Sugar Beet.

Of these dozen the first *five* provide more than *half* of the calories consumed in the world today!

The Fertile Crescent had *six* wild versions of these twelve *and* the regional variants were the most productive (in their wild form) and most easily domesticated and improved.

Scientists estimate that it would take around **200 years** of selective breeding to recreate these major Fertile Crescent species from their wild forms.

DOMESTICATED ANIMALS

Only *fourteen* major species were domesticated (as opposed to occasionally being tamed) before the 19th century.

Of these fourteen only five were of worldwide significance, the remaining nine either of geographically limited range or only spread in modern times.

The Major Five: Sheep, Goat, Cattle, Pig and the Horse.

The Minor Nine: Arabian Camel, Bactrian Camel, Llama/Alpaca, Donkey, Reindeer, Water Buffalo, Yak, Bali Cattle, and the Mithen.

CATS AND DOGS!

The two smaller species of domesticates that have proved important are **Dogs** (from Wolves, SW Asia, China and North America, c. 15-10,000 BC) and **Cats** (from Wild cats, c. 8000 BC, Egypt or Cyprus).

Neither has *normally* been used as a food or draft animal – however, the successful domestication of both these species were important developments in the path of human development.

The domestication of wolves into dogs pre-dates agriculture by many thousands of years and was probably the first step in that direction.

The domestication of the wild cat was long thought to have occurred in the Nile valley as an adjunct to the development of agriculture – but more recent discoveries suggest the cat was already domesticated before this and, possibly, even before the development of farming where it was domesticated (possibly Cyprus and the Levant).

The domestication of dogs was probably the first step towards domesticating other animals and the development of herding, itself a step towards farming.

FIVE MAJOR DOMESTICATED ANIMAL SPECIES

AREA OF ORIGIN	TIME PERIOD	DOMESTICATED ANIMAL SPECIES
Asia	8000 BC	Sheep (Mouflon Sheep), Goat (Bezoar)
Eurasia (China)	8000 BC	Pig (Wild Boar)
Eurasia	6000 BC	Cattle (Aurochs)
Southern Russia	4000 BC	Horse (Wild Horse)

THE BIG PICTURE

So there you have it – an outline of the human story from the earliest times.

Humans developed *four* vitally important technologies during this period, the first two being **fire** and **tools** (it isn't certain which came first and never will be), which allowed us to transform the environment to suit *our* requirements rather than *evolve to suit it*.

This enabled the spread of our ancestors across the whole of the planet, with the exception of the remotest islands and the Antarctic.

The unprecedented success of our species has meant *everything else has had to conform* – and, inevitably, *nomadic* hunting/gathering gave way to *sedentary* hunting/gathering and then the first permanent villages *where the environment was rich enough to support it!*

This was associated with the earliest large-animal domestication and the beginning of **herding**, humanity's *third* great technological advance.

Modern research seems to conclusively show that **agriculture** (the fourth big technology) *followed* the creation of the first permanent settlements and, very much, was a *consequence* of those settlements being created in the first place.

CONSEQUENCES

Agriculture made humans virtually unstoppable – concentrating food/energy for *our* advantage as no other species has managed.

Tools (and *fire* is a tool) enabled our ancestors to manipulate their environment more effectively – and to develop ever more complex tools.

DOMESTICATED OR TAMED?

Domesticated animals are those which are raised from young under the control of humans.

Tamed wild animals are those that are merely captured as adults but which will not or cannot be raised in captivity – Elephants and Cheetahs are easily tamed and trained but are reluctant to breed in captivity.

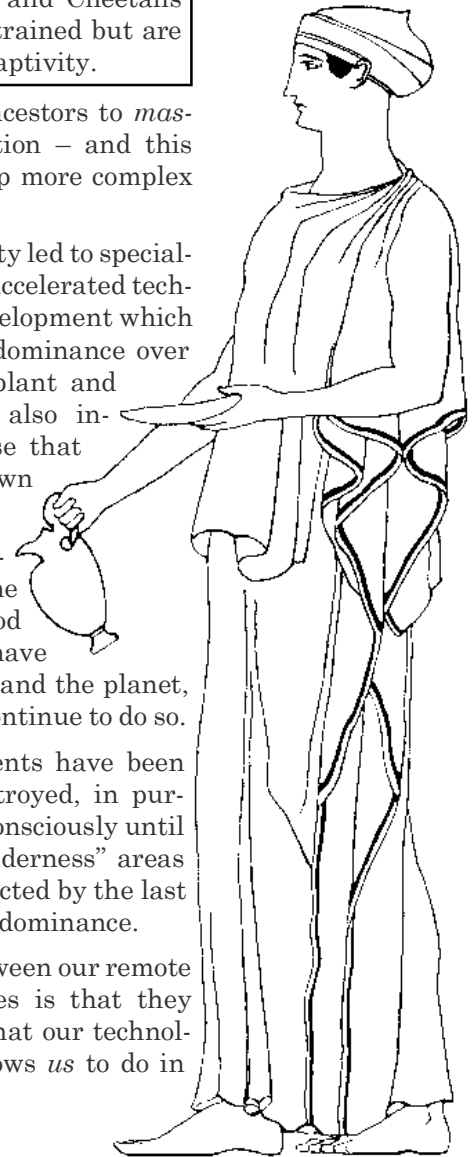
All this allowed our ancestors to *massively* increase population – and this led to a need to develop more complex social structures.

Greater social complexity led to specialisation which, in turn, accelerated technological and social development which further cemented our dominance over all the earth's major plant and animal species while also increasing our ability use that dominance for our own ends.

Today, the human species is undoubtedly the peak of the planet's food chain – because we have *remade* the food chain, and the planet, to make it so. And we continue to do so.

Species and environments have been transformed, even destroyed, in pursuit of this (mostly unconsciously until recent years) even “wilderness” areas today are hardly unaffected by the last 50,000 years of human dominance.

The only difference between our remote ancestors and ourselves is that they took millennia to do what our technology (and numbers) allows *us* to do in years or decades.



NINE MINOR DOMESTICATED ANIMAL SPECIES

AREA OF ORIGIN	TIME PERIOD	DOMESTICATED ANIMAL SPECIES
Southeast Asia	4000 BC	Bali Cattle (Banteng), Mithen (Guar)
Southeast Asia	4000 BC	Water Buffalo (Wild Water Buffalo)
Himalayas & Tibet	4000 BC	Yak (Wild Yak)
SW Asia & Egypt	4000 BC	Donkey (Wild Ass)
Eurasia	4000 BC	Reindeer (Wild Reindeer)
South America (Andes)	3500 BC	Llama, Alpaca (Guanaco)
Arabia	2500 BC	Arabian (One Hump) Camel (Wild Camel)
Central Asia	2500 BC	Bactrian (Two Hump) Camel (Wild Camel)

A MERE MATTER OF NUMBERS

One of the key questions that you'll want to be able to answer is, simply, *how many people are there?*

This has obvious consequences. Population density, and the technological level it can both create and support will have a direct impact on what the characters will be capable of doing.

SO, HOW MANY PEOPLE ARE THERE?
Current world population is known only to within +/-10% – and that's *with* access to sophisticated technologies and the *concept* of the *need* for a census.

Yet *before* the 20th century, this simply wasn't the case for much of the world, and before the 18th century, it wasn't even the case for what passed as the “civilised” (i.e. European) world.

Figures for world or national populations before the c. AD 1800 are *guess-work* of varying “reliability.”

WORLD POPULATION

Prior to the development of agriculture and herding world population, shown in **Table A** (an *average* of *several* estimates), was quite low.

Population density was *also* low compared to what became possible after the development of herding and farming.

The reason was simple – the margin for survival was so small that the human population was particularly vulnerable to natural disasters.

There is genetic evidence, for example, hinting that our ancestors were knocked back to a population in the order of only 10,000 individuals by the explosion of the Toba supervolcano in Indonesia around 75,000 years ago.

The 10000 BC figure for *world* population is estimated at 1-4 million. Which is probably the best that a “pure” hunter-gatherer lifestyle could support.

Even with the development of agriculture, population didn't rise *quickly*, though population *densities* in areas that adopted the new technology *did*.

It is only with the development of urban based *civilisations* that numbers jump – from around 2000 BC onwards.

There is also a correlation between the population density of an area and the length of time since it adopted agricultural and stock raising technologies.

Simply put, the longer you had the technology the bigger your population is likely to be.

After all, cities represent a *massive* concentration of population.

TABLE A: WORLD POPULATION (MILLIONS)

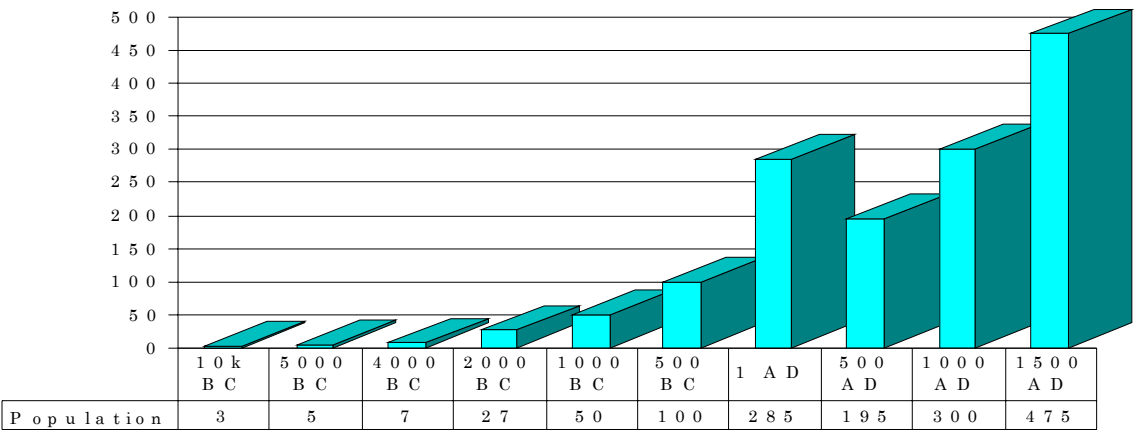
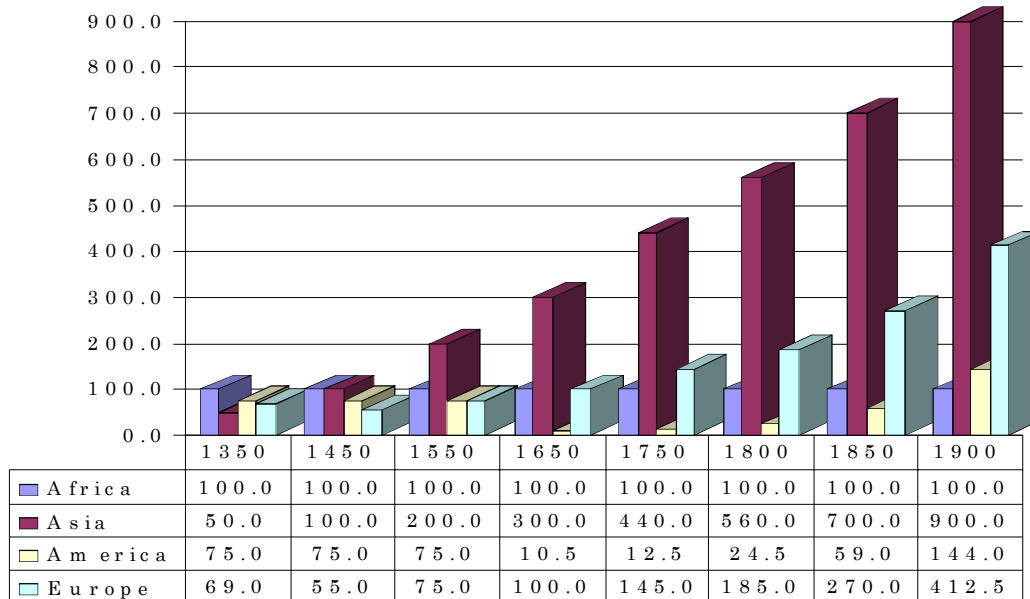


TABLE B: WORLD POPULATION BY CONTINENT



Still, world population did not exceed one billion (1,000,000,000) until the middle of the 19th century AD!

CONTINENTAL FIGURES

What about a breakdown by continent? See **Table B** (all figures are *averages* taken from several sources), over.

These figures are even more highly suspect than the worldwide figures – for example, it is certain that the early figures for Africa are overstated (the fact that they are all “100 million” is a dead giveaway, isn’t it?).

It was probably 25 million in AD 1650 and 25-35 million by the 1700’s.

The figures the Americas are also under considerable doubt, but no-one is certain whether they are *over* or *under*-estimates (and *that* argument continues acrimoniously).

Whatever the population *was*, it seems certain the bulk of was concentrated in Central America (mesoamerica).

Despite the doubts, they give a ballpark idea of relative magnitude by continent.

Demographers believe the relative percentages for AD 1650 probably applied to early periods – at least as far back as the BC/AD juncture.

As a general rule, areas of low population density are *either* unsuitable for agriculture *or* are occupied by cultures that have not yet developed/adopted it.

EUROPEAN POPULATION

What are the figures for an even more specific area? Europe, as the most likely candidate for basing a campaign on (or in) is fortunately fairly well covered – **Table C** (overleaf, all figures are *averages* from several sources) provides the figures, but note that the same caveats apply to these figures as for those in Tables A and B.

The figure for AD 1340 probably represents the limits that could be achieved with the agricultural technology of the time (the “carrying capacity”) – and, in any case, the Little Ice Age was starting to set in, only started to decline c. AD 1500 AD and really only “ended” in the 1800’s (and its progressive end and the good harvests that tended to accompany it are thought to have made the start of the Industrial Revolution in the UK *much* easier).

There is some reason to believe the effects of the Plague were so dramatic and drastic *because* the limits of population growth had been reached – most of the peasantry were *barely* getting by so they were susceptible to and contracted *any* disease especially one as devastating as the Bubonic Plague.



TABLE C: EUROPEAN POPULATION (MILLIONS)

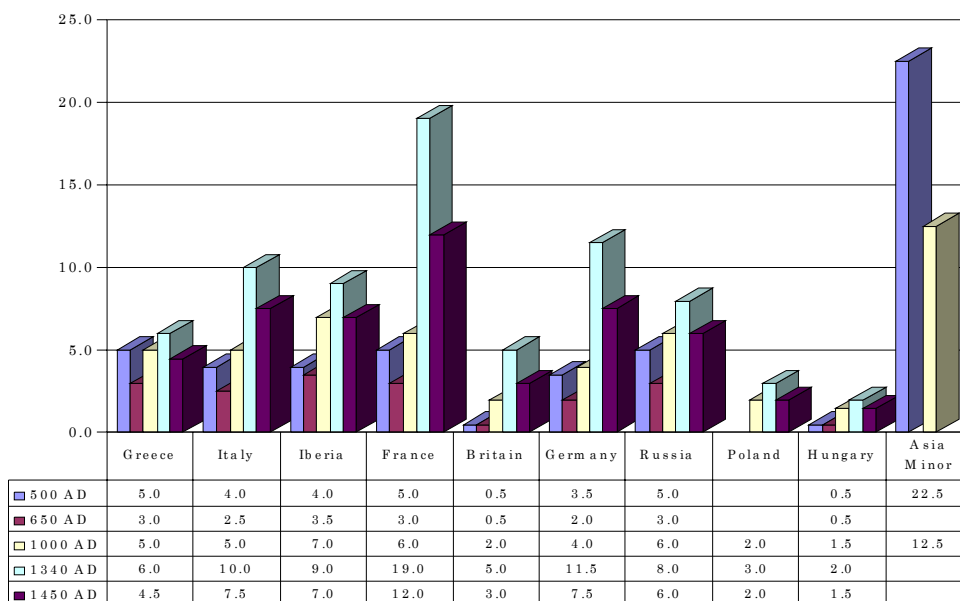


TABLE NOTE:

Greece includes *The Balkans*;

France also includes the *Low Countries*

Britain includes all of the *British Isles*

Germany also includes *Scandinavia*

Russia also includes all *Slavic areas*

Poland also includes *Lithuania*

Asia Minor also includes *Syria, Egypt, and North Africa*.

URBAN LIFE

What about towns and cities? Obviously the larger the population of a region, the larger they are likely to be – but there are limits.

Until the agricultural and industrial revolutions beginning in the 16th century AD (at least in Europe), 80-90% of the population of a region were directly involved in the growing of food. All non-farming specialists come from the remaining 10%, overwhelmingly concentrated in cities

Consider this: food could be economically transported no more around 20 miles (normally much less) by land, so towns and cities not on navigable rivers or seaports will be surprisingly small.

Late Republican Rome probably had a population of 500,000, which may have reached 1,000,000 by the 1st-2nd century AD. Constantinople eclipsed Rome and also reached a population of 1,000,000 at its height.

Chinese cities, probably several of them at a time, also achieved these magnitudes. Baghdad may have reached a million under the Caliphate.

For the rest? By the 15th century AD the largest cities in Europe were around 20-50,000 (Cologne and London were both around 20,000; Rome and Paris were possibly nearer 50,000), with Istanbul c. 400,000.

RURAL LIFE

With populations so low, compared to modern levels, and with towns much smaller as a percentage of overall population, what was the countryside like?

People tended to cluster together, so population densities could be quite high on a localised basis – but, overall, the landscape was much less populated than we take for granted today.

As late as the 15th and 16th centuries large swathes of western Europe were covered by (relatively) trackless “forest primeval” – with islands of civilisation scattered amongst the trees.

Southwest Asia and North Africa were rather different – because the process of civilisation had been underway there for much longer.

Goats, charcoal burners and farmers had mostly deforested the “Middle East” by the 2nd century BC (even in Greece land degradation was well under way by the 4-5th centuries BC).

METROPOLI AND MARKETS

The huge port cities such as late Imperial Constantinople, Islamic Istanbul or early Imperial Rome imported food, by sea, from as far away as Egypt and North Africa. The existence of these monster cities skews the “average” distance from which cities in Europe drew their food supplies – mostly it was no more than 5-10 miles!

The long term effects of farming, and of civilisation generally, is why much of the Middle East, North Africa and Greece are such a barren landscapes today – 2500 years or more of deforestation, over-grazing and erosion

But, as late as the end of the 18th century AD the majority of the world was still a relatively untouched and certainly mostly untamed wilderness!

Since then, with the massive and continuing increase in human numbers and the need for ever increasing amounts of farmland and grazing land to provide the food that they need, the “wilderness” and its denizens have been in a state of headlong retreat.

DEALT WITH AS WOLVES ARE ...

Wolves and Bears were a real danger to outlying villages and, in bad winters, even smaller towns (packs of wolves harassed *Paris* in 1420 and 1438!) – and, of course, to anyone who found themselves between lodging places while on a journey – throughout the whole of Europe (though largely exterminated from the British Isles by the later middle ages).

Wolves remained a problem in *some* areas of Europe (not just backward parts!) until the late 19th century AD.

LIONS, TIGERS AND ELEPHANTS ...

Go back further and the world was even more “wild” – the *Middle Eastern* elephant was hunted to extinction in ancient times (though the *North African* elephant survived until the time of Hannibal), as was the *North African-Ethiopian-Middle Eastern-Asian Lion*. Herds of *wild Horses* roamed the eurasian steppes – and, of course, the veldt of Africa was covered by vast herds of all sorts.

THE HUMAN HERD ...

Historically the Fertile Crescent crop package supported a population density of between 10 and 50 per square kilometer. Medieval France, blessed with an abundance of arable land, managed 40/km²; Germany and Italy, less well endowed, 33½/km²; the British Isles scored just over 16/km² (most in England and Wales).

Average *urban* population density in western europe was around 150 per hectare (150000/km²).

DEMOGRAPHY

In modern times we are used to women living longer than men and that, at birth, there will be more women than men (the normal ratio is 104-105 female 100 male babies).

Until around age 14 this birth ratio remained mostly static, but once a woman was old enough to be married things changed.

Dramatically.

Between the age of 14 and 40 the figure reversed and there could be as few as 67-77 females for every 100 males.

What was the problem?

Well, the *single biggest killer* of women until very late in the 20th Century was, as it has always been *pregnancy, child-birth, and related complications*. With pre-modern medical technology having children was both *almost impossible to avoid* as well as *extremely dangerous*.

LIFE EXPECTANCY

Life expectancy in pre-modern times was an *average* of 30-40 year.

Most deaths occur in the very young and the very old – and this was an extremely important fact.

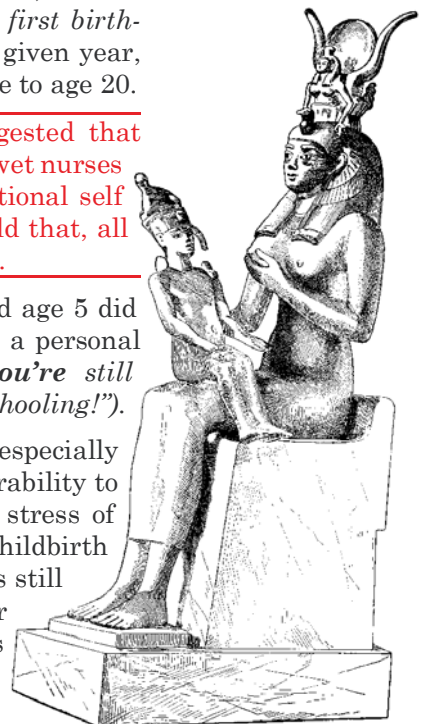
The death rate for *babies under five* was so high as to drag down the average.

As late as the 16th century AD, 25-33% all babies died *before their first birthday*; of all babies born in a given year, only 50% could expect to live to age 20.

Some historians have suggested that wealthy families employed wet nurses and nannies *partly* as emotional self defence. Distancing the child that, all too often, would *not* survive.

Only when children reached age 5 did their parents begin to take a personal interest in them (“Oh, *you’re still around!* Well, better start schooling!”).

Female life expectancy was especially affected by increased vulnerability to disease resulting from the stress of repeated pregnancies and childbirth – but in *some* pockets males still died more quickly and their could be a surplus of widows in some age groups.



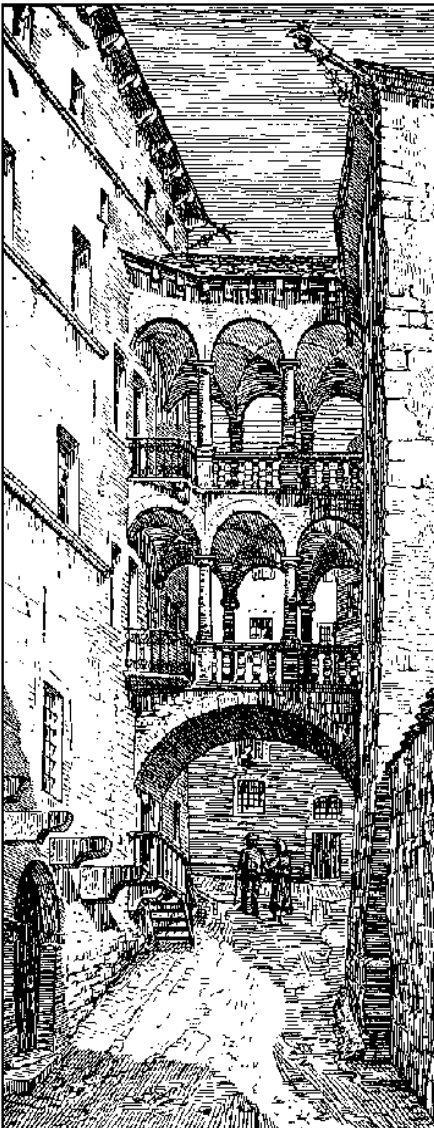
Overall, however, women did not live as long as men.

After these initial years, the chances of someone reaching an age in excess of 30-40 was much improved, though much fewer would reach ages in excess of 50-60 than do in modern times, and few indeed reached their biblically allotted “threescore years and ten.”

CHILDHOOD

In pre-modern times, childhood was very short – assuming that a child survived to *have* a childhood.

For all children the first few years of life tended to be very similar. Babies were generally wrapped up tightly in cloth windings (“swaddling clothes”) to keep them immobile until they were weaned, if not longer. Sometimes these windings would incorporate a board to keep them straight as well, especially for the children of the poor.



Wealthier families generally had a servant to tend to their babies, but in poor families the mother (or an older daughter) would carry it everywhere, strapped to their backs or laid down near where they worked.

Once a child was weaned, it was allowed slightly more freedom and probably enjoyed, briefly, a period something like a modern childhood.

In poor families, however, they will all too soon be given simple tasks to do to assist the father or mother in the running of the household or in the operation of the family business (farming, trade, craft or whatever it might be).

Certainly, in all families, rich or poor, a child will be either started in its formal “education” or “craft training” by the time it has reached its fifth birthday, if not somewhat sooner.

When did Childhood formally end? Well, there was nothing at all like the in-between status of “teenager” that exists today – you were either a child, and treated as one, or you were an adult.

Most commonly males and females were counted as being adults on or around their thirteenth birthday, and many pre-modern socio-legal codes use this as the cut-off point for the beginning of adulthood.

Why the thirteenth birthday? Simply because at around that age both males and females are likely to be able to do a full adult day’s work, or something reasonably close to it. And, of course, for the girls, it was around the earliest time that they were likely to start their periods – traditionally the definite sign that a girl was now a woman.

Of course, as social complexity increased, the need for ongoing learning to acquire the increasingly complex skills that civilisations were developing meant that the age of *effective* adulthood did then, and still does today, continue to increase!

GRANDPARENTS

Some prehistorians and anthropologists have suggested that one of the reasons for the boosted replacement rates that kick in around 10000 BC goes beyond the obvious effects (and benefits thereof) of agriculture and animal domestication/herding is the development of *grandparents*.

The theory goes that the increased resources available meant that the older members of the community could remain valuable even after they were too old and infirm to hunt, gather, herd or farm full time (or at all).

Their existence meant that they could act as child minders for their still active adult children which, in turn, meant that the children they looked after had higher survival rates.

Their continued survival meant that the community as a whole also continued to benefit from their experience, which could be passed on to future generations, increasing the *intellectual capital* of their tribe or society.

There is no firm evidence for this, but it seems plausible.

DISEASE AND DEATH:

BACTERIA, VIRUSES AND HISTORY

When the early hominids started to diverge from our common ancestors with the anthropoid apes in Africa several million years ago, they made a momentous decision that is *still* having an effect on the world of today.

The decision in question? To move out of the tropical rain-forest that was their previous home and onto the savannah.

Why *was* it such a momentous decision?

THE HOT ZONE

Tropical rain-forests are the environments that are the most densely packed with the largest variety of all types of living organism that exists.

The perfect breeding ground for all sorts of parasites, bacteria and viruses. Many varieties. In massive numbers.

Many of these micro- and macro-parasites can easily survive in the hot, wet, environment in a tropical rain-forest, even outside of their normal host (or hosts) – and this is a close to perfect medium for inter-species transmission.

LEAVING HOME

When our precursors *left* the rain-forests, they largely left behind the diseases that they were *already* commonly afflicted by, as well as an environment where inter-species disease transmission was likely – and against such diseases they had no innate defences.

Without pre-existing immunity, such new diseases result in high mortality until one of two situations arise –

** all possible hosts were dead*

** all possible hosts had survived and developed an immune response.*

An organism's to a new disease is *either* to reach equilibrium (becoming *endemic*) or to develop an immune response that provides partial or full immunity (normally passed on in the womb or during breast feeding).

WIDE HORIZONS

The tropical savannah was *not* disease free, and some of the new diseases that our ancestors encountered (and still encounter) there were at least as lethal as those they had been exposed to in their rain-forest homes.

However, there were *less* of them – and the further away these early hominids spread from the rainforests the fewer they were exposed to and the less likelihood there was of them making the cross-species jump *to* those hominids.

This reduced impact of disease meant that, the further from the rain-forests they spread, the more able they were to out-compete the local species.

This was a major, though unforeseeable, evolutionary advantage and is probably one of the major reasons for the success of the *hominidae* family.

It also explains the lack of demographic change in Africa – the maximum pre-modern carrying capacity was far lower than elsewhere because this was where the oldest diseases infecting humans also originated!

It also explains the reasons tropical rainforest-like environments are sparsely populated even today.

ENDEMIC VS EPIDEMIC

An **endemic** disease is one which is *constantly* present in any place, as distinguished from an **epidemic** disease, which prevails widely at some one time, or periodically, and from a **sporadic** disease, of which a few instances occur now and then.

Endemic diseases are *often* those that have reached a state of equilibrium in the target species, and which do not *generally* cause many deaths.

Epidemic diseases are *often* those that have *not* reached a state of equilibrium in the target species, and which *tend to* cause many deaths.

SOCIAL FACTORS

For many diseases death rates are boosted by *social breakdown* – people die from lack of basic care when friends and family abandon them and even the state is overwhelmed.

This is especially so with “virgin field” epidemics – diseases appearing for the first time. These can have death rates of 60% or more, yet drop back to 10% or less with basic care.

Some religious “rituals” also seem to have been developed (or to have provided a survival advantage) to deal with disease transmission without anyone ever really understanding *why* the practises were effective.

In other situations, these selfsame practices could have the opposite effect and actually *spread* diseases.

ORIGINS

Most human diseases are diseases of civilisation – they require large numbers of people living in close proximity to breed and spread, helped by pre-modern living conditions which are normally massively sub-standard in the area of public health.

In fact, the biggest single factor involved in the increasing average life expectancy of human beings over the last century or so (the biggest increase in history), has not been better medicines or improvements in medical science but simply improvements in public health and sanitation!

CIVILISED DISEASES

Medical historians believe that *almost all* human diseases are the result of cross-species jumps – either from our rain-forest heritage (for the oldest diseases, such as *Malaria*) or from more recently domesticated animals (such as *Cowpox* and *Smallpox*, though there is considerable scientific controversy as to what the exact relationship between the two diseases is).



This jump is not always successful – *Ebola* (too lethal too quickly) or SARS (sorta lethal, and slightly infectious).

DIRECTIONS

The trend of *most* diseases over time is for them to become *less* lethal, if not less *infectious*, reaching an *equilibrium* in their host population (and food source – an important consideration).

As far as Evolution goes, such a move is in the best interests of the disease organism – *and* of some benefit to the host organism as well.

This is certainly the case with diseases that become *endemic*, though not *necessarily* with those that remain *epidemic* (or even *sporadic*).

An obvious example of this progression are the so-called “childhood diseases” (Measles, Mumps, Chicken Pox etc.) which were, when they first appeared into an unexposed population (“virgin field”), mass killers on a par with Smallpox or the Plague (however, see the *Social Factors* box).

The scientific evidence suggests that it takes 6-8 human generations (150-200 years) for a new disease to mutate enough (or for human hosts to develop a continuing immune response) for such a balance to be reached and the disease to become endemic.

Of course some diseases do *not* make this change, either failing to make the cross-species jump *permanently*, effectively die out after one (usually) appearance (O’nyong-nyong fever, and, possibly, the Spanish Flu) or they become (or *remain*) *epidemic* and disappear back into their animal reservoir until conditions are right for them to re-appear (Bubonic Plague).

“An infectious disease which immunises those who survive, and which returns to a given community at intervals of five to ten years, automatically becomes a childhood disease.” *Plagues and Peoples*, William H McNeill

Many familiar diseases are historically quite recent – Mumps can only be certainly identified (as the plague that hit Athens at the end of the Peloponnesian War) from c. 400 BC, Leprosy (though in ancient times many disfiguring skin were *called* “leprosy”) only appears c. 200 BC, Epidemic Polio c. 1840 AD.

And, of course, AIDS only c. 1959 AD.

SOCIAL COLLAPSE ...

The arrival of a new epidemic disease (or a new series of epidemic diseases) can be so devastating as to have important and obvious effects on the society as a whole.

The plagues that hit the Roman world in the 2nd and 3rd centuries AD effectively sounded the death knell of the old pagan religions.

There were several factors involved in this – the pagan religions had no theological explanation for these plagues and, worse, no effective words of comfort for those who endured and survived them. Christianity *did* have those things.

Also many could be saved by quite simple nursing care – care that was seen as an important part of a Christian's duties to his fellow man.

Pagans often simply fled. Christians, more often, remained. Theologically, the Christians *believed* that they were doing god's work – Pagans had no such comfort.

Those who survived not only felt a debt, but also a sense of solidarity that the pagan "religions" simply could not match.

So Christianity survived and grew and paganism was eclipsed.

... IN MESOAMERICA

Something similar happened in the Americas where the native to 80%, *often within a single generation of first contact*, while Europeans were remarkably unaffected.

Obviously the "gods" of these newcomers were far deadlier, and more partisan, than the native gods, so it was a matter of *survival* to appease and worship.

Even the most advanced Indian societies collapsed, demoralised by the massive diebacks – and this, as well as the religious *need* to convert, resulted in complete subservience to the newcomers.

After all, *they* were not subject to the same "*wrath of god*" that the Indians were, and therefore *must* be the "*favoured*" of god!

Or so the surviving Indian populations believed.

MINIMUM REQUIREMENTS

There is evidence to suggest that diseases *require a minimum population base to become endemic*. Measles, for example, requires a minimum of 7000 susceptible people in close proximity *all the time* to remain endemic.

Since it *is* endemic, normally only children are the susceptible. For 7000 non-immune children to be available *constantly* an *overall* population of between 300,000 and 400,000 is required. This is a reasonable sized city!

Where the required numbers were not available (in rural areas or smaller towns), then Measles is *epidemic* and must be brought in from *outside*.

Other endemic diseases are harder to pin down, but there are hints that, at least in the earliest historical times, a *minimum* of about half a million people in close(ish) proximity was necessary.

A possible reason for the slow spread of endemic diseases beyond their region of origin is simply the low population density areas bordering major civilisations.

Where such regions of sparse population existed they acted as protective buffers for the bordering civilisations.

MIXED CONSEQUENCES

As human populations grew and their endemic diseases became more common, these diseases expanded geographically. They inevitably reached *other* civilised regions with *different* disease backgrounds.

This meant die-backs, sometimes quite massive, as *both* communities had to come to some sort of ecological balance with these "new" diseases. Three major examples of this intermixing are readily apparent in history –

- The recurrent plagues (not satisfactorily identified) that hit the Mediterranean world in the 2nd-3rd centuries AD, causing a die back of 25-30% (partly causing the collapse of the Roman Empire in the west).



TIME TRAVEL IMPLICATIONS

The disease strains time travellers have been exposed to will not *necessarily* be the same strain the *locals* have – which *may* mean that *both* groups are subject to “virgin field” epidemics (just as immunisation against *this* year’s influenza provides little or no *future* resistance).

- The recurrent outbreaks of the Bubonic Plague in the 14th and 15th centuries AD, causing a die back of 25-40% in Europe (also die backs of similar severity in Asia).
- The repeated massive die backs caused by the arrival of the combined Eurasian disease pool in the Americas, from 1492 onwards – around 70-80% within approximately a century.

FLIGHT OF THE WEALTHY

The wealthy often simply flee epidemics, abandoning the towns (the only places with a large enough population to *support* the epidemics anyway) and fleeing to their country estates where less crowded conditions, better sanitation, and a degree of isolation provide considerable protection ... for people whose better diets mean their immune system is operating one more than half its cylinders as well!

This flight of the wealthy has a major impact on civic life – these are the ruling and governing classes.

If the Mayor and Council flee, and all their main bureaucrats as well, then normal business becomes difficult to conduct. Such behaviour was common.

PLAGUE RULES

Normal life in an epidemic affected city was all but impossible for other reasons. A curfew kept all but a few essential workers indoors between dusk and dawn (those Priests and Physicians who have not fled and, of course, the convicts collecting the bodies of the dead).



Any household with a plague victim inside was required to seal itself up and *remain* sealed until a certain number of days had passed after the last

person there sickened and died – the only people allowed access being convicts collecting the dead or distributing food.

Since towns were not self-sufficient, and relied on daily markets for their food supplies, a plague could make peasants unwilling to bring fresh produce to the town’s regular markets, a great inconvenience at the very least.

MALNUTRITION

This is a general problem in pre-modern societies, and an important factor in the spread and lethality of disease.

Outbreaks of epidemic disease commonly (though not only) occurred in conjunction with crop failures and famine – as malnourished immune systems were less effective.

Even in a “good” year in a pre-modern society a normal person’s diet was marginal, and “regular” diseases which kill only those already sick today would also be major killers.

ANIMAL DISEASES

Many, if not most, human diseases were originally *animal* diseases and have been “acquired” post-agriculture when the increased population densities, human *and* animal, in close proximity vastly increase the chances of cross-species transmission.

Such diseases are most often quick acting and quite virulent, whereas those diseases that have long been associated with, first, proto-humans and then humans per se, are slow acting and much less lethal (at least in the short term!).

Civilisations that *also* have large numbers of domesticated animals tend to be the unhealthiest (such as, for example, Europe as against, say, Mesoamerica).

Strangely enough this has proved to be to the long term advantage of societies developing this civilised lifestyle – an advantage that is often ignored or misunderstood.

AQUEDUCTS AND BATHS

Roman cities were healthier than their successors for the simple reason that the Romans provided high levels of public health infrastructure – clean water, flush toilets, public baths etc. But they really didn’t *understand* why it was effective.

RACIAL DIFFERENCES ...

What about all those pointy eared or big bearded types popular in fantasy worlds? What diseases do *they* have?

Well, the most obvious answer is *if there are "half-pointy ears" or "half-big beards"* then the pointy ears and big beards are **human**.

Being able to interbreed and produce viable offspring capable of reproduction is an indication that pointy ears and big beards are **not** different "species" merely different *ethnicities*.

So they will respond to diseases *like humans* – with one possible variation. Some human ethnicities in the *real world* have genetic adaptations to some diseases (sickle cell anaemia, for example vs. malaria), so it is possible that this *may* apply to *some* of the diseases that exist.

However, it is not likely that any such immunity or resistance will apply diseases that have *not* been long epidemic amongst a population.

The reverse is true as well – ethnicities *other* than pointy ears and big beards will be unlikely to have resistance or immunity to diseases that affect the pointy ears and big beards!

However, they also have some immunity to them, so when a society with such a background comes into contact with societies *without* such exposure, *their* diseases kill *more* than any inter-societal conflict does.

Nomadic herders, even though they have close contact to larger numbers of animals, do *not* have the same level of exposure/immunity because their communities are not large enough for inter-human transmission to occur.

Hunter-Gatherer societies have neither the density of human-human contact nor the closeness of animal-human contact to develop such immunities.

Finally, societies that have high density populations but who do *not* have high densities of domestic animal populations are *also* less "disease experienced" and vulnerable.

The classic example of this is when the dense urban populations of Mesoamerica and the Andes. They had no *dense*

populations of domesticated animals and were *extremely* vulnerable to Eurasian diseases brought to the Americas by the Spanish and Portuguese.

The result? A 90-95% dieback of American Indian populations within a century of the first contact with *no* similar dieback amongst the invading Europeans (or back "home" in Europe).

ANIMAL ORIGINS

As indicated elsewhere, medical scientists believe that most diseases were originally diseases of animals and crossed the species barrier in past times, though this can still happen and the fear of what could happen when it does is the basis of the overhyped fears of **SARS** and **Bird/Avian Flu**.

SOME ANIMAL DISEASES

Measles is probably related to *Rinderpest*, a disease of cattle; **Tuberculosis** is also originally a bovine disease as is **Smallpox** (a mutation of *Cowpox* or vice versa); **Influenza** is originally a disease of Pigs and/or Ducks and **Pertussis** is common to Pigs and Dogs.

Malaria seems to have originated in birds. The **Bubonic Plague** was originally a disease of small rodents, and was so devastating in Europe because the Brown Rat, the main carrier, was *killed* by disease and the fleas that carried the infection spread to humans.

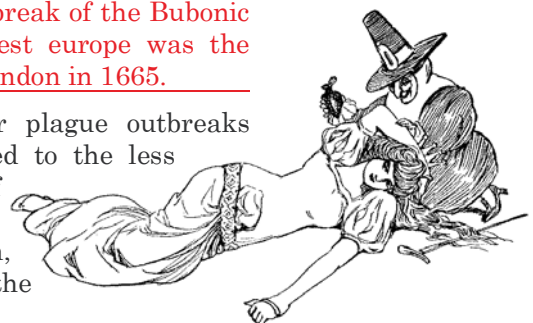
AVOID IT LIKE THE PLAGUE

One theory for the end of the Plague epidemics is that the European (Brown) rat was *exterminated* by the disease and replaced by the Norway (Black) rat which *hosts* the disease but is *immune* to it ... and so changed from a mass killer to an occasional one.

Another theory is that better nutrition and the increasing number of brick and stone built homes reduced the chances of contracting the plague in two different, but equally effective, ways.

The last *mass* outbreak of the Bubonic Plague in northwest Europe was the Great Plague of London in 1665.

Since then, major plague outbreaks have been confined to the less developed parts of the world. They were, even then, nowhere like the



mass killer that the Black Death was in the 14th century AD.

There are typically no more than 10 case per year reported in the US (mostly in southwestern states bordering Mexico) and, worldwide, an average of 2000 cases per year (China, Congo, India, Madagascar, Mozambique, Myanmar (Burma), Peru, Tanzania, Uganda, Vietnam, and Zimbabwe have reported 100+ cases pa in the 1990s).

MODERNITY

The major development in mankind's relationship with disease in the last several millennia has been that increased travel speeds have brought all of the previously isolated disease pools into close contact.

As long as they were separated by space and time, the infrequent transmission of diseases from *other* disease pools led to massive outbreaks accompanied by massive die-backs until some sort of eventual balance was achieved – something that did not always occur.

Faster travel changed this – making all the major epidemic diseases of the main disease pools more likely to be *endemic*, and develop into childhood diseases which could be countered by increased birth rates, rather than remaining demographically disastrous though relatively infrequent *epidemics*.

Of course, not all major epidemics diseases have changed in this way and they may remain a danger – of sorts.

However, the development of a scientific understanding of the causes and means of transmission of diseases and the development of public health measures to minimise these factors coupled with actual *treatments* for many of them has reduced their likely impact to virtually nil.

EMERGING THREATS

Thus we arrive at the present – a present where the threat of killer epidemics is outside the personal experience of almost all of the likely readers of this book, and un-



HEALING MAGIC & DIVINE FAVOUR

If you are looking at a world where “magic” (or “divine power”) allows healing spells/miracles, is the information herein irrelevant?

Probably not. In most fantasy based game systems healing spells or miracles are *severely* limited – so severely limited as to have almost no impact on the existence or spread of diseases.

Think about them – they are rarely available to beginning characters and are only able to “cure” one (or a small number) of diseased people at a time, and there are almost always usage limitations that mean they cannot be used very many times in a day.

Since the assumptions underlaying most roleplaying systems assume that the numbers of people with such spells will always be *extremely* limited, this means that their impact in the face of a real pandemic will be virtually nil. They will be able to save a few of the wealthy, and that's all.

But there are more problems. Do these “cure” spells/miracles provide *immunity* to the disease they cure? If they do *not* then the “cured” individual will likely contract the disease again – especially if the area is suffering from a pandemic!

Similarly, do these spells/miracles “cure” *all* diseases? Or only *known* diseases?

What of diseases from lands far away from where the spell was originally researched?

Or diseases from lands where the deity responsible for the miracle isn't worshipped?

And what about magical/divine diseases? Will one college of mages (or one group of clerics) be able to counteract the disease(s) created by another?

All *sorts* of problems are likely.

In all likelihood “magic” and “divine favour” will remain of little interest to most people – public health measures are going to be more important in preventing disease.

And *non-magical* and *non-divine* practitioners will always be more important than wizards and clerics.

common even amongst the inhabitants of the less developed parts of the world.

But have things changed? Mostly yes. All the “old” killers have been tamed, if they have not been eliminated completely (as Smallpox has, theoretically, been).

But new diseases have emerged, and continue to do so, and *will* continue to do so for the foreseeable future. But medical technology is mostly more than a measure for them, but –

– disasters sell newspapers, so we have wildly exaggerated claims about “potential” killers such SARS, with only 8096 cases *worldwide* in 9 months, of whom a mere 774 died. A mortality rate of 9.6%! A *nothing* compared to real killers such as the *Spanish Influenza* (see below)!

Does this mean that there is *no* likelihood of such a disease occurring?

Not at all! The chances of something like the Spanish Flu occurring again are much less than they once were – but *not* impossible.

WHAT’S CHANGED?

Several things have changed to make the outbreak of new epidemic killer diseases less likely –

- There are no unincorporated disease pools left from which an *existing* disease could come.
- The agricultural revolution of the last 400-500 years has *mostly* moved mankind, even farmers, away from close proximity with animal herds in which *new* diseases commonly arise (for example, *Avian/Bird Flu* and *SARS* are thought to have originated in Asian societies where peasants still keep animals in close proximity in their homes).
- The scientific revolution of the last 400-500 years has meant that we now know the most common methods of disease transmission, and have also developed the public health measures needed to interrupt them.
- The same scientific revolution has led to the development of medicines that can either entirely cure or at least minimize the effects of serious epidemic diseases.

Of course, *less likely* is *not* the same as “impossible” – but, even if a major epidemic disease *does* appear and spread worldwide, it is *extremely* unlikely to be as bad as those of the Spanish Flu.

The Spanish Flu killed 40-100 million people worldwide in around nine months. The Black Death killed a mere 30 million people in Europe from the 14th century, but in multiple outbreaks spread over 100 years! SARS and Bird Flu? Overhyped media scare tactics.

Which is less than relevant if *you* or someone close to you is a victim of a “less severe” epidemic that, say, carries off a “mere” 1% of world population (64 million people or thereabouts, at the current estimated world population of 6.48 billion).

For example, the most recent “real” pandemic, the *Hong Kong Flu* of 1968-69, killed “only” around 700,000 people worldwide, mainly because of better public health measures based on better scientific understanding of how diseases work and spread.

FINAL PANDEMIC?

The likelihood of a pandemic, or even a series of pandemics, having the same massive die back effects as they did in pre-modern times is not high at all.

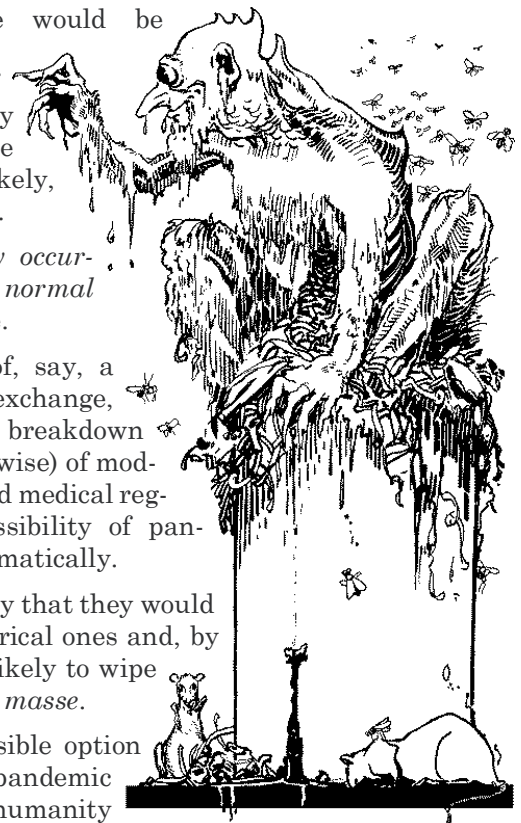
That any disease would be capable of infecting and killing most of humanity in a very short period of time is *extremely* unlikely, probably impossible.

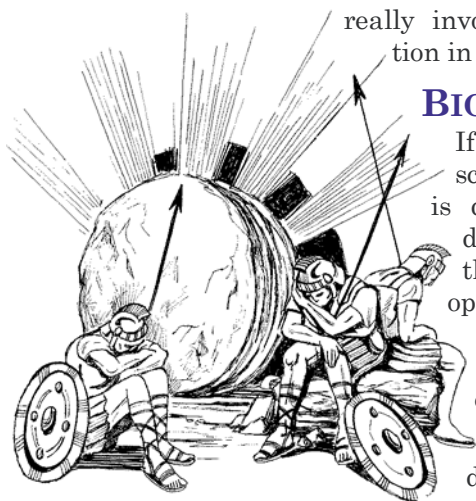
Assuming *naturally occurring* diseases under *normal* conditions, of course.

In the aftermath of, say, a massive nuclear exchange, and the consequent breakdown (temporary or otherwise) of modern public health and medical regimes, then the possibility of pandemics increase dramatically.

Even so, it is unlikely that they would be worse than historical ones and, by themselves, are unlikely to wipe out the survivors *en masse*.

The only other possible option for a worldwide pandemic that exterminates humanity





really involves human intervention in the process –

BIOWARFARE

If you *really* want a scenario where humanity is destroyed – or *almost* destroyed – by disease, then the only realistic option is to assume the involvement of some sort of *engineered* disease. A *bioweapon*.

But even that option doesn't bear too close an examination – at least with our present biological knowledge.

THE FINAL PLAGUE

So, let us consider the basic parameters that you will need for such a world-ending plague (or, at the very least, a *civilisation* ending one) –

- It has to be close to 100% infectious.

If it isn't, then there is a chance that some people will simply never contract the disease. And there has to be little or no chance of anyone having any “natural” immunity to it.

- It has to have multiple modes of transmission.

This is required to maximise the chance of transmission ... protecting against one mode of transmission is relatively easy. Against *several*, it is increasingly difficult.

- It has to have multiple vectors.

If it *only* affects humans, then when the local population density falls below a certain level it will not simply fail to spread further, it will be pooled in the alternative vector and continue to spread.

- It has to be immune to normal treatment regimes.

If standard antibiotics or antiseptics treat the disease effectively, then it isn't a threat. If only exceptional and heroic measures can treat it, then it is.

- It has to remain viable in a dormant state for long periods of time.

So that even where the alternate vectors are not present, the disease remains a constant threat.

No *natural* disease fulfills all of these criteria – if it did, then humanity would not be here!

Developing a disease that *does* have all the above traits is, despite the scare-mongering of anti-genetic engineering types, unlikely in the extreme to happen *by accident*; and developing one *deliberately* also seems *unlikely* with our present state of knowledge and ability (or, indeed, at any near future level of knowledge or ability).

THE LAST PLAGUE ...

Wiping out an intelligent species with the sort of geographical range and population levels of *homo sapiens* is, as you can probably guess from the notes below, so unlikely as to be effectively impossible.

Diseases simply do not work the way they would need to to be able to do this ... not even genetically engineered diseases that we could reasonably be expected to create at our current (and likely future) levels of scientific knowledge.

There will be *some* people who will either be completely immune or who, by luck or design, will not be infected even though they may not be immune.

Even if the disease is far and away more lethal and infectious than anything in our historical experience, at some point, the “carrying level” of the remaining survivors (and their likely dispersal) will make any further spread (and any further deaths) unlikely.

Even multiple diseases won't likely do any better.

IN THE BEGINNING:

THE BASIC RULES

So, what can we learn from the information in this section, and how can it be applied to designing (or *redesigning*) civilisations?

Rule #1: Any intelligent species will develop tools, which are one of the signs of intelligence. This often includes the mastery of fire as a first step.

Fairly simple and non-controversial, eh? Self evident, even.

If you don't have intelligent species, then you don't have civilisation, and if you don't have civilisations of *some* sort, you don't have a game background.

Of course, tools *don't* have to be *obvious*. For example a psionic race could have few or no *physical* tools *if* they used mental powers instead ... in effect, their *minds* are the tool(s), and an aquatic race would not develop tools using fire (though they might use subsea volcanic vents to smelt metals, one supposes).

Rule #2: Intelligent tool-using species living in areas rich in wild foods develop semi-permanent, then permanent, settlements *before* they develop stock raising (animal domestication) and farming (plant domestication).

The archaeological record is increasingly clear that *villages* pre-date both domestication of animals and of food plants. The only reason no-one suspected this is simply that farming, when developed, displaced *everything else* and its very success meant that the farmers dominated the richest lands.

Nomadic hunter-gatherers were soon left with marginal land not really suitable for farming *or* hunting. They simply could not compete.

Rule #3: The development of permanent or semi-permanent settlements inevitably leads to natural selection of suitable local food plants in such a way as to make them suitable for farming and, indeed, makes their growth cycle *reliant on human intervention*.

The evidence for this is increasingly there. The development of farming in the Fertile Crescent followed this pattern because, fortuitously, the most suitable wild plants were native to the region. Those areas that had less suitable wild plants took longer to develop a suitably mutated alternative.

North America, for example, was on the verge of doing so, only to abandon it in the face of the arrival of a subspecies of maize adapted to the local climate.

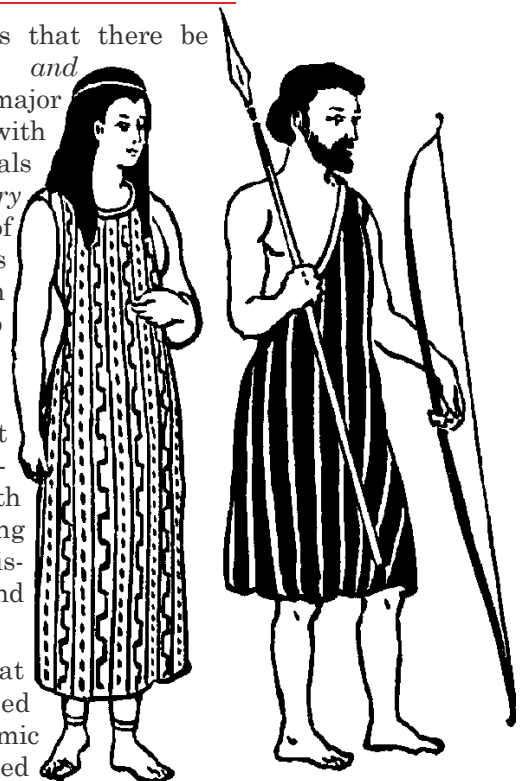
In Australia, the Aboriginal people were hampered even more than the North American natives in that their basic raw material was even less suitable, but there is evidence to show that the process was underway in several areas well before the arrival of the first european explorers.

Rule #4: The development of permanent or semi-permanent settlements based on agriculture *and* stock raising inevitably leads to the development of endemic and epidemic diseases "native" to those settlements.

The requirement is that there be *both* agriculture *and* stock-raising on a major scale. Generally with large bodied mammals in the mix, but *very* large numbers of smaller mammals and avian species in *close* proximity to the human populace will do as well.

All except *one* subset of historical civilisations developed both – the exceptions being the new world civilisations of Central and South America.

Everywhere else that civilisation developed endemic and epidemic diseases largely based



on the diseases of the stock animals the civilisation possessed *also* developed.

This is *not* to say that “uncivilised” areas are *necessarily* healthier places – tropical rainforests most certainly are *not*. However, with lower population densities (both of humans and domesticated stock animals), they *mostly* are.

The creation of civilised “disease pools” seems to require a minimum population, in *close* proximity, of *around* 250-500,000 people.

Such a “disease pool” is important for the *expansion* of civilisations.

Rule #5: Population dense agriculture trump population diffuse nomadism (hunter-gatherer/herding). *Always.*

Farming *always* allows a greater population density than hunter-gatherer (or even nomadic herder) lifestyles can support, even in the richest of lands.

Population density also means disease, and this is another advantage for the agricultural civilisation.

For example, groups living in woods or forests are unsustainable in the long term against full time farmers, and the same applies to groups living in caves/caverns.

This is based on sheer numbers but, also, on the *diseases* that the population dense agricultural societies bring with them. Diseases that their low population density forest-woods-cave dwelling brethren simply *do not have* and, consequently, from which they die in huge numbers.

There *might* be exceptions, but they would *be* exceptional. There would *have* to be some mechanism that would explain how the woods/cavern dwelling group managed to obtain as much food as regular farming groups from an environment that simply does not allow for intensive agriculture.

Numbers are king, in the long term. And even in the medium term.

POINTY EARS AND BIG BEARDS ...

Rules #5 and #6 mean that the ever popular woods dwelling pointy ears (Elves) and cavern dwelling big beards (Dwarves) simply don't make sense *the way they are often presented*.

All those snooty aristocratic Elves and their “highly civilised” cultures – well, back home, *who produces what they eat? Who creates the artifacts they use – and who feeds those artificers?* The answer, all too often, seems to be ... “Uh ... Uh ... Uh ... !”

As for the all those blue collar Dwarven metal (and other) smiths ... *where do they get their food from?*

You *could* argue they trade their smith-work for it. But that begs the question, “... *how did they feed themselves while they were developing those skills?*”

There *are* ways around these “problems” – and ways that do not require some magical or theological *deus ex machina*. But they require a level of thought (or detailed social and cultural description) beyond what is often provided in game backgrounds.

Rule #6: Civilisations are cultures that create *cities*. This requires (and implies) division of labour and *specialisation*. Cultures that do not have cities are unlikely to be able to support a *civilisation* (certainly, there is no historical precedence for such a situation).

Cities require *large rural populations* to support them. Until modern times (the 19th century, really) cities only maintained population levels and grew in because of migration from *outside*.

Inside?

More people died than were born.

Without large populations your society will have minimal division of labour, which means that very few (if any) people will be able to *specialise* in a particular process or skill.



And *specialisation* is the basic requirement for a civilisation to progress, giving it increasingly large competitive advantages over societies with smaller populations and fewer specialists.

It is *politically correct* for some primitive hunter-gatherer societies to be called “civilisations.” Resist the temptation, no matter how worthy, they are *cultures*.

Rule #7: Once a culture has developed farming, populations do *not* remain low and geographically limited, they expand to the limits of geography and resources available. Much more quickly than you would think.

European populations expanded to the maximum carrying capacity of available farmland/agricultural technology within 5-10 generations of its introduction in a given area. The same pattern holds for all old-world civilisations

Inevitably this has social implications. Once all the available fertile land is in use, how do you split it up between the family?

HERDING VS. FARMING CULTURES ...

Historically, nomadic herding cultures enjoyed considerable success vs. sedentary farming cultures – at least on the vast steppes of the Eurasian landmass allowed for large numbers of nomads.

Mobility gave considerable military advantage in pre-modern times when individual differences in armour and weaponry between sedentary and nomad cultures was minimal.

However, once gunpowder was discovered and gunpowder weaponry gradually perfected, they were swamped.

Only those population dense cultures that could pay for these expensive new weapons – and which, not coincidentally, had large enough specialised workforces to develop and construct them – were competitive.

The nomads, who can do none of these things, became overnight also rans.

Or changed into something that *was* competitive – usually by becoming the dominant ruling class over a sedentary civilisation (the Magyars in Hungary and the Manchus in China).



All to one son? Or equal amounts to all? Before Napoleon, the first method was the most common in France; after Napoleon, the latter was. Hence the strange and unproductive size of most French farms.

This means it is unlikely in the extreme that *any* area will remain sparsely inhabited (or, indeed, uninhabited) for any extended period of time once an intelligent, tool using, species arrives.

Even massive wars do not retard this drive to populate for long, if at all.

For pre-agricultural societies this process seems to be much quicker than most people would, at first, accept.

For example, calculations show the Australian continent could have been entirely populated by a single extended family group over the course of 2000 (100 generations) years, and that is without the benefit of agriculture (recent discoveries have shown that some aboriginal groups were approaching a proto-agricultural stage of development!)

CONCLUSION

So, there you have it. Seven broad rules to guide you in the first steps of civilisation creation (or civilisation reconstruction!).

More detailed information, and “*crunchier*” rules, are provided in the following sections ... *Farm, Forge and Steam*.

FARM



"Don't pray for the rain to stop; pray for good luck fishing when the river floods."

— Wendell Berry, *Farming: A Handbook*

"Farming looks mighty easy when your plow is a pencil and you're a thousand miles from the corn field."

—Dwight D. Eisenhower (1890-1969), 34th US President

"You can make a small fortune in farming - provided you start with a large one"

—Anonymous

"Buy land. They ain't making any more of the stuff."

—Will Rogers (1879-1935)

THE PROBLEM WITH FARMING

Most people think food comes from the corner store (or supermarket) and have little or no understanding of how it is produced, or how many people are involved in producing it.

A modern first world farmer can produce enough food, per capita, to feed fifty (yes, 50!) or more people; even a collectivized soviet era second world farmer could produce enough food for twenty or more people.

Modern mechanised, chemically assisted (fertiliser and insecticide) agriculture is *massively* productive.

Most of the world does not enjoy these advantages, and their farmers are *much* less productive.

The *majority* of the world is *still* at *subsistence* levels of agriculture, just as they were in pre-modern times

Which means that these farmers produce *barely* enough to feed themselves, have enough seed grain left for next year's crop, and have a tiny surplus. Typically less than 1/10th of the amount needed to feed a person.

In a *good* year.

On average, pre-modern societies could expect famine at least four years in every ten in any given province sized area. Oh, and the low level of transportation technologies in pre-modern times meant that moving grain from regions of plenty to regions of famine simply wasn't a realistic option.

Until the great advances in scientific agriculture began to really get under way in the 17th century, for most of the world, this was the state of affairs. It took around *nine or ten* full time farmers to produce enough food surplus to support *one* non-farmer.

From this *tiny* surplus *all* of the ruling class, warriors, priestly class, and *all* the non-farming specialists (smiths to scribes, masons to courtesans) of pre-modern societies were supported.

THE MARGIN OF SURVIVAL

Calculations from the early 18th century show that around 1.5 hectares of "average" *agricultural* land was needed to support a single person, allowing for the needs of crop rotation.

The yields gained from the principal crops, cereals such as wheat and barley for the most part, were extremely poor compared to modern results.

The margin was so thin that a single bad harvest was hardship but two consecutive crop failures were a disaster. Plague. Flight. Even cannibalism

Famine was a recurring problem even in the richest agricultural regions – the average European country could expect to suffer from a *general* (i.e. *nationwide*) famine one year in ten, but it *could* be as often as one year in *four*.

Localised famines were as common – and as devastating, given the primitive state of transportation technology.

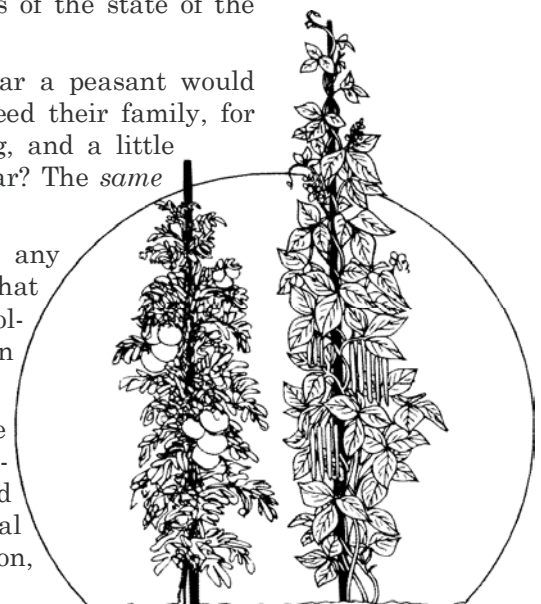
TAXATION IN KIND

Taxes and rents (whether paid in kind or in money) were *fixed* and came *off the top*, regardless of the state of the harvest.

In an average year a peasant would have enough to feed their family, for next years sowing, and a little over. In a bad year? The *same* tax was paid.

So, paradoxically, any food reserves that existed were controlled by the urban populations!

In famines large numbers of starving peasants would descend on local towns in desperation, begging for food.



Recurring famine in Asia it could be *terrifying* – national or local famines could be so bad that survivors were forced to resort to **cannibalism** – as often as three or four times a century.

Even the more primitive peripheries of Europe could suffer greatly – the AD 1696-7 famine in Finland reduced population there (*perhaps* by emigration as much as starvation) by 25%-30%.

Cannibalism was not unknown even in relatively well off western european countries, but was never as widespread as it could be in asian famines.

But lack of food was not the major problem. In the most widespread famines starvation was overshadowed by disease as the major cause of death.

Under such circumstances, death could result *either* from major epidemics that tend to arise in hunger-weakened populations *or* simply by contracting a “normal” disease that a hunger weakened immune system couldn’t fight off.

The problem was compounded as epidemics were only rarely of one disease, multiple concurrent outbreaks seen as “one” epidemic were common.

EUROPEAN FAILURE

Wheat exhausts the soil in which it is grown to the extent that it cannot be grown in the same field two years in a row *unless artificial fertilisers or large quantities of manure are used*.

And that was where whatever manure was available was used on the wheatfield *exclusively* – so an acre of Wheat would produce *twice* the yield of an acre of Barley, the reverse of the modern situation.

The dilemma facing pre-modern farmers was that to produce more food they had to either bring more land under cultivation *or* they had to make the land more productive.



SHIT AND HISTORY ...

Artificial fertilisers are only available in modern times, mainly as a result of industrial development resulting from the Industrial Revolution.

Manure was limited in availability by the limited availability of fodder for the animals that produced it – low productivity meant only limited numbers of domesticated animals could be kept. Human manure was used in some parts of the world (mostly Asia) but was looked upon with great suspicion and complete disgust in other parts (especially Europe).

But the only way to make it more productive was to use more manure on it, and the only source of manure was from livestock.

The problem was that they couldn’t raise more livestock because *that* required more pasture and, by the 17th century AD, they had run out of suitable pasturage. It was simply more productive to grow more crops on newly cleared land than it was to increase production by a greater use of manure).

AVERAGE CROP YIELDS

In Roman and pre-roman times the *average* crop yields across the range grown were on the order of 2-3:1, or between two and three kilos at harvest for every kilo sown in average years.

From the harvest totals you had to first subtract the seed needed for *next years* crop, leaving 1-2 kilos to feed not only the farmer and his family, but the *entirety* of his societies non-farming specialists. A *very thin* margin.

However, improvements in agricultural techniques and technology meant that, from the around the 11th century AD, yields had improved to a ratio of 3-4:1.

By the middle of the 13th century crop yields made another sustained jump to a yield of 4-5:1, but only in France and the UK (reaching to Germany and Poland by the 16th century, but the rest of Europe as late as the *early 19th century*).

It was *this* major jump in productivity that enabled the massive urban growth rates of the later middle ages and which gave rise to the expansion of towns and cities on a scale not seen even under the Roman Empire.

More food = more people = bigger cities

By the beginning of the 16th century the UK and the Netherlands made the next big productivity jump to a return of 6-7:1 (only achieved by France, Italy, Spain, Portugal, Germany, and Scandinavia in the 18th century).

The final pre-20th century improvement occurred in the UK and the Netherlands from the middle of the 18th century, when productivity jumped to a 10:1.

The 20th century brought mechanisation and industrialisation processes to agriculture, boosting yields to 20:1 by the middle of the century and 40:1 by century's end.

BETTER TECHNOLOGY?

There is an ongoing and vigorous debate as to *why* agricultural output improved so dramatically from classical times onwards.

Older theories imply it was entirely due to the introduction of the *heavy mould-board plough* and the *three field system* of crop rotation while more recent arguments counter the importance of these.

Certainly improved ploughs (requiring larger teams of oxen, creating *more* manure which boosted crop yields by itself!) were a factor in *some* areas and *not* in others.

The *three field system* *did* provide extra forage for the larger plough teams, but only with certain soil types.

It seems that there were a whole host of small things, minor tweaks, that, when all taken together, added up to this substantial improvement.

TIME TRAVELLERS ...

Time travel stories are popular genre choices, but do they stack up?

Drop a *single* character or a *small* party into a pre-modern society and they *probably* won't over-stretch the local food supply.

But drop a *whole town*? Especially one without extensive farming assets, into that same pre-modern society and the picture changes *lethally* – as the local food supply is overloaded.

Unless the inhabitants can survive till they *can* grow crops – or steal it.

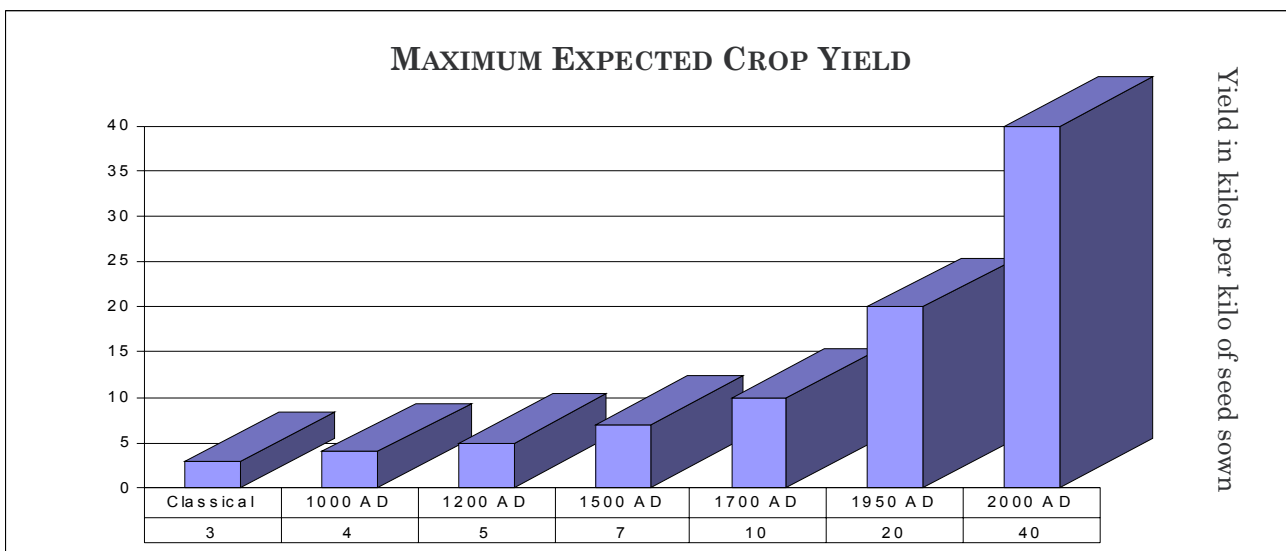
Climate change also played some role – periods of more stable or less stable weather helped along/retarded crop yields as a whole.

Also important was the introduction of foreign (non-native) crops into Europe which offered improved yields or which grew on land previously thought to be marginal or useless.

Europe also had a significant advantage over China and Asia because they used marginal land for raising stock, an extra source of protein meat-averse asians did not have and using land that, in asia was unsuitable for growing the staple crop, rice.

GROWING INFORMATION

To confuse the issue completely there is considerable evidence from medieval Europe that monastic orders that owned *and directly managed* agricultural lands were able to achieve yields of at least *double* the expected maximum (i.e. a return of 8:1).



The assumption is that the increased yields were because the monks were capable of keeping better records and had the capital available (from bequests by the faithful) to experiment with improved farming techniques.

If the techniques proved to be superior, records proved it, and allowed other monasteries to learn the same lessons.

Temporal landowners, even wealthy ones who had the capital, rarely had the literate staff to manage their widely dispersed holdings who could benefit from such knowledge dispersal.

TRANSPORT

At least as important as the other problems – was *transportation*.

Until the invention of the railroad and steam locomotive in the 19th century there were only two ways in which any sort of food could be transported – by land or by water.

Water transport was greatly preferred, and sea transport was greatly preferred to river transport.

LAND TRANSPORT

Land transport involved the use of animals, either as pack animals or to draw wagons. And these animals inevitably consumed food themselves.

Worse, since land transport over any distance *and* many agricultural and industrial processes required animal power, those animals had to be fed, and every hectare of pasturage and every kilo of grain provided them was effectively a hectare or kilo *less* available for the human population.

A rule of thumb was that animal drawn conveyances carrying food would consume the same amount of food as they could carry in 200 kilometers of travel.

In spring and summer this could be minimised by using oxen which could do useful work entirely on green fodder available anywhere.

Even horses were *more* economical because they could be fed on green fodder *supplemented* with grain.

But come autumn and winter and the supply of green



CROP YIELDS AND SOWING DENSITY

The problem with determining crop yields for a given time and place is that there are, until the medieval period, few, if any, records of such.

Even medieval records are scattered and incomplete – so the picture we gain from them must *also* be tentative.

One *possibly* significant factor is that the typical *broadcast* method of sowing crops (taking a handful of seed and casting it outwards in a semi-circular motion, to fall randomly on the ploughed field) was *also* associated with a *lower density of planting per acre* than modern cropping.

At some indeterminate time and place, *probably* during the medieval period, this changed to a *higher density of planting per acre* – but still not to modern levels.

The obvious result? The same amount of land could now produce more food.

The gradual development of agricultural machinery – the seed drill, for example – meant that crop density per acre (and yield per acre) could be boosted proportionally.

A big result from a simple, change!

fodder disappeared and animals had to be fed from stocks of hay and grain which were finite.

This simple fact, availability of green fodder, was one of the key reasons, for example, why pre-modern military operations ceased in autumn and could not begin again until early spring.

SEA AND RIVER TRANSPORT

Sea transport was *much* less costly, you could transport grain between sea-ports thousands of clicks apart for less than it would cost to haul it by land for a couple of hundred clicks.

River transport was more problematic than sea transport. Suitable rivers connecting areas of shortage with areas of plenty were not common and the weather that affected the crops of one area could result in low water levels in the river access that would render an otherwise suitable river unusable.

Worse, the whole length of the river was subject to interference and interdiction by land based forces whereas for

seaborne trade only the ports at each end could be easily interdicted.

MECHANISATION

The final improvements in agriculture have all been either through more productive crops or more labour efficiency.

The *real* bonus started during the 17th century at the same time that population increase and improved technology kicked off the *Industrial Revolution*.

Even though industrial productivity of was low even compared to the 18th and 19th centuries, improved tools dramatically increased the productivity of agricultural labour.

Since population growth had *already* caused the conversion of all suitable land to farming, this meant the number of people needed to feed the existing population plummeted.

The excess rural population were readily soaked up by the cities as cheap labour and the cost of undertaking all sorts of industrial expansion and experimentation *also* plummeted.

The innovations that resulted from this improved farm output considerably, they also provided a vast market for manufactured goods and for the food needed to feed the increasing number of industrial workers.

The result?

A population/productivity explosion that continues even today.

AGRICULTURAL PRODUCTIVITY ...

One hectare of *average* farmland produced three hectoliters of wheat from one hectoliter of seed (about 230 kilos per hectare) – *average* food consumption was approximately 3 hectoliters per person per year.

Therefore, 1 km² of average farmland could produce 23 metric tons of wheat, of which 7.7 tons has to be reserved as seed grain for next year's crop.

The remaining 15.3 tons could feed around 65-66 people for a year.

In a good year.

When a 3:1 yield was considered "normal."

And not allowing for spoilage.

FROM THE RICE BOWL

A hectare of paddy field will produce around 3000 kilos (about 39 Hectoliters) of rice per annum, but some weight is lost in the processing (unlike wheat or barley), so actual *food grain* production is c. 2100 kg.



Rice has important advantages over cereals commonly grown in Europe. Firstly, it can be grown repeatedly on the same plot of land, year in, year out, with no need for crop rotation. Secondly, you can get two, possibly three, crops per growing season!

The downside is that it requires *lots* of water and this limits where it can be grown (all those terraced hillsides are *very* recent developments, born of desperation) *and* the fact that it requires *much* more intensive human intervention in all stages of its growing.

Rice (*aquatic* as opposed to *dryland* rice, and aquatic rice is the productive form) was a latecomer on the agricultural scene, only appearing (probably on the Indian subcontinent) around 2150-2000 BC and reaching China (by sea) within a century or two.

Before that time (and after, in northern China) Sorghum, Millet and Wheat were the staple crops.

These early varieties of Rice were slow to mature, only producing a single crop a year. Fast maturing Rice was only developed after the 11th century AD.

Strangely enough, Japan adopted Rice based agriculture even later.

It didn't arrive there until some time in the 1st century AD and did not become the dominant crop until the 17th century!

Prior to that?

Millet, Barley and Wheat were the staples and, of course, the Japanese population was quite low compared to what was possible after the introduction and spread to dominance of rice aquaculture.

THE ASIAN MARGINS ...

Lands not *easily* suited for rice aquaculture were mostly ignored and sparsely populated until asian populations reached the limits that could be supported by existing lands.

Then they went to massive efforts to convert marginal land (by terracing hillsides for example) before the introduction of new world crops made dryland agriculture attractive.

ORIENTAL CONSEQUENCES

The adoption of rice aquaculture provided a more productive and secure crop base which allowed for larger non-farming populations (and for larger or simply more numerous cities), but there were serious consequences.

The most obvious was that the peasant farmers who grew the rice were almost completely consumed *with* working it (it is *very* labour intensive to cultivate) unlike european peasants who had free time between sowing and harvest.

This meant that the european world had a much larger labour pool available for non-agricultural pursuits on a seasonal basis than did the asian world, partly or completely negating the numerically larger populations that could be supported in the east.

The other major problem was that the massive success of rice aquaculture turned the asian populations away from using marginal lands at all while european populations used them as intermittent croplands or, more commonly, as pasturage for meat and fiber bearing animals that supplemented their agricultural production.

In times of real, severe, multi-year famine, asian communities had none of the cushion these marginal lands provided European communities and were therefore much more likely to be forced to the extreme of cannibalism for survival.

These factors meant Asian populations were less flexible and less productive in non-agricultural areas than the populace in the european world.



THE NEW WORLD

The two major food crops of the New World, maize (corn) and potatoes, were unusually productive compared to *any* of the old world crops.

Their introduction to Europe, though slow, allowed population growth beyond that sustainable with improved and more productive traditional crops.

Despite the conservatism that meant European farmers were slow to accept these crops as viable and, even when they did, slow to accept them as suitable for anything other than animal feed.

MAIZE

Maize was probably the last of the major food crops transformed from a wild ancestor by man, the long and complex process (see *(A)Maizing Origins*) probably beginning some time in the 2nd-3rd millennium BC, but probably not being recognisably complete until some time in the 1st millennium AD.

Originating in central Mexico, maize cultivation spread slowly north and south, and was, for example, in the process of being climate adapted to the northern parts of the eastern seaboard of north america when the first european explorers and settlers arrived.

Unfortunately, the whole domestication and acclimatization process was so slow that it did not allow time enough for the development of cities and civilisations outside of mesoamerica, though trends in that direction are obvious.

Maize has some admirable qualities to recommend it – the plant is quick growing and the grain is edible even before it ripens fully, and the kernel may be stored for long periods

Yields are very high, a return of 70-80 kilos per kilo of seed sown being the *minimum* in even the most marginal (semi-arid) areas, and yields of 150 kilos are a *bare minimum* for good land.

Where incomplete climatic adaptation had been achieved, yields were lower, but still attractive.

In perfect conditions, yields of up to 800 kilos return on a kilo of seed were recorded in pre-modern times.

The major drawback is that it is an inadequate food by itself, the meso-

(A) MAIZING ORIGINS

The *Teosinte* plant – proved to be the ancestral form of Maize by modern DNA testing – is so different from its descendant, and so obviously unsuitable (in its primitive form) for agriculture of any sort, it is still a matter of considerable scientific argument not only as to how *long* it took to be transformed into Maize by selective breeding, but *how* it was transformed.

Americans had no suitable *large scale* source of protein, though varieties of beans and squashes were grown in a permaculture arrangement with it.

Apart from game birds and animals, fish, and the Chihuahua dog, the meso-americans had no real source of animal protein, so the Spanish were taller and stronger than the local Indians (on average) because *they* had significant quantities of protein in *their* diet.

Maize was grown in some parts of the Balkans and Venice as early as the 16th century, but it did not become a major food crop until the late 18th century.

Even when it did “catch on” it was as a food for *livestock* and the *poor*. Peasant farmers sold their wheat crop, fattened up the stock they intended to sell on it, and ate maize flour.

It was as slow to catch on in Asia, only adopted (again by the poor) in the 18th century AD when the limits of suitable land (even counting hillsides that could be, with much labour, terraced) had been reached and the expanding population had to feed itself from land totally unsuitable for rice aquaculture.

POTATOES

Potatoes *probably* originated in the Andes, *possibly* at high altitudes.

Certainly they were a commonly grown food crop by 2000 BC, especially as they *could* be grown at the high altitudes that where maize would *not* grow.

Despite high yields and an ability to grow in marginal land, European farmers were even slower to adopt it than they were to adopt maize, though *gardeners* grew it for its decorative flowers (as they did with tomatoes, which were thought to be poisonous!).

It did not become a widespread *euro-pean* food crop until the late 18th/early

19th century, though then it quickly became a staple, along with a little milk and cheese to supplement it.

Potatoes were adopted slowly and with great reluctance, despised even by the desperately poor unless faced with starvation. *Despite* the fact that land supporting only a single person if used to grow *wheat* would support *two people* if *potatoes* were grown instead.

CONCLUSIONS

If farming was so obviously superior to a life of nomadic hunting and gathering, why was it not developed sooner, and why was it developed sooner by some cultures than others?

The fact is, to a hunter-gatherer who has no concept of agriculture and no idea of how to develop it, it *isn't* “obviously superior.”

The peoples who *did* develop it (rather than acquiring it from someone else) had *no idea* that they were doing so.

They did *not* simply sit down one day and say, “*Hmm. Let's invent agriculture!*”

They had *no idea at all* that that was where their actions were leading. It just happened fortuitously.

PROTO-AGRICULTURE

The late neolithic “hunter gatherers”, at least in the “Fertile Crescent” where agriculture first developed, *already* had a sedentary, settled, lifestyle.

They lived in what would later become some of the richest farmland around.

The land was rich in wild plant foods and had an abundance of wild game that enabled proto-villages to come into being without the *need* for farming to be invented!

The development of these proto-villages was the watershed in the development of agriculture.

So sedentary town life pre-dated and led to the development of agriculture, and *not* the other way around as most of us would have guessed.



The earliest domesticated crops were those that had a single gene, mutant variant that made them suitable for domestication and human intervention in their growth cycle – but which was actually deleterious in the wild version.

For most grass-descended crops (wheat, barley etc.) this was a mutation that prevented the stalk just below the ear shattering when the seeds were ready to be scattered.

If the stalk did *not* shatter, the seeds would not be spread. But the *mutant* form, where the stalk does *not* shatter, is better for farmers. leaving the grains on the stalk where they are easily harvested rather than fallen and scattered on the ground.

These early proto-farmers, by the simple fact that they tended to gather the seeds of the plants *with* the mutation preferentially (since they were easier to gather), were actually, without knowing it, *selectively breeding for the mutation to become dominant.* And that is, of course, exactly what happened.

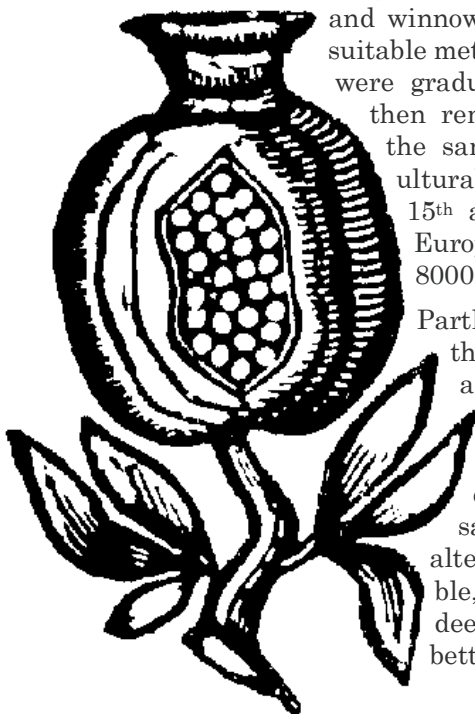
UNSUITABLE TOOLS

But, even so, the technology available for harvesting, processing, and storing the grains gained from this process took longer to develop than the selective breeding did.

Crude, unsuitable plough designs, broadcast sowing, hand held sickles for harvesting, labour intensive threshing and winnowing, and marginally suitable methods of grain storage were gradually developed, and then remained substantially the same until the “Agricultural Revolution” of the 15th and 16th century (in Europe, at least), some 7-8000 years later.

Partly this was because the solutions that were adopted and gradually improved *worked.*

Partly it was because it wasn't necessarily obvious that alternatives were possible, or needed, or, indeed, would prove to be better or more economic.



But, probably, it was mostly because the *really* good improvements required *other* developments to be made before they were *possible*, let alone *feasible.*

For example, Scythes are far quicker to use for harvesting than Sickles, but they are also less precise and lead to a small, but significant, wastage of the crop being harvested.

As long as the productivity of agriculture was extremely low, *any* level of wastage was unacceptable.

Then, of course, a Scythe required more iron than a Sickle, and was thus more *expensive*, and only became affordable when better technical means for producing iron and steel were adopted.

Harvesting machines, even horse-drawn ones, are even faster and more efficient in their use of manpower.

But they require mass produced precision machined parts and lots of iron, and the infrastructure *for* all that to be available.

These were simply not available to the early agriculturalists, and the technologies that made them possible required hundreds, or even thousands, of years of change, development, and invention before they could *become* available.

AGRICULTURAL DETERMINISM ...

So, was the development of agriculture inevitable?

The evidence that is available to us *seems* to strongly suggest that the answer is *yes.*

Everywhere that human beings settled where it has proved *possible* to lead a settled, agriculture based, lifestyle, this lifestyle was either fully developed *or* there are (or were) signs that the local people were moving in that direction.

So, yes, *eventually*, even without trade and colonisation spreading the most useful crops beyond their areas of origin, it is likely agriculture would have developed *everywhere it was possible.*

Of course that development process would take *much, much longer* in some places than in others because of the poor basket of potentially domesticable plants and animals available.

AND GIVE US OUR DAILY BREAD

For most of the pre-modern period, *cereals* and *vegetables* have formed the *overwhelming* bulk of humanity's diet for the simple reason that agriculture provides 10-20 times the food output per acre than does stock raising.

That said, however, until European population started to push the absolute limits of land availability (and the absolute limits of pre-modern agricultural techniques) and "wild", uncultivated, land filled up around the 17th century, meat (from domesticated stock or wild game) formed a small, but still significant, part of the diet of all but the very poorest.

Asia was a different matter entirely since Asian societies basically ignored the possibilities of raising stock on land unsuitable for conventional (in their case, often rice) farming and left those areas uninhabited and unused.

A well fed modern male requires around 3500-4000 calories per day to maintain good health.

This sort of caloric intake was *probably* achieved by the upper classes and well-to-do in pre-modern times, it was *not* achieved by the lower classes on a sustained basis (if at all).

But the rural and urban poor probably survived on no more than 2000 calories per day.

However, this figure does not include wine or beer, so the dietary deficit was *possibly* not as huge as it seems.

Still, chronic malnourishment could (and *did*) have serious consequences for populations as a whole (as detailed elsewhere).

CEREALS & BREAD

In pre-modern times Wheat was rarely grown by itself, it was normally found being cultivated alongside fields of other cereals – especially Spelt, Oats or Barley, and Millet.

In fact, the rural poor (including most peasant farmers or serf equivalents) didn't *eat* the wheat they grew, it was sold at the local town market to raise the cash needed for payment of taxes or for the purchase of those things that even the most self-sufficient farming family simply could not make.

Alternately, if money taxes were not levied then taxes in kind were at a preferential rate for wheat).

BARLEY BREAD

Barley was the cereal grain of choice for making the daily bread of the typical peasant or urban working poor.

It was *also* the main crop used for feeding horses that were required to do heavy work, especially those used in warfare (either for cavalry mounts or to carry supplies), and a bad harvest of that crop could considerably reduce the possibility for campaigning (in the more northerly parts of Europe, however, Oats tended to replace Barley).

THE COST OF A CRUST

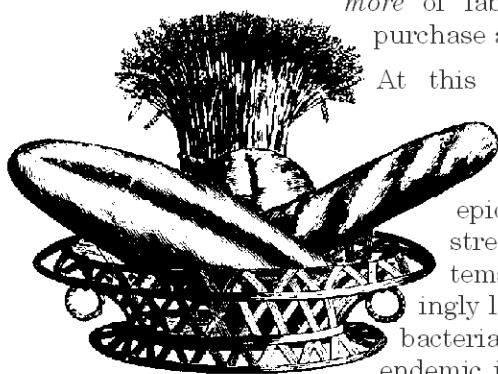
In good times, the cost of a kilo of bread was *an hour's labour*.

If the cost rose *above* this level, an ordinary rural peasant or urban worker could economise and survive with some little difficulty.

If the cost of rose above *two hours* of labour, hunger becomes a spectre, but *most* people (even the poor) would not *starve* to death (though death rates from disease would rise as malnutrition begins to compromise immune systems).

Real famine, and *likely* starvation for *many*, is reached when *three hours* or





more of labour is required to purchase a kilo of bread.

At this point, there is an increasing *likelihood* of an outbreak of one or more major epidemics as hunger stressed immune systems become increasingly less able to cope with bacteria and viruses that are endemic in the local environment or which have been introduced, fortuitously, from elsewhere.

Though these figures obviously apply to societies using the eurasian agricultural crops and dietary preferences, the same cost thresholds that determine the level of hunger or starvation would apply regardless of what society is being examined.

The only difference would be in what the “meal equivalent” of a loaf of barley bread in that society was.

FAMINE GRAINS

Rice was actually well known in pre-medieval europe, imported from the Middle East, and, after a hiatus during the “Dark Ages”, it reappeared by the 14th century (at the latest) and was actually cultivated fairly widely in parts of the Iberian peninsula, the northern Italian plains and parts of the Balkans – but it was never more than a *famine grain*.

Recipes for “famine bread” include a mix of Rice and Millet flour.

Other flour substitutes used in times of famine included ground up *Chestnuts* and *Buckwheat*, and famine breads often had a high *sawdust* content to provide bulk, and were often so tough that they had to be cut with an axe and soaked in water for several hours before they could be eaten.

During the medieval period, at least, the *price* of a loaf of bread was often fixed, and enforced strictly, but the *weight* varied according to the price of the flour from which it was baked.

OTHER STAPLES

European diets, though largely based on cereal grains in their several forms (bread, gruel, brewed drinks etc.) were supplemented by staple vegetables such as Pulses, Lentils, Beans, assorted varieties of Peas and Chickpeas.

SEAFOOD

Though the Romans and Greeks ate large quantities of seafood, this was mainly confined to the Mediterranean and, though important, was never a staple, the small and enclosed middle sea simply couldn't provide the quantities of seafood needed.

In any case, the lack of an acceptable airtight storage technology combined with the slow speed of land transport meant that fresh fish was never seen far from the coast.

Even salt fish was not much further travelled, unless shipped up a major navigable river or canal.

With the collapse of the Roman Empire, fish lapsed in importance in western, non-mediterranean, europe, becoming mostly a poor man's food.

This did change as the medieval period progressed because the Church increasingly enforced Fast Days (around 166 days a year by the late Middle Ages) on which *meat or poultry* could not be consumed, so fish became the accepted alternative.

Even so, it was not until the discovery and exploitation of the Newfoundland Banks from the end of the 15th century that there was a sufficiency of fish on the European market.

In Asia, Fish was more commonly consumed than meat or dairy products but, even so, per capita consumption was low, perhaps an average of 6 kilos a year in many places.

SALT

Salt is vital to both animals and humans – perhaps more so for humans as it has always played an equally vital role in the most common processes of food preservation.

For the most part this meant that humans have always been fast to exploit any available rock salt mines in a given area and, where these do not exist or

are inconveniently far away, they will often resort to evaporative production of salt from sea water.

In Europe there was often a political dimension to salt production. The vast bulk of the evaporative salt production was concentrated in or around the Mediterranean, yet the output of these industries were increasingly largely consumed, from the Medieval period onwards, by the fishermen exploiting the northern seas to produce salt fish.

The trade in salt was so vital that it was allowed to continue even between mortal enemies and even in wartime.

SUGAR AND SPICE

Originally the only source of “sweet” things in Europe and most of Asia was honey.

This was *expensive* for the simple reason that the harvesting of a hive (whether in the wild, or one kept in a man-made structure) almost always resulted in its destruction.

This changed after AD 1860 when the invention of the removable frame hive allowed non-destructive harvesting *as well as* the ability to check for disease.

For this reason, beeswax was also expensive and, since the best sources of light were *beeswax candles*, these were also expensive and generally used only by the rich.

SUGAR CANE

Sugar cane is native to the Bengal coast in India and did not arrive in Europe, and then only as a medicinal, until the 10th century, via Persia, which, in turn, acquired it probably by sea trade, with China around the 8th century AD.

It was grown in Egypt by the 10th century, so much so that cane residue was used as a fuel to smelt metals, especially gold.

It was “discovered” by the Crusaders in the 12th century, from whence its cultivation rapidly spread to Cyprus, Sicily and the Iberian peninsula.

Sugar did not have a major dietary impact until the 17th century when it reached the West Indies and Americas and the massive production achieved there made it more common in Europe, though penetration was spotty until “recent” times.

Sugar Beet, a substitute suitable to the Western European climate, was known by the end of the 16th century.

However it was not widely grown until the middle of the 18th century. Only really taking off after the Napoleonic Wars when advances in agriculture (and a *lot* of selective breeding) made it economically viable.

PEPPER

Pepper was known even in pre-Roman times, and was always a great drain on the precious metal stock of the Mediterranean world, so great was the demand.

However, once the Portuguese opened up the direct routes to the Indies in the 15th century it became more and more common until it lost its “fashionability” and, with a decline in prices resulting from sufficient supply, became a spice widely available to all but the poorest.

COFFEE

Coffee is first recorded in Aden around 1470 AD, having originated in Ethiopia some considerable time before.

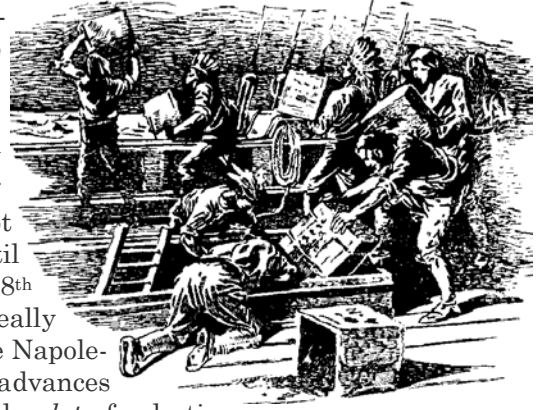
It spread throughout the Muslim world with amazing rapidity, almost everywhere by the late 16th century.

It did not start to penetrate the European world until the very end of the 16th century, but, again, the spread was rapid. It had colonised all of Christendom by the end of the 18th century.

TEA

Tea was known and grown widely in China by c. 400 AD, but did not reach Europe until the opening of trade to the Indies (Indonesia) in the early 17th century allowed European merchants to trade with Chinese merchants at that intermediate meeting point.

However, it did not really begin to become *commonly* available until the latter part of the 17th century, and did not become *widespread* until the early 18th century ... and did not become the national drink (almost!) of the British Isles until the later 18th century.





CHOCOLATE

Chocolate is, of course, native to mesoamerica, but it did not reach Europe until the 17th century, and didn't really become widely popular (except in Spain) until the 18th century.

TOBACCO

Tobacco was first seen by Columbus being smoked by natives in Cuba in 1492, and arrived in Europe as a botanical curiosity soon after. It was in use (as *Snuff*) as a medicinal by the late 17th century.

Chewing and inhaling were, initially, the main ways it was consumed. Pipe smoking did not become popular until the late 17th or early 18th centuries, and cigarettes were only invented (in the New World) in the early 18th century, and only became common during the Napoleonic wars.

Interestingly, governments throughout Europe and Asia tried to ban its use almost as soon as it appeared, with a notable and ongoing lack of success!

Of course, a suitable alternative was soon found, and governments either taxed the trade directly or sold government backed monopolies in it to make it an attractive economic proposition.

THE DEMON DRINK

All but the most primitive cultures have had some form of alcoholic drink for a *very* long time and, if not, they generally have some other drug that enabled them to feel better about their often dismal lives.

WINE

For the Mediterranean world of the classical and medieval period, the beverage of choice was *wine*, normally fermented grape juice (sometimes fermented date or palm juice), rather than brewed drinks (Beer or Cider).

In China, wine grapes were first imported during the 2nd century BC, but the first definite mention of European style wine does not occur until the 7th century AD.

The main problem with wine before the adoption of bottling and *corking* the bottles in the 17th century was that the containers (dovetailed and hooped wooden casks) commonly used (since Roman times, at least) were not fully airtight, allowing the wine to go sour.

Prior to the storage of wines in wooden casks, the storage method of choice was the pottery amphora, and though some amphorae *may* have been provided with a semi-airtight seal (pine resin, which may be the origin of *Retsina*) inside *and* an airtight seal at the neck, this was not universal.

There was no certainty that any wine stored in such containers would not go sour the same way that wine in *ordinary* (unlined) amphorae would. This may explain why the Romans abandoned amphorae for wooden casks.

Some Roman sources hint that ancient vintages were known of and enjoyed, though there is argument as to whether these were really what we would understand to be "wine" today).

Typically "old" wine was sold for 1/10th the price of the current year's vintage.

Before the agricultural revolution beginning around the 15th-16th centuries, the output of vineyards was not particularly high and, since agriculture itself was a marginal pursuit, relatively little land could be economically put under the vine.

But with better technology and practice, yields rose and, of course, more land could be spared for vineyards, and so production – and consumption – rose dramatically.

By the Renaissance the common people of the Mediterranean world were drinking an average of around 100-120 liters per year (though, of course, not of the best vintages!).

BEER

Beer is almost as old as Wine, being first discovered by the Sumerians around 5-6000 years ago, and brewed from yeast mixed with Wheat, Oats, Barley, Rye, Millet and even Spelt, though always mixed with some other element for flavour (such as poppy seeds, aromatics of various sorts, honey, sugar, bay leaves and more).

Hops were not an ingredient before the 8th century (first mentioned in Germany) and did not reach the Low Countries until the 14th century and the British Isles only in the 15th.

For most of the classical and medieval periods Beer was either unknown in the lands where viticulture flourished or was seen as the drink of the poor.

In those lands not suitable for wine grapes, the status of Beer was higher, though still seen as inferior to wine (which was imported for the wealthy).

CHINESE “WINE”

There is no ancient Chinese word for “wine,” and the word normally used when referring to it *actually* means “distilled or fermented.” So most ancient Chinese texts that seem to mention “wine” are actually referring to beer, cider, or distilled liquor.

CIDER

Cider was known from ancient times, but was very different from a “modern” cider, made by boiling fruit pieces (typically apples or pears) in a vessel with fermented juices.

These early ciders were extremely popular and Charlemagne passed laws to punish anyone who harmed an apple tree because of the value placed on *Perry* (the older term for cider).

Cider (or Small Beer) made from Cider Apples originated with the development of Cider Apples in the Biscay region of France in the 11th century.

It spread slowly, only reaching Brittany a century later, where the idea of *pressing* the apples for juice to ferment was developed, and then to the Low Countries in the 14th century and Normandy in the 15th-16th centuries.

It was *also* seen as a drink for those too poor to afford wine.

SPIRITS

Distilled alcohol was first discovered in China some time during the 7th century, probably as an unexpected development of alchemical research or perfume distillation, though whether this was based on distillation of wine or of some brewed beverage is not certain.

Islamic alchemists seem to have independently discovered a distillation

EARLY BRANDY DISTILLATION ...

This involved the use of open vats of wine being boiled while sheepskins were hung above them, wool side down.

The alcohol, having a lower boiling point, would evaporate first and then be recovered by removing and pressing the sheepskins from time to time.

No wonder early brandies were rare and expensive!

technique in the 9th century, and the knowledge spread to southern Italy as early as the 12th century (but only as a *medicinal, aqua vitae* [“water of life”] distilled by Apothecaries).

Spirits were entirely a product distilled from *wine* (that is, the products were *Brandies* in modern terms) until at least the 16th century.

Spirits did not reach France even as a medicinal until the 14th century.

Spirits only became common in the 16th century, *more common in the 17th*, and were only widely consumed from the 18th (as a result of increasingly efficient distilling techniques).

ICE WINE

The steppe nomads of central asia discovered that wine could be “fortified” by being frozen, the water-ice was removed, leaving a much higher alcoholic content, probably some time in the 3rd century AD.

The Germans discovered “Ice Wine” in the 1700’s – in grapes frozen by an early(ish) freeze.

Pressing frozen grapes produces only 20% of normal, but it is concentrated, sweet and can have up to 14% alcohol by volume (2% more than the 12% for “normal” wines and 4% less than the 18% expected in Fortified Wines).



ALL IN A DAY'S WORK

FARMING: THE BASIC RULES

What can we learn from the information presented in *Farm*? How can it be used to update an existing background – or designing a new one from scratch?

Rule # 8: In pre-modern times, farming is an *extremely* precarious pursuit, and there is *no* way of ensuring security of food supplies.

Until the development of improved farming technology even the availability of extremely productive crops (such as quick maturing rice or maize) could not ensure that there would be enough to eat everywhere.

Famine, sometimes to the point where massive population reductions occurred (on the order of 20% or more) and even to the point of cannibalism and mass suicide, were a regular occurrence and could not be guarded against in any significant way.

Rule #9: The *rich* don't starve. And don't care if the *poor* do.

The way of the world is that most land is owned, or taxed, by the rural nobility and gentry and the well-off urban upper and middle classes, and when there are food shortages, these classes may have to forego their normal levels of consumption, but they won't starve.

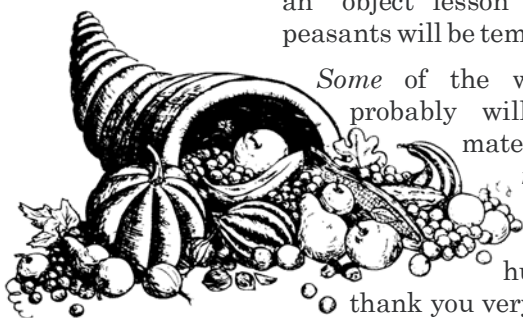
The *poor* rural and urban workers?

They starve or die of the diseases that commonly stalk the starving.

Or they become revolting.

And if they revolt, the well-to-do crush them with the greatest of brutality as an "object lesson" so that no *other* peasants will be tempted to do the same.

Some of the wealthy may (and probably will) provide *modest* material aid to *small* numbers of the poor (*alms*) but they won't be going hungry themselves, thank you very much.



Rule#10: The *overwhelming* majority of pre-modern farmers are *subsistence* farmers. Lack of capital, human and physical, means that they are generally unable to undertake even the most basic steps to increase the productivity of their land.

The fact is that the low yields of pre-modern times were *not* inevitable.

There was nothing *inherently* limiting about the technology available – but the vast majority of the population were subsistence farmers who had neither the physical capital nor the education needed to take advantage of even these basic improvements.

A BALANCING ACT ...

Rule #9 is true – the rich *don't* care if the poor starve, but there *is* a balance. The "lesser orders" *do* have a place – they are, after all, needed to do the scutwork and grow the crops that can be taxed to feed, clothe and otherwise look after the rich.

If too many die – or flee – then the rich will be somewhat discomfited. They *may* have to pay higher wages, reduce taxes and rents (slightly, and temporarily, of course), or even (with extreme reluctance) grant some legal concessions on status or rights. And they won't like doing it *one bit*.

They'll claw back any concessions as rapidly as they can. They'll make sure the concessions are as localised, limited, and short term as possible.

If the peasants are revolting? No concessions. No quarter. No mercy. Not to the rebels. *Possibly* to the cowed survivors – but only once they have been taught their place.

Of course, the rich can't simply kill *all* the rebels – that would be counter-productive. But wiping out an entire village here or there? No problem!

Wat Tyler, for example, didn't survive *his* leadership role – and neither did most peasant leaders.

THE TRANSPORT PROBLEM ...

Land transport was the limiter for famine relief – at least until the invention of the steam locomotive.

Why? Well, land transport in pre-modern times was based on *muscle power*. That meant that the *owner* of the muscles had to be fed – whether a human porter, a pack animal, or a draught team pulling some sort of wagon or sled.

The result was a practical limit as to how far food could be carried – at some point the amount consumed by the porter/draught animal would equal what they could carry.

Worse, the number of draught animals that could be supported in any region even in non-famine times was limited by the simple fact that they had to be fed either the same crops that humans ate *or* whatever it was that they *did* eat had to be grown on land that could *not* be used for growing crops for humans.

Steam locomotives changed all this. They didn't consume food. They didn't require agricultural land to be set aside for their maintenance.

They “ate” coal – and coal was a far more concentrated form of energy than wood (which required farmland to be grown anyway) *and* coal could be mined in such large quantities by such small numbers of miners that the food required to support steam locomotive technology was minimal in comparison to the benefits it brought.

Of course, steam engines, their underlaying technology, the tools needed to construct them, and the infrastructure needed to support the technology and tools needed to construct them were probably not possible at all significantly before the 1800's – or a similar level of technology, infrastructure and support in a created background.

Still, they changed the face of history ...

Famine no longer *needed* to be a common occurrence.

Even the upper classes often weren't much better placed. They may have had the physical capital, but they lacked the *educational* background to be able to grasp the concepts for even basic improvements to be implemented.

Those groups in a society who had *both* physical capital *and* educational backgrounds needed could, and did, regularly achieve crop yields *twice* the average expected in the period up to the 16th century.

However, even these groups did not have enough *additional* resources to spread these improvements to the less favoured in society. It took millennia for these resources to be gradually accumulated – but, by the 16th century the “take off” point had been reached and there was an acceleration in agricultural yields unlike anything that had been achieved before.

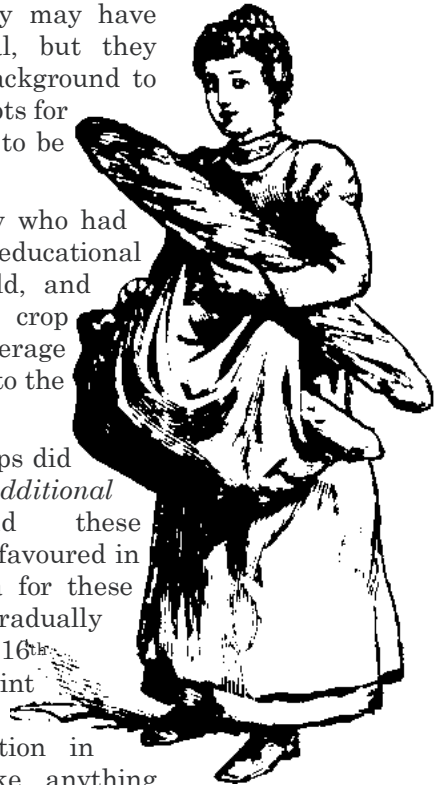
Rule #11: It doesn't matter if there's an abundance of food *somewhere else* if there's no economical or practical way of getting it *here*. Famine can be an intensely localised thing as well as being widespread.

The abysmal level of transportation technology in the pre-modern period meant that many famines occurred in quite limited geographical areas within a “nation.”

There was often plenty, or at least sufficiency, in *other* areas but the cost (both in money and in resources) of transporting the food from those areas to the area that was afflicted was almost always prohibitive.

The only real exception was for those areas close to a seaport – sea transportation being the only real economic option. But even this was limited – the large scale infrastructure of ports and ships suitable for and intended to carry grain and foodstuffs was limited.

What it almost always meant was, again, that the *rich* survived while the *poor* suffered.



FORGE

"Everything that can be invented has been invented."

Duell, Charles Halliwell (1905-1970), US Commissioner of Patents

"What, sir, you would make a ship sail against the wind and currents by lighting a bonfire under her decks? I pray you excuse me. I have no time to listen to such nonsense."

Napoleon (1796-1821) to Robert Fulton

"In questions of science the authority of a thousand is not worth the humble reasoning of a single individual."

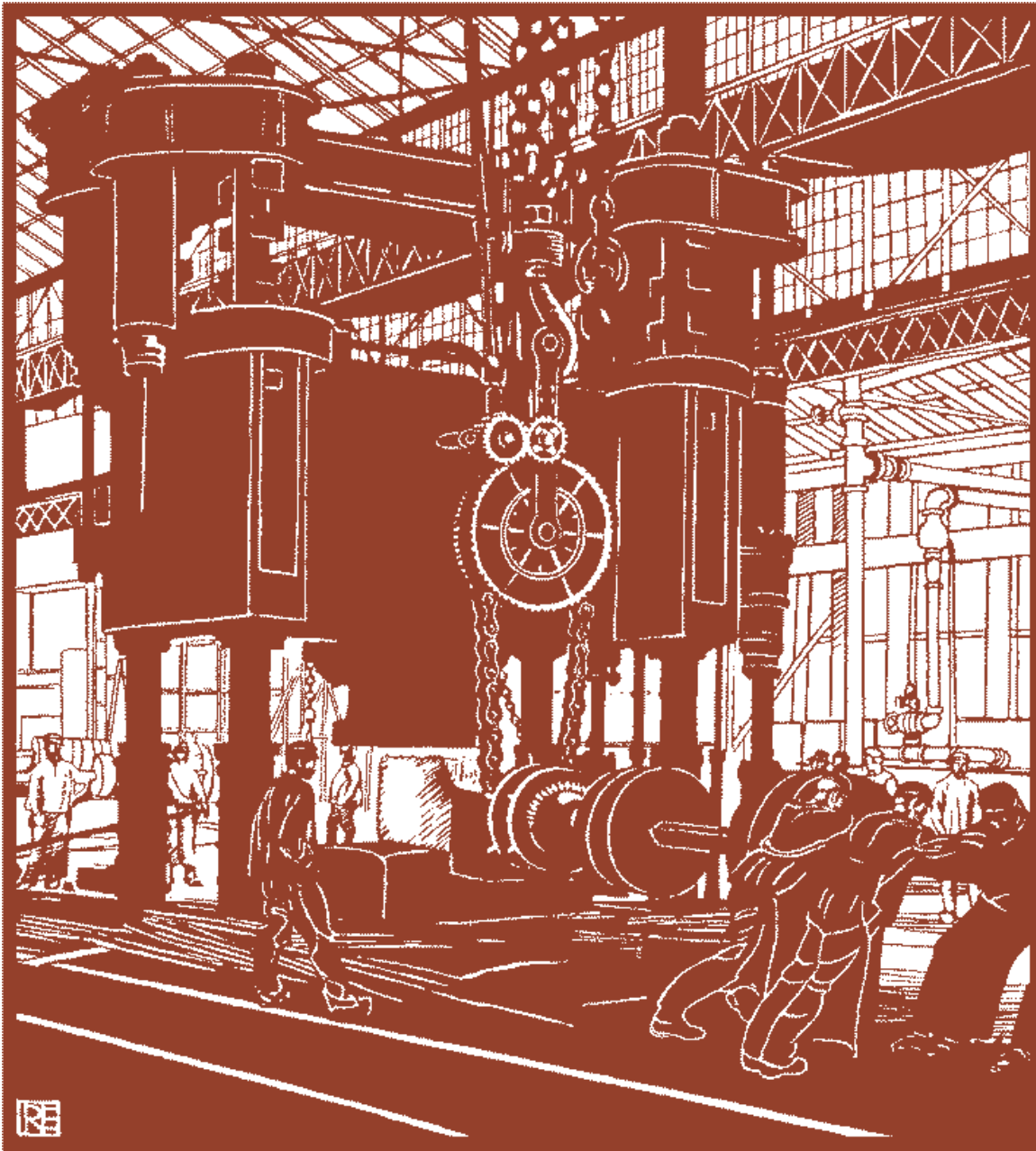
Galileo Galilei (1564-1642)

As long as men are free to ask what they must, free to say what they think, free to think what they will, freedom can never be lost, and science can never regress.

Julius Robert Oppenheimer, US Physicist (1904-1967)

"For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled."

Richard Feynman, US Physicist (1918 - 1988)



FROM THE FORGES OF THE GODS

The key element in the advance of civilisation, apart from agriculture, was the discovery and gradual mastery of metals, but this was a slow and uncertain process and it took many millennia before the *age of metals* could, at last, be succeeded by the *age of machines*.

THE AGE OF METALS

Metals were *initially* used for *decoration*. Neolithic technology was perfectly suitable for proto-agricultural and proto-urban lifestyles.

Only when these proto-civilised societies reached a “critical mass” social complexity and sophistication that this began to change.

THE FIRST METALS

The first metals used were obviously those that required the least processing – which meant mainly gold (available as nuggets and “dust” in alluvial deposits) and copper (which is also found as “nuggets” under some circumstances).

Neither were really useful for anything *other* than decoration (they are *far* too soft), and they were in limited supply anyway.

USEFUL THINGS

However, neolithic peoples eventually discovered how to fire pottery (probably by accident) and, in turn, developed pottery kilns which achieved temperatures high enough to smelt copper ore.

This, in turn, probably by accident, led to a great increase in the availability of metals more suitable for day to day use, starting with the discovery of copper.

THE BRONZE AGE ...

Archaeologists estimated that the *native* production of Bronze in Egypt during the “Bronze Age” was on the order of *four tons per year*. This meant that most of her requirements had to be imported from elsewhere.

In contrast, the eastern Alps probably produced *four times* as much per year.

The theory is that ground up copper ores were being used as glazes and that the high temperatures *accidentally* smelted the metal, and that things went from there (the theory that it started with rocks around a campfire has been discarded as the temperatures achievable, 600-700°C, are not enough to smelt copper (1200°C) whereas a pottery kiln easily achieves temperatures exceeding 1400°C).

These developments just “happened” to occur where existing cultures developed high temperature pottery kilns (Sumeria and Egypt), so the connection seems reasonable around the end of the 6th millennium BC.

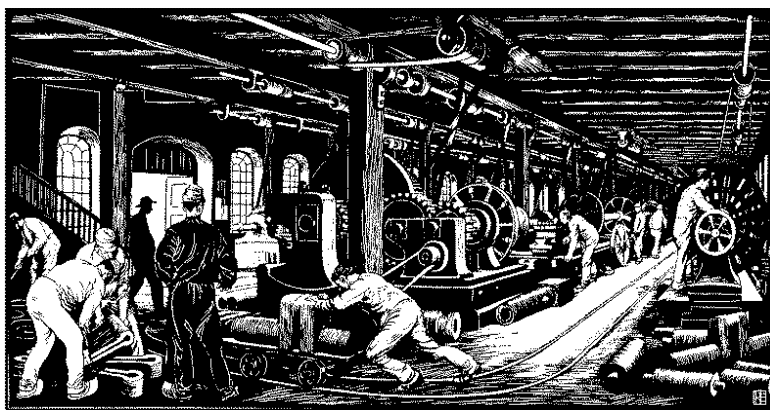
THE COMING OF BRONZE

Copper, *by itself*, is far too soft for use in tools intended for extended or heavy use, and it was only towards the end of the 4th millennium BC that metalworkers in the near east made a series of discoveries that changed this.

Some copper ores contain *arsenic* and a copper-arsenic alloy is *considerably* stronger. So, despite poisonous fumes, arsenical copper spread widely.

With the benefits of alloying having been firmly established, ancient metalworkers seem to have experimented with *others*. They eventually stumbled across *tin* which, alloyed with copper, reduces the difficulty involved in *casting* copper, reduces the *melting point* of the alloy to around 950°C, and produces an alloy, *Bronze*, that is many times harder than copper alone, especially *when heat treated*.





THE PROBLEM WITH TIN

The first tin-copper Bronzes appeared in the ancient near east c. 3500 BC and, despite the expense of tin (even today it costs *eight to ten* times what copper does), there were soon major Bronze industries in Sumeria and Egypt.

Not only was the expense of tin a significant factor, the fact that there are no known significant deposits found anywhere in the area was also important.

There is evidence of alluvial tin deposits somewhere in the middle east, but no-one has found the main ore bodies. Deposits exist near Aswan, Egypt, but were unknown in ancient times.

It is thought tin *had* to be imported from as far away as Cornwall and, possibly, Hungary, even Asia (Burma, Thailand or even, possibly, China).

This led to the collapse of the civilisations of the eastern Mediterranean when the *Sea Peoples* disrupted the tin trade c. 1200 BC. Bronze was replaced what by “obviously” inferior *iron*.

IRON

Only in the 16th and 17th centuries with the adoption of coal as an industrial fuel and increased mechanisation of industrial processes did iron and steel start to become ubiquitous.

The Iron Age began c. 1500-1200 BC (probably in Anatolia, with the Hittites), but this simply meant that people had learnt to smelt and work iron, not that it came into widespread use.

Part of the problem was that iron and steel production required the development of entire new technologies to be exploited efficiently, technologies that simply didn't exist it was first figured out how to, *quite inefficiently*, smelt it.

This development took *time*, a *long* time, and, as it turned out, depended on a massive supply of cheap fuel.

But by the time most of the wrinkles had been worked out, as we have seen above, supplies of the cheap fuel of the classical and medieval world, wood and charcoal, were rapidly being exhausted.

To give an idea of just how rare iron was, the entire Roman Empire in the 1st century AD probably produced no more than 20,000 tons of iron a year!

Even at the beginning of the 18th century european blast furnaces were only used intermittently because of problems in acquiring enough suitable fuel and transporting it to the furnace site.

It is estimated that each such installation produced no more than 150-200 tons per year (about two tons per firing per day, meaning that the furnaces sat idle for most of the year).

Even as late as 1800, *worldwide* production of iron and steel was only *slightly* over a million tons, and only exceeded two million tons around 1840.

In the 1970s Europe alone produced 720 million tons of iron and steel!

Its weight and the lack of cheap transport *also* limited its spread, a problem not overcome till the late 18th/early 19th century, with the increasing spread of steam powered ships and locomotives.

STAR METAL ...

The earliest known iron implements actually predate the “iron age” by several thousand years and have been dated to 6000 years ago (i.e. About 4000 BC) in finds from as far apart as Sumeria and the Nile Valley.

The high nickel content of these artifacts indicate their non-terrestrial origin. They were from meteorites and the metal could not be, at that time, be gained from any other source.

Around 3000 BC a scattering of iron artifacts begin to appear in the near east that are *not* meteoric in origin and it is thought that these were probably chance products of copper smelting.

Certainly, the technology of the time was not up to reliably reproducing the necessary conditions, and was not able to do so until around 1200 BC.

UNSUITABLE AT ANY PRICE

One of the reasons for the late dominance of iron and steel was the fact that early smelting methods were only marginally suitable.

Melting iron requires a temperature in excess of 1537°C, much higher than that achieved in any pottery kiln.

What you get at temperatures lower than this is threads or droplets of pure iron mixed in with the slag at the bottom of the furnace and this has to be beaten and worked free from the “bloom” of slag and iron by repeated heating and hammering.

Other problems were that this Wrought Iron was softer than bronze (even when cold worked), didn't hold an edge well. It also oxidised by rusting all the way through on exposure to the slightest amount of moisture (bronze oxidises with a patina that is airtight and prevents more than surface corrosion).

Some improvements were gained in the reheating of the finished ingot, as even an addition of 0.1% carbon “steels” it, and “steeled” iron is far harder than Bronze.

Of course, this was normally only a thin layer of “steeled” iron over a wrought iron core, rather than true steel.

STEEL

The Hittites seem to have discovered, by accident, how to turn iron into *Steel* (with 0.2-1% or more carbon), by working it in a bed of charcoal and not letting it cool down until finished.

Steel was far harder than Bronze and held an edge far better. They also discovered that cold working steel made it even harder (though brittle).

The Romans made the next important technical contribution, they found out how to *temper* steel, only slightly reducing its hardness while making it far less brittle than untempered metal.

The west only developed a means of producing liquid iron, cast iron (2% or more carbon), quite late.

This was because the bellows used in western furnaces were of the vertical accordion type which could only deliver a draught of air on the downstroke.

BOG IRON ...

One of the common sources of iron in northern European countries in pre-modern times was *bog iron*.

It is likely to be found anywhere that mountain streams run into peat bogs.

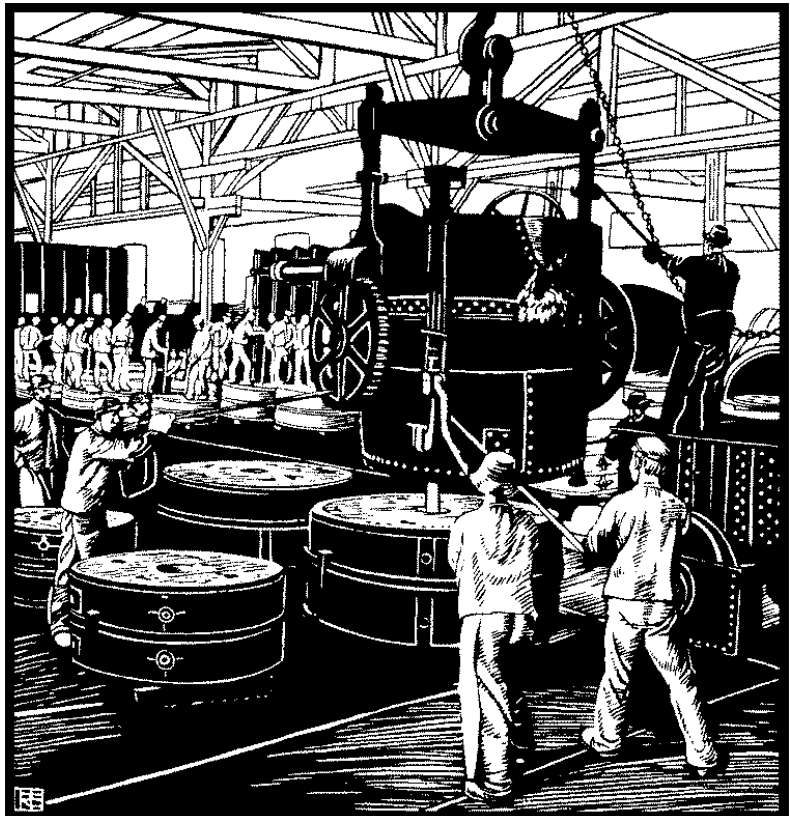
The iron is concentrated partly by the fact that bogs are acidic and partly because two of the common anaerobic bacteria found in such bogs concentrate the iron as part of their life cycle.

These bacteria leave an oily, iridescent, film on the surface of the water to show the presence of the concentrated nodules that they create.

These nodules, around the size of a pea, can be easily harvested by simply cutting and folding back the peat turves – and the best part is that this is a renewable resource!

The processes continue as long as the bog is there – and the “harvesting” of the ore can take place about every generation (20-25 years).

Of course, a given bog probably won't produce more than around 40-60 kilos of iron – and the fact that they were an important source of iron shows just how little iron was actually produced in pre-modern times.





The earliest models were also physically limited in size as it has to conform to the height of the (normally single) user pushing the bellows up and down.

It was only when vertical bellows were coupled to a camshaft and a water or windmill that the needed quantities of air to liquify the metal could be achieved, around the 14th or 15th centuries AD (coming into general use even later – at the end of the 18th century).

ORIENTAL IRON

Things were *very* different in the east where they used the horizontal box bellows which provided air on *both* the “in” and “out” strokes, and also allowed unlimited scaling upwards in size.

They also started to use coal (and, perhaps, coke) as an industrial fuel *much* earlier than in the west. These factors enabled the Chinese to make massive castings in bronze and also develop cast iron as early as the 5th century BC.

The Chinese were thus producing iron items (e.g. buckles and ploughshares) by mass casting *and* were able to reliably produce large quantities of steel *at least* 1800 years before Europe could.

Unfortunately, they largely abandoned the whole idea, and, certainly, anything resembling mass production.

WOOTZ WORKS

In India a third method of making steel was developed, the “wootz” process (sealing up small pieces of wrought iron, wood and other plant matter in a small crucible and heating it for several hours until it melted).

TECHNOLOGICAL BLIND SPOTS ...

So, *why* didn't the Chinese make more of their early mastery of cast iron? There doesn't *seem* to be an obvious reason.

Western historians have suggested that the centralised and monolithic Chinese State and Chinese society may have been the reason(s).

The argument suggests that, with no significant outside competition, and with a tradition of centralised control, the state organs saw no need for large scale production of iron.

All they saw a need for was enough iron so that every peasant could have the appropriate tools – like communist *apparatchiks* and central planning, there was no room for *individual* decisions or for competition.

Innovation was seen as dangerous to the social order – which, of course, was seen as nothing short of perfect by the bureaucrats who ran things. The mass production of cast iron was an innovation and, so the theory goes, it was banned for that reason.

In Europe, the argument continues, the many small, competing, principalities meant that no State could afford to ignore *any* useful (or potentially) useful technological advance if it wanted to survive – and, in any case, if it *did*, then the inventor merely had to move over a border to somewhere that was *far* less picky.

Such arguments are very eurocentric but *may* have a germ of truth in them.

Which begs the question, of course, as to why the *europeans* didn't pick up on the asian Box Bellows on which asian cast iron technology was based.

Even if they didn't *invent* it, there was enough contact between europe and asia for key ideas such as printing and gunpowder to be transmitted between the two (though the local implementations may well have been entirely independent) – so why didn't such a simple, basic, invention with such obvious advantages make it?

Perhaps the theory of cultural “blind spots” and technology cut both way? And Europe could be as blindly ignorant as Asia? Seems likely.

The process distributed carbon *evenly* through the ingot(s) so created, creating superior consistency to anything created by blacksmiths working with wrought iron, and as good as the Chinese metalsmiths could create (though it only produced tiny quantities).

Wootz (Indian) steel was known of, and much desired, in the Mediterranean world from at least the 3rd-4th century BC, when it is recorded that Alexander the Great received 100 talents of Indian Steel (about 570 pounds, or 258.5 kilos).

It was *possibly* independently discovered in the middle east in the 10th century AD but, for reasons that are not fully understood, was lost or abandoned by them in the 17th century. It was independently rediscovered in the UK, at Sheffield, in the 18th century.

MINING

Another key problem faced by early civilisations and their metalsmiths were the limits of mining technology.

The most obvious problem was, with no explosives to break up ore bearing rock, miners had to use *hand tools*, tools made of wood and bone, then of copper and bronze, and finally of iron and steel, which could only cut through about 20 cm of hard rock *per day*.

The easiest method was to find ore bodies *either* in soft rock, which could be easily removed with hand tools, *or* in a highly fractured rock matrix which could then be further fractured by building fires at the tunnel face.

A fire left burning overnight would heat and crack about 30 cm into the rock face. Though miners threw water on the heated rock face, this was not to assist in fracturing, it was to cool it down so that they could start work!

By the 5th century BC at the latest, more advanced technology ... iron tools instead of bone or stone, for example, were being used to assist in the process, but it was still primitive, hard, and difficult work.

Because of the difficulty of removing the rock, shafts, though generally squared off, were rarely *more* than 1-1½ meters high and a meter wide, and were often so shallow that miners had to dig while they lay on their sides.

Access to the mining galleries was down circular shafts no more than 1-2 meters wide and up to 200 meters deep.

These primitive methods meant many ore bodies had to be ignored as their rock matrix made them uneconomical to mine. All too often, these were the richest bodies of ore.

PUMPING IRON

A less obvious problem, but one with more far reaching and long term effects, was the lack of any effective and cheap pumping technology.

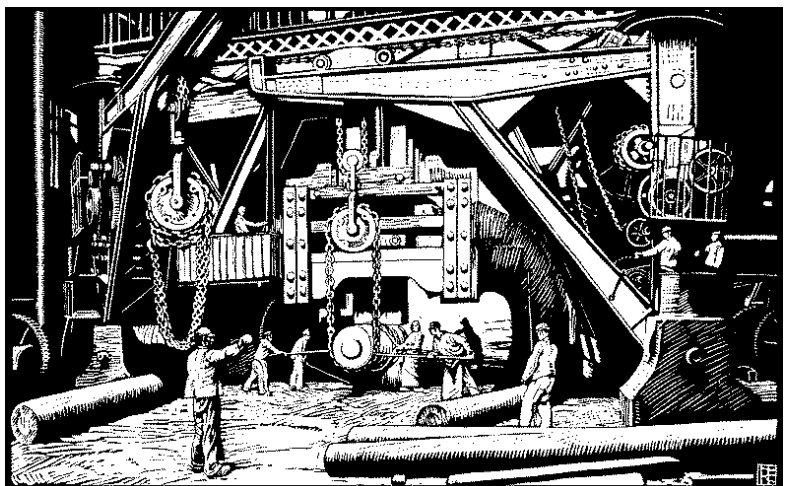
This meant once an ore body dipped much below the local water table and could no longer be drained by gravity, the mine could not be drained easily. And would normally be abandoned.

The ancients gradually developed a whole series of pumping techniques using waterwheels, archimedean screws (found in several large Roman era mines) or treadmills, but, even so, they could not *economically* lift water more than 20-30 meters.

This further limited the sites that could be mined and, as “surface” deposits were exhausted over the millennia, made the problem of finding an adequate supply of metals a significant one.

This problem could not be overcome until a reliable source of *high power density* could be provided to power water pumps – which required the development of improved metal working techniques and more plentiful fuel supplies to the problem.

The solution? The *Atmospheric Engine* of Thomas Newcomen (see the *Steam* section of this book for details) in the 18th century AD.



A REVOLUTION IN METALLURGY

"Necessity is the mother of invention ..."

– Plato, *"The Republic"*

By the end of the Renaissance, Europe was facing a metallurgical crisis.

Economically recoverable mines were being exhausted and it was increasingly difficult to find the fuel needed to process the metal that was being mined. It seemed as if stagnation was inevitable.

With the benefit of hindsight we know the components for a solution were all in place, though no-one discovered the right combination. Nothing is *ever* as simple as it seems, except with the benefit of 20:20 hindsight!

Unfortunately, the problems that had to be overcome required solutions that were complicated *by* the problems.

To smelt the ore needed required increasing amounts of fuel, but the fuel of choice was *charcoal*, and the forest primeval of the classical and medieval eras were but a fading memory in western Europe.

In England, laws against burning trees for charcoal to fuel blast furnaces unless they were coppiced (plantation grown) were being passed as early as the 16th century..

A replacement fuel was badly needed, but the "obvious" choice (which was, of course, *not* obvious), *coal*, could not be mined in the quantities required because economically recoverable deposits of *coal* were being exhausted as well!

To access this fuel, and increase the availability of metals, some sort of *economical* pumping mechanism had to be discovered.



AN OBVIOUS SOLUTION

The *obvious* solution was a *powered machine*, but the existing power sources of wind, water or human and/or animal muscle were inadequate.

The answer was, of course, the *steam engine*. But *that* required large quantities of cheap fuel (coal) and cheap and strong metal (iron).

What was the problem it was meant to solve? Lack of fuel? Lack of metal?

Looks like a circular problem, you couldn't solve any one part because you'd have to solve all the others first!

So maybe hindsight is missing some of the problems?

THE COAL PROBLEM

Why was coal *not* being considered as a solution for a cheap industrial fuel?

There were several reasons: some, to do with mining, mentioned above, but there others.

Most coal has a significant sulphur content and, if used in ironworking, this makes the iron it is used to smelt brittle and useless.

Worse, coal is *much* softer than charcoal, and tends to collapse into a slumped, cloggy, mass at the bottom of the furnace, choking and requiring expensive work to be removed.

COKE ADDS ...

The solution was *another* "obvious" one, use *coke* (coal partly burnt in a low oxygen atmosphere, just like charcoal).

But it took around a century from the first large scale use of coke (in the Beer industry, for drying hops) to its adoption by Abraham Darby of the UK as a fuel for the smelting of iron (1707-9).

Exactly *why* no-one before him had put the ideas together is unclear – except in noting that 20:20 hindsight is a wonderful thing.

But it *was* a major step along the road to the Industrial Revolution.

OLD COMMIE JOKE

"The USSR has huge machines that dig coal and iron from the ground which we then send to huge factories to be made into huge machines to dig coal and iron from the ground."

METALS AND INDUSTRY

THE PRIMACY OF STEEL!

What are the lessons of *Forge*? And how can they be used to update or improve a campaign?

Rule #12: Never underestimate the power of human stubbornness, sticking with “what was good enough for grandpa” *unless* faced with dire necessity.

That seems to be the overall rule. Inventions were, as often as not, ignored. Even when (to us) they were obviously better than whatever it was that existed before their invention.

This quirk, anomaly, or whatever you want to call it, *cannot* be overemphasised. Of course, it shouldn't be used as an all encompassing excuse for simply nixing all progress, either.

The key was the *cost*. An invention that cost more to produce and maintain (often forgotten, though *vital*) and use than whatever it would replace won't be readily adopted until that situation changes. Which may not be for *ages* ...

Rule #13: The “age of metals” was really the “age of small amounts of expensive metals” for most of history.

Metals were rare, expensive to mine and smelt, and, therefore, used *only* where they *had* to be.

Most everyday items were made of nonmetals: wood, leather, fiber, stone, bone and the like, held together with fastenings of the same materials.

Think ploughs with blades not much bigger than a Bowie knife costing as much as a modern tractor .

Or a Roman Legionary's weaponry and armour being equivalent to the cost of a Humvee or Offroad truck, or a good chunk of a M-113 APC.

Or a medieval Knight's “lance” (the Knight, his Squire, and several mounted Sergeants, with all their armour and weapons) as being the equivalent to the cost of an M-1 Abrams tank.

This only starts to change around the end of the medieval period, speeds up through the renaissance, but only really starts to end at the very beginning of the industrial revolution.

Even in Asia, where more advanced technology *was* developed, it was abandoned because it didn't fit the social and political realities of a centralised, unitary, and inward looking state.

Rule #14: Despite expense and (relative) rarity, the search for metals and the ways in which they were recovered and smelted was the major driving force behind the development of overall improvements in technology.

Demand for metal drove development of mining technology: better tools and techniques, for example, which, in turn, drove demands for more metal.

Smelting the ores required huge amounts of fuel, and led to deforestation (having an impact on agriculture) and shortages, which led to demand for new sources of fuel, which led to demands for more mines, and more metal.

Moving the ore, fuel, and finished metal around meant that improvements in transport were required, meaning more and better tools and, inevitably, more and better metals to make those tools.

Greater demand led to the exhaustion of easy to mine ore bodies and forced the move to less easily mined sources, which required more and better tools, which required more metal.

And, as these newer mines reached the limit of pumping technology and existing power sources it led to the development of the first new power source in millennia. Engines based on mechanical power from steam.



STEAM



SECTION

4

“Machines are worshipped because they are beautiful, and valued because they confer power; they are hated because they are hideous, and loathed because they impose slavery”

“With the introduction of agriculture mankind entered upon a long period of meanness, misery, and madness, from which they are only now being freed by the beneficent operation of the machine.”

Bertrand Russell (1872-1970)

“A tool is but the extension of a man’s hand, and a machine is but a complex tool. He that invents a machine augments the power of man and the well-being of mankind. “

Henry Ward Beecher

“Men have become tools of their tools.”

Henry David Thoreau

WIND, WATER AND HEAT

ENERGY IS POWER

Until quite recently mankind has only had three basic (and limited) sources of directly productive energy available: muscle energy (from humans or animals), kinetic energy (from wind and water) and (theoretically) heat energy (from wood, charcoal or coal).

In practice, only the first two provided direct and actual mechanical work, heat energy was only used passively.

MUSCLE POWER

Human beings aren't a very useful energy source. Depending on a variety of factors they can't provide a sustained output of more than 0.03-0.04 HP.

Horses, however, provide a sustained output of between 0.3 and 0.55 HP.

Of course, human muscle power has an advantage over animal power (and also over wind and water power) in that it is *versatile* and *self directing*.

Humans tend to remain the prime energy source as long as, relatively speaking, *their* energy cost is less than that of the alternatives. So it has been that, until very recently, the bulk of civilisation's "power output" has been provided by human "engines."

This gave them an advantage even over animal power, as the low productivity of pre-modern agriculture meant there was a limited surplus available for feeding working animals.

HORSEPOWER PROBLEMS

The problem was that, although horses did around 5-7 times the work of a man they also *ate* 5-7 times as much.

So their wasn't an *obvious* economic advantage in using horses.

In fact, it wasn't really possible until improvements in agricultural technology (at least in part dependent on increased use of animals for powering it! Catch 22!) and the agricultural surpluses it created led to a consistent and sustained drop in the cost of feed grain,

HORSES AND HORSESHOES

Horses have quite fragile hooves – one of their biggest vulnerabilities.

In the wild, when their hoof has been worn down, and the foot becomes tender a horse will move away from rocky or hard terrain to grassy or soft terrain until the hoof has regrown and the foot is no longer tender.

For domesticated horses, the situation was more problematic.

In the very earliest civilisations, it may not have been as great a difficulty as roads were often little more than dirt tracks which did not cause excessive wear and tear on the hoof.

This may explain why the very first recognisable *metal* horseshoes start to appear in Roman times, as early as the 1st century AD, because of the hard surfaced all weather roads that the empire built in great numbers.

These early horseshoes were actually more like sandals – in fact they were called *hipposandals* – and were strap on plates. Recognisably modern style shoes that were nailed to the hoof were available as early as the 8th-11th centuries AD, but were *mostly* of cast Bronze rather than Iron.

Iron horseshoes did not dominate the field until the 13th-14th centuries AD.

Horses were a luxury that few could afford for unproductive tasks (mounts in warfare or for personal transport, for example), and not many more could afford even for productive tasks.

And it is only *after* better technology allowed more economical use of horses that they become common as work animals, replacing oxen.

So think *ox drawn* ploughs and waggons for the most part.



For example, even at the beginning of the French Revolution, estimates are that there were about 3 million oxen to around 1.7 million horses, and of those, about 1.5 million horses were used in agricultural pursuits ... and this proportion seems to have been reasonably universal for Europe at that time.

WIND/WATER MILLS

Even though both wind driven mills and water driven mills had been known of in Europe and the Middle East (and in Asia) for a long time (from classical Greek times for the water wheel), the real revolution in their spread and use did not occur until the 11th century and was limited (initially) to Europe.

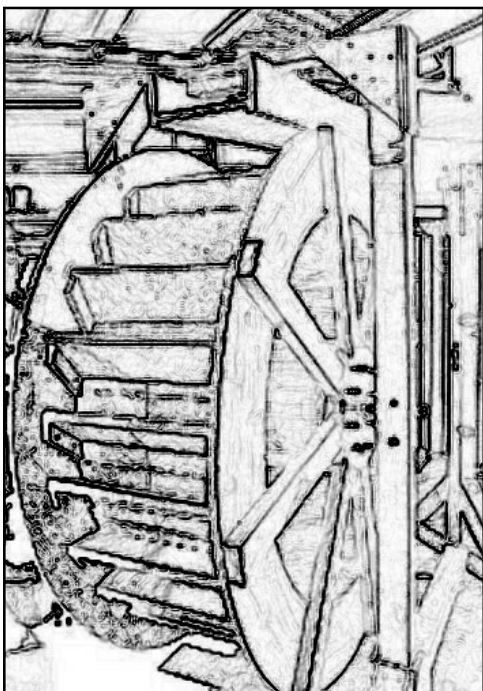
Neither of these types of engines were particularly powerful, 2-5 HP for a water wheel and 5-10 HP for a windmill (for designs standard through to the 16th century), but they were far more powerful than any other single source available.

WATER MILLS

The big advance was partly in converting the very earliest horizontal water wheels into vertical wheels, achieved in the Mediterranean world by Roman times at least, but mostly because the wheel was then harnessed to *gears* that turned the attached device (initially a grinding stone for grain) five times faster than the wheel itself.

The use of water wheels to do something other than simply grind grain, however, was the major development where medieval Europeans advanced over the Romans was in how they converted grain mills to a variety of other uses – *industrial* uses.

Once this developmental leap had been made, water wheels were soon adapted to provide power for a whole variety of direct industrial use (such as for driving trip hammers, aiding ironworkers; or pow-



WATER ENGINES

The earliest water wheels are mentioned in Greek sources of the 1st century BC, though it is possible the idea may have originated much earlier, possibly in China.

These early wheels were mounted on a vertical axis, with the wheel submerged completely in the flowing water (imagine a modern water turbine, sans casing) and were not very mechanically efficient, developing, at most, ½ hp.

These were replaced by the horizontal axis wheel in the 3rd-4th centuries AD – the first type introduced being the *undershot* wheel where the bottom of the wheel *only* was immersed in the water flow.

The major problem with this design was that it required a continual flow of water at a set level. If the water level dropped below that, the wheel was left high and dry.

The earliest designs were also rather inefficient, being able to convert, at most, around 25-30% of the flow energy of the stream into mechanical energy (increasing to 70% with 19th century designs – where they utilised artificial dams and mill races to increase seasonal reliability).

A solution to the problems of the *undershot* water wheel was the *overshot* water wheel which required a sluice to feed water onto the *top* of the wheel.

The earliest examples *may* have appeared in the Roman Empire of the 5th century AD, but they did not become common in medieval Europe until the 14th century.

This required a dam somewhere upstream and a drop equal to the diameter of the wheel, but it could work as long as any water at all flowed – if sited well and with a good vertical drop, an overshot wheel could routinely be around 75% efficient.

Modern turbine style “water wheels” first appeared in the early 19th century and had low efficiencies, but rapidly improved and, by the middle of the century were as efficient as horizontal axis waterwheels. Improvements raised this to 92% efficiency by the end of the century!

ering pulp mills) or indirect infrastructure use (driving pumps to de-water mines, or to pump water from rivers to supply a town).

From very early on in the Middle Ages (according to the Domesday Book of 1086) there was *around* one (1) water mill per 400 people in England, but on the very eve of the industrial revolution, at the end of the 17th century, the ratio was around 1 mill (wind or water) per 30 people throughout Europe.

WINDMILLS APPEAR

Windmills were a much later invention, originating in muslim Iran probably in the 7th century, and certainly by the 9th century, but these early mills were powered by horizontal sails.

Some time during the 12th century, in southern europe, this design developed into a *vertical* sail, greatly increasing the power they could generate.

The new design was supported by a single post, and the whole unit had to be rotated when the wind shifted, by hand.

Despite these drawbacks, the design spread rapidly, if erratically, though faster in in northern than southern regions (which explains Don Quixote's perplexity with *his* encounter!).

While Windmills were more expensive (and more maintenance intensive) to run than watermills they were important for several reasons. The obvious one being that they could be built even in locations where there was insufficient running water for a water mill.

They certainly replaced the man- or animal-powered treadmills that had been used in such areas before the introduction of windmills ... rapidly.

In the early 15th century the post mill was replaced by the more efficient *tower mill* where only the cap at the top of the mill rotated to catch the wind.

Because this design could be built into a permanent structure on fixed foundations it could be built much higher, to catch the wind better (and, of course, with larger diameter sails) and generate more power than the older design.

However, the cap still had to be turned manually if the wind changed – but since this was much smaller than the

MILLSTONES AND TEETH

The original invention of the water mill was for the grinding of grain into flour – done with large, flat, stones, one of which rotated by the mechanical power provided by the mill wheel.

This was simply a larger scale version of the hand quern (mill) and, like the original tool, mill ground grain was full of grit from the grinding action of the mill stones.

Even if you avoided breaking a tooth on a large piece of grit in your bread, then the cumulative wear and tear on teeth was such that most people had worn them down to the gum by the time they reached their late thirties (perhaps even earlier).

The use of finer grained, and much harder, stones for grinding grain reduced the wear and tear, but only the replacement of stone with metal grinding equipment completely removed the problem.

Just remember that the next time you dig into something made with “stone ground flour!”

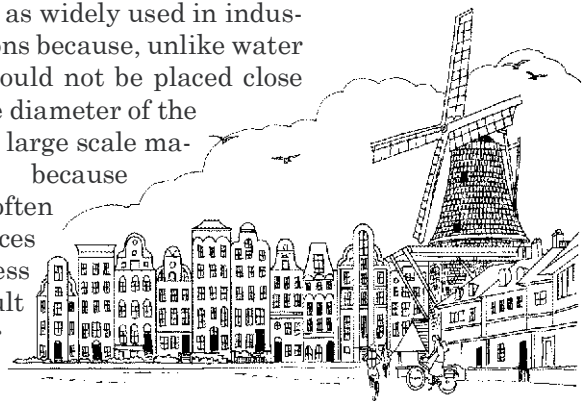
post mill structure, it was proportionally easier to move.

It was not until 1745 when the *fantail* was invented, a small windmill at the rear of the cap that would turn gears to turn the vanes into the wind if and when the wind shifted, automatically.

This transforming invention did not spread outside europe except *with* european settlers and colonists.

Like the water mills, windmills were used to run millstones and grind grain when they were first invented, and later were used to power other machinery, especially pumps in the Netherlands (to keep the polders drained).

They were not as widely used in industrial applications because, unlike water wheels, they could not be placed close (because of the diameter of the sails) to power large scale machinery and, because they were often sited in places where access was difficult (hilltops, for example).





WOOD AS FUEL

Until the 18th century, the primary source of fuel for fires and forges throughout the world was wood, or its derivative, charcoal.

Wood was also a vital structural material – from housing (even for stone or brick structures) through transport (carts and ships were almost entirely constructed of wood).

Where metal was used, it was kept to a minimum. The so-called “Iron Age” was more accurately an age where iron was available, *not* where it was ubiquitous.

The vast forests that covered much of pre-modern Europe were an important advantage over most other Eurasian societies (which either had few or no forests, or which had exhausted them in their first steps towards civilisation); they provided fuel for cooking and heating as well as industry and also provided materials for housing, shipbuilding, machinery, and other vital technologies.

Pre-classical Greece, before the cultivation of the olive tree (which was both a result of and an accelerant of deforestation fuelled erosion of the thin rocky soils common there) became a staple of local agriculture, was a land of forests, not of barren hillsides; the flag of Lebanon sports a giant cedar tree, because in classical times its landscape was dominated by whole forests of such giants and was not the treeless terrain of modern times.

Charcoal was always the preferred fuel over raw wood, it was lighter, burned hotter, was more or less odour free (though care had to be taken not to use it in a sealed space, as a charcoal fire could kill with the carbon monoxide it produced)

It was also more mechanically durable (its hardness made it more suitable for use in smelting metals, not collapsing into the soggy mass of bloom and cinders that a coal fuel furnace did).

LIMITS TO THE INFINITE

Other ancient civilisations were hampered either by an almost total lack of available wood (such as virtually treeless Egypt, though the Egyptians *still* used charcoal as a fuel for cooking and industry, and were hampered by their shortage), or by a lack of suitable woods, or both.

However, even the bounty that Europe began with was *not* limitless, and even the vast forests of northern Europe were being exhausted by the late medieval period.

By the 16th century the forests of the Baltic states were being tapped as the last European reserve of the large trees so important for ship construction (keels *needed* to be made from, and masts were *preferably* made from a single log, which meant an *old* tree).

One of the key advantages that the Royal Navy had over its French and Spanish competitors was that the Royal Navy ensured that *they* controlled access to those vital Baltic forests, while denying access to their enemies and potential enemies.

This control was never seriously challenged, and was a key asset that ensured the resilience of the Royal Navy and the merchant marine in time of war,

One of the reasons for the British settling Australia was the belief that there were large supplies of good quality *large* trees suitable for use by the Royal Navy and the merchant marine. As it happens, most of the trees at the early settlement sites proved to be termite eaten and unsuitable.

FOOD OR FUEL

One of the problems that all the major civilisations eventually came up hard against was the choice between producing fuel for industrial and domestic purposes or growing food for a burgeoning populace.

Trees grew on good farmland – so the choice was stark.

Food? Or fuel?

Eventually the adoption of coal as a fuel solved the problem – coal mines take up little farming land (and pollution was about the same).

COALFACE PROBLEMS

Another problem was that much of the coal available had a high sulphur content which made it useless for many the industrial processes.

High sulphur coal is useless in most steps of iron and steel making (not to mention the fact that soft coal is a mechanical problem in blast furnaces that hard coke is not), contaminating the product and rendering it useless; and it tends to add unpleasant flavours and odours in brewing and food production industries.

TRANSPORTING THE FUEL

The bulky nature of the material meant that wood as fuel was ideally located close at hand to the industries (or population centers) that needed it.

The cost of transporting wood by land more than around 30 clicks was generally prohibitive.

Sea or by river transport was a different matter.

Huge “floats” (log rafts up to 250 feet long) were found in Poland (supplying western europe) by the 14th century, and France by the 16th century, and are not an american invention.

The situation in China was much the same from around the 14th century.

FUELLING THE FURNACES

The situation was becoming critical, and vital industries were being crippled. It was common for blast furnaces to be left idle (despite the increasing importance of iron as the industrial revolution speeded up) for as much as nine weeks in ten (and commonly three weeks in four) because of difficulties in accumulating the vast quantities of fuel needed for their operation.

It could take months, even years, for the supply chain needed to provide the needed fuel to be set up *even after a furnace was constructed*.

The fuel requirements were immense – a single blast furnace of average size required the clear felling of around 2000 hectares of forest. Eventually, the demands were simply insupportable, and an alternative fuel to wood simply had to be found.

That alternative, obvious in retrospect, was –

COAL

Coal was *known* in ancient times, but was not mined and was definitely not used in any industrial projects.

Where it was available it was simply because there were surface outcrops (often on exposed cliff faces on the coastline where the coal knocked off and washed up onto local beaches by wave action was referred to as “sea coal”).

It was only adopted as an industrial fuel quite late, in a limited way from the 11th–12th centuries, but on a major scale only from the 17th–18th centuries.

There were many reasons for this late adoption – mainly *convenience*

Forests tended to be much more geographically widespread than coal deposits, so could be more easily accessed by local communities, and, additionally, were much more likely to be near to a navigable stream or river that could be used to transport them to communities that were some distance away.

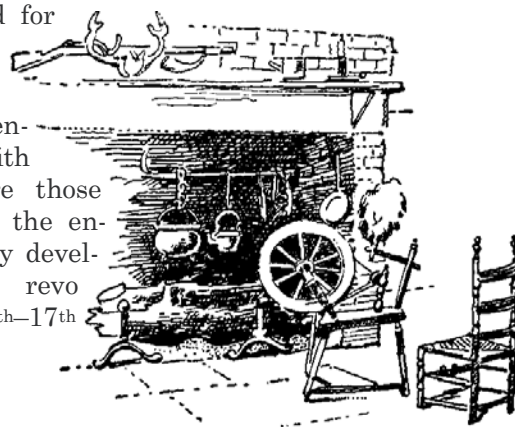
In fact, even when the other limitations of coal had been more or less solved, it was the cost of transport that meant that coal was more expensive than the increasingly scarce alternatives of wood and charcoal.

And, of course, mining was *expensive* compared to forestry.

So it was only when the great primeval forests of Europe were being exhausted, and there was a vital need for a replacement fuel for wood and charcoal, that coal began to be used.

Only once it began to be used more commonly were developments made that enabled it to be used in more and more industrial processes, replacing charcoal and wood for most purposes.

In europe those areas that were conveniently co-located with coal deposits were those that tended to be the engines of the rapidly developing industrial revolution of the 16th–17th centuries.



Tyne valley (from northern England) coal was shipped in vast quantities to London and the rest of the UK and as far as Malta as early as the 16th century!

COKE ADDS LIFE ...

It was not until the impurities could be removed from coal and a harder form of the basic fuel could be produced in *coke* that coal really took off as an industrial fuel, and this did not occur until the early 17th century when coked coal was first used in the Brewing industry.

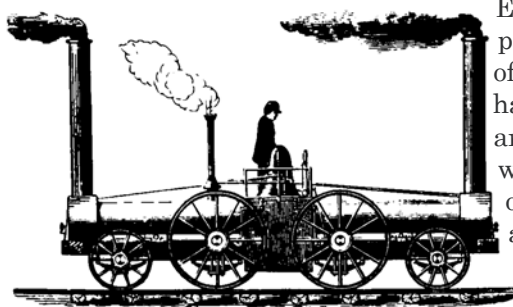
Despite this development, it was not used widely, if at all, in the iron industry until the last quarter of the 18th century, an all too typical example of social inertia preventing the adoption of a (in *retrospect* of course!) far superior alternative.

With the adoption of a fuel that was available in (comparatively) inexhaustible quantities, coal and coke, western Europe was poised to make the leap into a *true* mechanical and industrial revolution the like of which had not been experienced anywhere in the world previously.

Even so, the creation of the necessary underlaying and yet interconnected infrastructure and industrial pre-requisites was a *slow* process, only being completed, in Europe at least, in the early 20th century and only truly reaching the take-off point with the development of the first new power source *ever*, the steam engine, at around the same time (being a pre-requisite for and a product of cheap coal) as coal was adopted as a common industrial fuel.

PRE-STEAM STATUS

Before the invention of the steam engine, the sources of power that were available (described above) generated power in the order of importance: animal power, burning wood, water power, manpower, wind power and sail power.



Europe immediately prior to the invention of the steam engine had a population of around 145 million, with yearly power output supplied by about 40 million animals (about 10 million hp or 7.5 mW),

burning wood generated around 4-5 million hp (3-3.75 mW), water wheels generated 1.5-3 million hp (1.125-2.5 mW), 50 million workers generated around 900,000 hp (675 kW), windmills 0.375-0.75 million hp (280-560 kW), and sails generated around 235,000 hp (about 175 kW).

Asia relied far more on manpower, less on animal power, and less on wind and water mills, which gave Europe a long term economic and competitive advantage. The Europeans simply had more power available.

STEAM POWER

Soon after, an improved power source to run pumps to drain mines was solved by a Thomas Newcomen's *atmospheric* engine (so called because *atmospheric* and not *steam* pressure caused the piston to work).

By 1712 the first example was draining a mine at Dudley, Cornwall, to an unprecedented depth of 50 meters below the water table! The engine had a 48.26 cm (19") diameter cylinder and a 182.9 cm (6") piston and worked at the rate of 12 strokes a minute – and each stroke raised 45.5 liters (10 gallons) of water, developing around 5½ hp (about 4 kW).

AN UNSAVERY MATTER

Thomas Savery had already patented any engine *using fire* (the Patent was active from 1698-1733). Even though his design was impractical, unsafe, and bore no resemblance at all to Newcomen's engine, the company simply declared that their Patent covered Newcomen's work.

So Newcomen had to form a partnership *with* the Savery Company and this is *one* of the initial reasons for the slow spread of the Atmospheric Engine. Or he could take them to court – with no certainty of winning.

The first models constructed cost £1000 and made 6-8 strokes per minute, but Newcomen managed to improve this to 10-12 strokes per minute with time.

Newcomen was neither credited for the invention by the Savery syndicate during his lifetime (they pretended he didn't exist, selling "Savery Engines") and received little reward (compared to Boulton & Watt).

CYLINDRICAL PROBLEMS

One of the reasons why Newcomen engines were so slow to catch on was to do with their cost – yes, they were a cheaper way of dewatering mines, *but* the cost of the engines could be prohibitive.

The problem was that there was no extant precision machinery capable of boring or finishing the large bore cylinders that they required – they had to be finished by *hand polishing*. Even then, leather gaskets were needed to ensure a tight fit between piston and cylinder.

The problem of cost was only solved accidentally when some French artillery officers examining a Boulton and Watt engine mentioned the continental practice of casting solid cannon and using water powered boring machines to ream them out to something resembling absolute tolerances.

Once this method was adopted, the initial capital cost dropped dramatically, and, coincidentally, made steam powered precision machinery an affordable reality.

The ideas *behind* Newcomen's engine had been around since the days of the Romans and, more recently, had been developed (or redeveloped) by scientists such as della Porta (1606), Guericke (1672), and Papin (1695) working with the properties of vacuums.

But Newcomen, an ironsmith, put them all together and made them into a practical working machine (there is no evidence that he was *directly* aware of any of the above). His role in the development of steam was almost stolen by Thomas Savery (see previous page) and was only acknowledged years later, almost by accident.

The big advantage with Newcomen's engine was that it was *simple*.

It worked on low pressure steam that did not compromise the mechanical strength of the poor quality iron then available *and* transmitted the power generated through a slowly moving beam that required nothing in the way of high tech materials or even precision machined parts.

It *did* have limitations, though –

PRACTICAL PROBLEMS

Even then, 30 years later (1742) there were *exactly three* operating, the one in the UK and two more on the continent, hardly a revolutionary change!

It was only in the next *thirty* years (to 1772) that *sixty* more were built, mostly in Cornwall, to pump mines dry (mostly because coal was nearby or could be brought in cheaply by sea).

Part of the reason, but only part, was because the engine was *grossly* inefficient: less than 1% of the heat energy generated was converted into mechanical energy, and so it chewed through coal like it was going out of fashion.

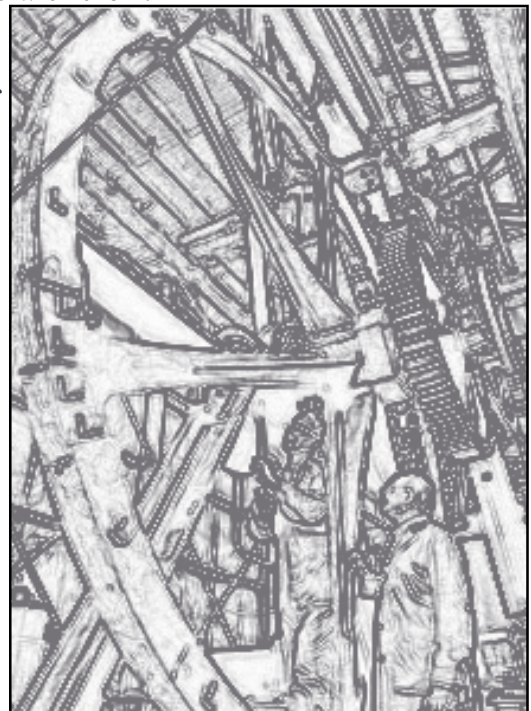
It was only economic when situated *right at the pit-head of a coal mine* or where a coal mine is *very* close by.

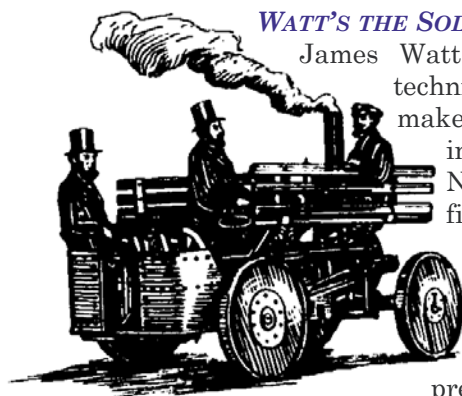
A Newcomen style atmospheric engine with a bore of 30 cm and a stroke of 150 cm could pump over million liters a day for £1 worth of coal; a team of two horses (in two hour shifts) could pump only a quarter of that and cost more.

It was also ill suited to turning the up/down motion of the donkey beam into circular motion, which meant its use for anything *other* than pumping was severely limited.

Still, by 1777 there were 75 Newcomen engines at work in the Cornish mines alone, so the problems they dealt with were obviously more important than the costs associated with them.

These new machines, the first truly new source of power to become available for thousands of years, paved the way for the improvements in metallurgy and mechanics that made Watt's *steam* engine possible – and, by doing *that*, allowed for the development of precision machines that enabled the development of the internal combustion engine some years down the track.





WATT'S THE SOLUTION?

James Watt was a university technical instrument maker and, when repairing a model of the Newcomen Engine, figured out some simple ways to improve the design. He used steam at about the same pressure but improved heat efficiency by providing a separate condenser to one side of the piston: this meant that the cylinder remained hot and that only the condenser had to be cooled.

This meant a Watt engine required only $\frac{1}{3}$ rd the coal of a Newcomen engine! It was such an advance that, within 10 years of its introduction only one of the 75 Newcomen engines in Cornwall was still operational.

Watt kept tinkering and, in 1782, introduced a double acting steam engine, one that used steam on *both* the up and down strokes of the cylinder, and now completely relied on the expansive power of the steam (at 0.7 kg/cm or 10lb/sq. in.) to do the mechanical work.

He also figured out the mechanics of turning the up/down motion of the piston stroke into rotary motion, making it eminently suitable for powering machines in factories, and not just for pumping water.

As the spread of the Watt engines allowed for improved precision machinery to be built, and for better quality iron and steel to be produced, it was not long before later inventors managed to build improved designs that operated at higher pressures and which were therefore more powerful and smaller (starting with Trevithick in 1801, with an engine working at *five times* the pressure of a standard Watt engine).

Eventually, Trevithick high pressure steam engines were developed into double, triple, and quadruple expansion designs that extracted the last possible amount of energy from the steam that was generated by the engine.

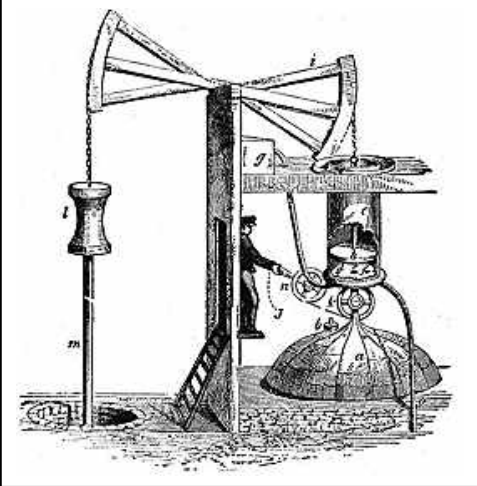
Eventually, engineers developed steam engines that used steam to *directly* create rotary motion by squirting

WATT'S THE PROBLEM?

Even though the Watt engine was more economical *of fuel*, it was expensive to run because the Boulton and Watt (which ran from 1785-1800) which allowed them to charge not only a flat fee but also a percentage of the cost of the fuel savings it allowed (a good chunk of money right there – and an *ongoing* expense).

This meant that that Newcomen engines were *still* being built many years after the availability of Watt engines, especially as better transport (rail lines and steam ships) reduced the cost of coal.

In fact, at least one was still being used to pump water for the city of London's water supply until the 1950's (converted into a standard Watt-style engine by the addition of a condenser, of course)!



steam into a turbine, the first practical model being demonstrated in 1884 and, by 1888, they were being used to drive dynamos in electrical power stations.

INTERNAL COMBUSTION

With improved metals and better and more powerful precision machinery and machine tools it was possible to develop improved machines in turn, which led to the development of improved *engines*.

COAL GAS ENGINES

The first internal combustion engine that was a commercial success was constructed in 1860 and was based on the design of a standard steam engine, and used an open flame alternately exposed and shuttered by a slide valve to ignite a gas-air mixture.

The Lenoir engine had the piston attached directly to the edge of a flywheel, and the flywheel powered whatever machinery was attached.

Even though over 150 were in use throughout Paris by 1864, it was not a particularly successful design as it did not compress the gas/air mix and consumed a great amount of gas for the power developed (no more than 200 revolutions per minute).

The next practical step was to develop a four stroke engine, achieved by Otto in 1876 (though there was an earlier French patent which had never been developed and which had expired).

The Otto engine used only one quarter the fuel that a Lenoir engine required for the same amount of power, but which still ran on coal gas.

In 1878 a Scottish engineer developed a two stroke engine, the Clerk engine, which was *much* simpler (requiring many fewer parts), but the downside was that it ran much more roughly and used more fuel (still coal gas at this stage) than a four stroke engine.

INTERNAL COMBUSTION VS STEAM

The huge advantage was that internal combustion engines were largely capable of operating without constant human intervention and supervision, certainly for hundreds or thousands of hours at a time.

Steam engines required constant supervision to be run safely.

The consequences of an internal combustion engine malfunction were fairly minor – for the most part, the engine simply ceased to work.

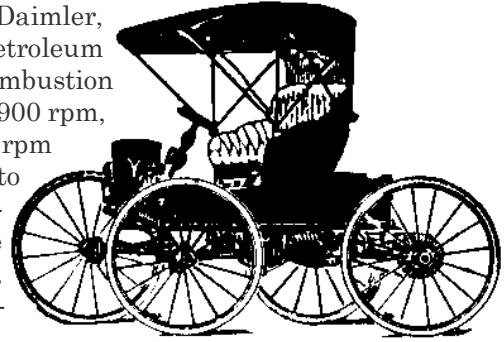
Steam engine malfunctions were much more dangerous, and more often than not resulted in dangerous explosions which, even if they killed no-one, could severely damage or destroy the engine itself.

POWER TO WEIGHT

The Otto gas powered internal combustion engine of around 1880 massed 267 kg per kW of power generated (/440 lbs/hp) – an improved Daimler petrol powered internal combustion engine of 1900 massed around 5 kg/kW of power generated (9 lbs/hp) – a development achieved within only 20 years.

PETROL ENGINES

In 1883, a German, Daimler, developed a liquid petroleum powered internal combustion engine which ran at 900 rpm, compared to the 200 rpm of the Lenoir and Otto engines, thus developing much more power for its weight, and using a conveniently portable fuel.



In 1890 another German, Diesel, developed a compression ignition engine which did not require a complex electrical ignition system and which could run on heavier, less refined, and cheaper fractions of crude oil.

The Diesel engine enjoyed much greater initial success, especially in large scale applications (locomotives, shipping etc.), than the petrol engines of the time.

However, it was the liquid petroleum engine that enabled the leap into the skies and the first new form of transportation technology for millennia.

Likewise, the age of the internal combustion engine rapidly replaced that of steam, but could not have occurred without the changes that the steam age had begun.

ENGINES OF INDUSTRY

THE POWER TO REMAKE THE WORLD

What lessons can we learn from *Steam*? And how can they be used to update or improve a campaign?

Rule #15: As late as the 18th century the main source of industrial power around the world was *muscles*. Overwhelmingly *animal* muscles in europe and european colonies. In Asia the dominance of animal power was less pronounced, but still dominant.

What this means is that almost everything that is made or grown is made or grown by *hand*.

What tools exist are overwhelmingly *hand tools* (for example, the potter's wheel or the spindle for spinning thread into cloth).

Hand-made *doesn't* mean shoddy or inadequate. What it *does* mean is that the items will be far more expensive than we inhabitants of an industrialised, machine-dominated, society can fully grasp.

A common problem in role playing game "civilisations" is a failure to understand this. The products are, all too often, simply thinly disguised variants of the modern world, with knights and dragons layered over the top.

Hand made means, as a general rule, that very little that is expensive is available "off the shelf" – and, if it is, then most likely it is either second hand *or* is available only in small quantities.

For example, it would be rare to be able to be able to walk into an Armourer's

workshop off the street and purchase, off the shelf, a full suit of armour.

You would *order* it, and wait many months for it to be made, most likely completely from scratch.



Or, alternatively, they will have second hand armour available. You know the deal, "*One owner, low mileage, slight slagging where the flaming dragon's breath charred the unfortunate wearer!*"

Which will, of course, require several sessions to be properly fitted to you and which *doesn't* come with any sort of warranty at all!

Similarly, you can't walk in off the street and buy a suit of ready-made clothes unless you buy second hand. What you do is go to a tailor who will measure you up and then make the clothes on order.

There are some exceptions to this: pottery of all sorts, for example, is always in demand for domestic and industrial use and is produced in large amounts.

But, in general, only raw materials or unfinished products are available in bulk (and that term is only relative to the time!)

Rule #16: Water and Wind powered machines were always a *supplementary* power source, though they could supply higher density, continuous, power that muscle power could not.

The *next* most important pre-modern power source was the *water wheel* which only started to be used to generate power for something other than grinding grain into flour in the early middle ages (the 11th-12th centuries on).

Even so, things remained largely hand made, and the water mills were normally used only to provide brute force in applications where human muscle was inadequate or too slow (or both).

Windmills were well behind water mills in importance and overall power output because of reliability issues. Water flow is generally less fickle than the winds.

Mills were the precursors to modern industrial plants as far as their cost is

concerned. Mill owners were, unless completely incompetent, rarely poor men. The capital required to build and, considering the inadequate materials mills were built from, maintain a mill was not inconsiderable.

However, they were limited in utility, not particularly versatile, and could not generate the sort of power needed for a real level of industrialisation.

In fact, given the inadequacy of the materials available (wood, stone, and ceramics with very little iron or steel) for their construction, it is unlikely that later developments that made water power so useful in modern times would have been possible without modern materials (lots of iron and steel and other metals).

Rule #17: Wood has to compete with food for growing space, so there is often a choice between eating and having fuel for cooking, heating and industrial applications. This becomes a greater a problem as populations increase.

It is a truism that, whoever made the earth, they aren't making any more! In other words, farmland, even marginal farmland, is in limited availability.

As populations increase, as they inevitably do as they become more and more adept agriculturalists, this means that there is increasing competition for what is available ... and firewood grows on the same sort of land.

This puts pressure on prices – of food and of fuel. Choices have to be made – unless an alternative fuel source that doesn't require scarce farmland can be found ...

Coal or Oil are the obvious alternatives, and coal is generally the easiest to mine and requires the least technology and capital to access.

Other, more modern, alternatives (solar or nuclear power, for example) are simply not technologically practicable in a pre-modern society. Though, of course, *if* the pre-modern society is based on forms of magic, this *may* change things.

Of course, if you *do* have magically augmented high energy density power supplies, then you do *not* have a pre-modern society for very long at all!

Rule #18: Take anywhere, high density, versatile power supplies were quite late to develop but, until they did, industrialisation was only marginally practicable.

The invention of a practical steam engine, the first take anywhere, high energy density powerplant in history, was delayed by the need to develop the metallurgical technology such a machine required, because the theoretical underpinnings of its operation had not only to be developed and understood, but widely disseminated.

Most of all, however, it was delayed by the lack of a perceived need *and* the high economic cost of construction, support and operation.

Once these issues were resolved, however, the adoption and development of steam power enabled massive increases in the productivity of labour in all fields, and the development of new sources of power that furthered these developments, even accelerating the rate at which they were achieved.

Rule #19: As power generating machines became larger (and more expensive) and capable of generating more power, there was a move away from craft production to what progressively became large scale production (if not necessarily *mass production*) in concentrated facilities – factories.

Yes, the factories of the early Industrial Revolution *were* “dark, satanic, mills,” but they *also* increased the productivity *and* the living standards of the *whole population* quite massively.

It is only looking back from our modern, materialistic, times that results in the impression they were indescribably awful and worse than anything preceding.

And, after all, those factories and the changes they supported laid the very foundations of the modern world.



Rule #20: Nothing remains static.
Change is a constant.

Even in societies that seem to have been static, even anti-progress, the evidence is plain ... change continues. Just at a slower pace.

Societies that, consciously or otherwise, attempt to limit social and technological change are on a slippery slope to, at best, marginalisation and loss of independence, at worst, complete devastation and total destruction by societies that have not made such a decision.

You simply can't ignore the world around you. Sure, you can try and, for a time, you may *seem* to succeed. But it simply isn't a viable long term option, as both China and Japan found out.

Ultimately, this makes almost all role playing game "civilisations," well, unbelievable.

They all seem to be in a state of denial of reality and complete social and technological stasis. At best, they would be developing *magic* as technology – not remaining the same for millennia.



HOUSEHOLD MATTERS

Pre-modern households were notably lacking in contents – especially those of the poor (but the rich were only comparatively better off). Even the poorest third world rural villager is likely to have more possessions than the pre-modern poor.

The dwelling, probably made of inferior materials, was small mostly because they couldn't afford the materials for anything bigger. The contents?

A crudely woven sack to contain some straw used for bedding. A cauldron or pot in which all the food that wasn't roasted over the fire was cooked. One or two pottery jugs or containers. A wooden or bone spoon – perhaps one for each person in the family, perhaps not – for eating with. Wooden plates and mugs – perhaps enough for each family member, perhaps not.

Perhaps a simple stool, but probably not more than one. A simple wooden chest – probably more a box than a chest – in which the family's few possessions would be kept.

Clothing? One set. Most of which was worn all the time, except on the hottest days of summer. No night clothes – and probably no blankets, you simply slept in the clothes you had worn all day. Each adult probably had some sort of utility knife – used for everything, including eating.

Windows, if any, would have, at best, wooden shutters for use inclement weather. Doors would rarely have metal hinges, let alone a lock of any sort – they probably swung on leather hinges and were "locked" by the simple expedient of propping a wooden pole against it from the inside.

The farm and domestic animals? Quartered in the family house and, if the family were well off, they might have a separate room – more likely there was a simple stall formed from a corner of the one room dwelling.

The Industrial Revolution changed all that. The poorest citizen of a modern industrialised nation has more possessions than all but the wealthiest pre modern nobles would have possessed, and lives in greater overall comfort.

INVENTIONS

SECTION

5



"A tool is but the extension of a man's hand, and a machine is but a complex tool. And he that invents a machine augments the power of a man and the well-being of mankind."

– Henry Ward Beecher (1813–1887)

"The greatest inventions were produced in the times of ignorance, as the use of the compass, gunpowder, and printing."

– Johnathan Swift (1667–1745)

"To invent, you need a good imagination and a pile of junk. "

– Thomas A. Edison (1847–1931)

"The greatest misfortune that ever befell man was the invention of printing."

Benjamin Disraeli (1804–1881) , British Primer Minister.

CULTURAL TECHNOLOGY

WHY DIDN'T THEY JUST ...?

When one looks at past history it is easy to find any number of inventions that were within the grasp of this or that culture *much* earlier than the actual date of adoption. Inevitably the question arises, “*Why wasn’t xxx invented sooner?*”

The answer is often fairly simple.

If you remember that we are looking back at history knowing already that the invention in question is not only possible, but will actually work and, more importantly, will be a huge economic benefit it is easier to consider things from the point of view of the people actually alive “back then” when none of those things were true.

Or, to put it another way, perfect 20:20 hindsight is a wonderful thing. It just isn’t helpful for a real perspective.

SOME PROBLEMS

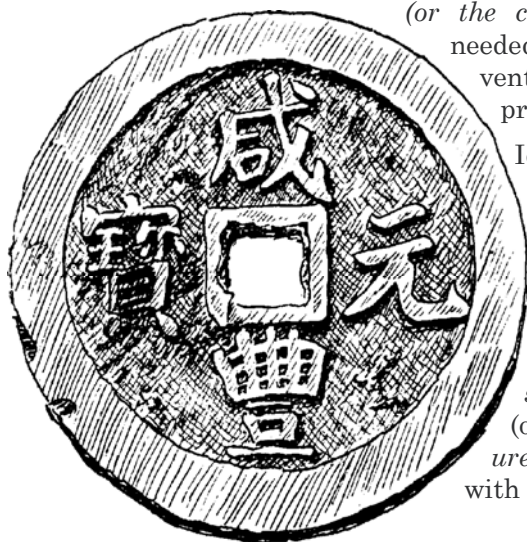
Inventions might not be thought possible, *or* there could be an alternative that served well enough so there was, *without perfect hindsight*, no need for a replacement.

Even when an alternative was known it might be that it wasn’t *obviously* better.

Finally, even if the conceptual leap *was* made, and its superiority *was* obvious, the lack of supporting infrastructure (or the cost of creating it) needed for the new invention could be the problem.

Ideas were not always quickly identified and adopted, and the reasons seemed pretty good *at the time*.

So let’s consider some key ones (other than Agriculture, which is dealt with in Section #2).



MONEY

From the very earliest times, even when mankind lived in small nomadic extended families, there was probably a need for some form of *trade*, the exchange of goods and/or services.

As humans moved from a nomadic society relying primarily on hunting and gathering to a sedentary or semi-sedentary society relying increasingly on abundant wild plant and animal food resources and, eventually, on the domesticated plant and animal species, the scope for trade between individuals and communities expanded rapidly.

Such trade required a way of determining the value given and received by the

BARTER IN THE MARKETPLACE

Barter is the simplest form of economic activity – the direct exchange of goods or services for other goods or services with no intermediate step using symbolic exchange (money).

Even in the 21st century many people around the world engage in barter transactions as an everyday activity – and, as often as not, cash money plays little role in their lives.

The obvious problem with barter is that it is a rare case where the buyer and seller have an exact match – mostly the buyer will have something that the seller does not want (either because they already have enough or because they do not want it).

There was no perfect solution to this problem – the seller could take what the buyer has to offer and hold it to trade onwards to someone else who *does* need it, or the seller could try to trade what *they* have for something that the *seller* wants.

Multiple levels of exchange are possible and, indeed, likely.

In modern day terms? Think CCG swap meets!

GRESHAM'S LAW

Gresham's law states that "bad money drives good money out."

More simply it means that in an economy the appearance of a debased form of coinage leads to the hoarding of older issues with a higher bullion content.

Since the issuing authority (the government) has issued the debased coinage *because* of its lack of bullion, this is often accompanied by attempts to accept only older issues in payments *to* the government while the government offers payments in debased coinage for *its* debts.

This *worsens* the economic crisis as people hoard the more valuable older coins even *more*.

The situation may even end with the government seizing tax (and other debts) in *kind* (in the form of goods or forced labour) at rates set by itself (which tend to be firmly in its favour and which tend to worsen the economic crisis even further).

The law also applies to modern "token" currencies that are not directly convertible – such as those of the former Soviet bloc prior to the collapse of communism.

The Russians had a saying that showed they were well aware of the manipulation they were being subjected to – "*They pretend to pay us and we pretend to work.*"

In such instances, the black market value of currencies from economies where they *are* directly convertible in the world economy is *vastly* higher than the "official" rate of exchange as stated by the government.

Worse, items that are scarce (either naturally or imported from hard currency countries) are often not purchasable for the local currency, requiring special coupons or hard currencies – adding further to the cynicism of the citizenry.

In any case, periods where states suffered from such problems *tend* to be more common in the past or, in modern times, under totalitarian or autocratic regimes.

But it isn't new.

parties involved, especially where there was a disparity in the amount of goods and/or services on one side as compared to the other.

In other words, there had to be a way of determining *value*. And a way of *storing* value in a concentrated form.

Until the Industrial Revolution, the primary means of carrying on economic activity throughout the world was *Barter*, even in those countries in western Europe and Asia that had money based economies.

In effect, even in pre-modern money based economies a significant portion of economic activity, while carried out in terms of the *monetary value* was still in the actual form of *goods and services*. In fact, barter *remains* dominant in the large subsistence sectors of Third World economies even today.

Part of the reason for this was simply that, prior to the invention (and adoption) of token currencies (i.e. with have no inherent value) there was never an adequate supply of what was deemed "precious" to fuel a money economy.

This perennial shortage led to a recurring cycle of inflationary pressure leading to the debasement (admixture of base metals to reduce the amount of precious metal) of whatever a country's bullion coinage metal was.

Or, alternately, it led to economic collapse as the limits of credit that could be supported by the amount of bullion coinage available was reached. Or both.

EARLY MONEY

The very earliest forms of money started to appear in the 8th-7th centuries BC, more or less at the same time in east Asia and Eurasia and consisted of lumps of metal either cast in the shape of a common barterable item (east Asia) or crudely stamped with the symbol of a barterable item (Eurasia).

This gradually developed into a true coinage stamped with engraved dies from strips or sheets of bullion (gold or silver) or, for small change, from a base metal (most often copper or bronze).



Most sizeable states had more than one Mint and might sell the right to mint coins to private contractors.

The engraved dies with which coins were stamped were works of art – as they were a ready medium for propaganda glorifying the state or its ruler!

COINAGE IN USE

Gold coins *tended* to be used to settle inter-state debts, silver coins were mostly used for every-day debts, and copper or bronze (or base metal) coins were used for small change.

But precious metals were valuable *because* they were rare – and, because they were rare, they had uses other than directly economic ones.

Hoarding of precious metals in the form of objets d'art and the like sucked up as much as 75-80% of *all* available bullion, depending on the time and place.

GOLD AND SILVER

In ancient times, the ratio of silver to gold was *around* 12:1 (with modern production and recovery technology, silver is worth *much* less today).

This was often used as a basis for the relationship between issued coinage of silver and gold – but it was an *approximate* ratio, not an immutable one.

Speculators could make a considerable profit by moving the appropriate coinage from one place to another.

MONEY AND CREDIT

Because of the historic shortage of bullion, from the very earliest city-states in Sumeria, developed instruments of credit to assist their limited, but still important, money economies.



However, these credit instruments were normally limited in their geographical scope – mostly no further than the larger cities in bordering states.

The Greeks developed a primitive version of credit around the 2nd century BC, allowing for transactions

HOW MUCH DO COINS WEIGH?

According to a popular fantasy role playing game, all coins, weigh in at 1/10th of a pound.

Imagine attempting to carry around *any* amount of money where coins weigh more than an ounce apiece! It's obviously impractical – unless you're a game designer, it seems.

Historically, the average *bullion* coin in circulation weighed in at around 1-5 grams; base metal coins *could* be somewhat heavier.

So, for a standard avoirdupois pound (c. 453.6 grams), a 5 gram coin fits 90 coins per pound.

For a troy pound (c. 373.24 g) you get c. 74 coins – and for a Roman *librum* (327.45 grams) you get around 65 coins.

A *huge* difference from a mere 10 coins per pound. And more so for coins massing less than 5g.

Larger, higher value, coins *did* exist, but were relatively rare and were normally commemorative issues.

through clearing “banks” and this was copied by the Carthaginians (in the western mediterranean). The system withered away under the Roman Empire, as they preferred payment in coin.

The only other way of transferring money in classical era Europe was to finding a merchant owed money by another merchant in a city you planned to travel to and “buy” the debt, *or* you had to actually carry coinage or other portable valuables *with you*.

Such credit transactions were gradually reborn during the medieval period in western europe, mainly as a function of the regrowth of international trade through the huge medieval Fairs.

Gradually, some “fairs” developed to be entirely about the settling of credit accounts and the payment of exchange bills, in a process resembling the clearing of cheques in more recent times.

Over time this *slowly* developed into *Bills of Exchange* or *Bankers Bills* which could be bought in one location and then cashed at another, for the full amount at an associated merchant-banker or at a discount rate elsewhere.

HOW MUCH BULLION WAS THERE?

Prior to the discovery of the New World and the eventual opening of gold and silver mines there, the stock of precious metals in Europe is estimated to have been around 2000 tons of gold and 20000 tons of silver, barely adequate for what passed as a monetary economy at the time.

Between the beginning of the 16th century and the middle of the 17th the Spanish fleets *officially* brought around 200 tons of gold and 16000 tons of silver to Europe – increasing the stock of coinage in circulation and also ruined the Spanish economy because of the way it was spent.

A BOOK OF ACCOUNTS

Accounting even predates the invention of money – records of goods acquired by barter, intended for barter, or produced for local consumption needed to be kept for large estates in even the earliest times, if only to determine the ration issue “wage” for the workers employed by estates.

However, early accounting systems were crude – mere lists of items bought and sold – and were of little value in calculating whether an operation was running at a profit or a loss.

Double entry book-keeping, the foundation of modern accounting practice, did not arise until the 12th or 13th century in northern Italy, as a result of the increasing volume of international trade resulting from the first Trade Fairs of the era.

BANK NOTES

By the 17th century these *Bills of Exchange* developed further (in the UK), as *Bankers Notes* issued by the Goldsmiths (backed by the gold they had on deposit from private individuals) in London from around 1640.

By 1666 one Goldsmith had £1.2 *millions* worth of these notes in circulation.

The formation of the Bank of England in 1694 formalised and centralised this important function and gave the British an considerable economic advantage over the less forward thinking states of the continent.

Indeed, it is almost certainly why Britain repeatedly defeated France.

ASIANOMICS

South Asia and the Indian subcontinent developed sophisticated credit transfer and banking services too and, certainly by the medieval period, they were *much* more sophisticated and their geographical scope *much* wider than the European equivalents.

The web of financial services that developed spread as far west as the Islamic nations of the middle east, as far south as the islands of Java and Sumatra, and as far north as China.

In fact, one of the reasons for the success of European trading relations with Asia was access to the much more sophisticated banking and credit arrangements on the spot which, added to the European military and technological edge, gave them a huge comparative advantage.

PAPER MONEY

China may have adopted recognisable paper banknotes as early as the 2nd century BC, though what came of this early experiment is not known, except that paper money did not appear again until the 6th century AD it was definitely in limited use, though it did not enter widespread use until Kublai Khan began paying his soldiers with it in the 11th century.

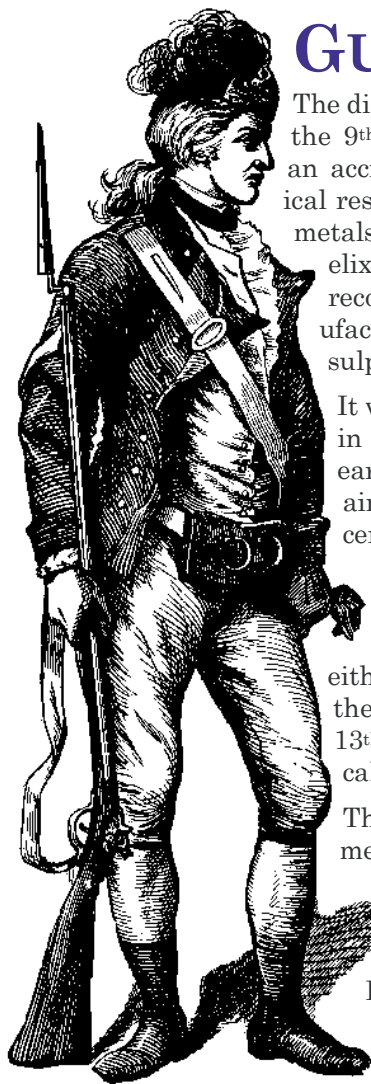
However, paper money was never accepted at face value, and almost from the first traded at 1/5th the value of actual copper or bullion coinage, declining through the life of each issue (which were not necessarily made each year),

By the middle of the 15th century continued abuse of paper money by successive imperial administrations, printing more and more money to meet debts without having the taxation resources to back the paper up, and the massive inflation that this led to (paper money was worth 1/300th or less than the face value) caused the Chinese to abandon paper money till they re-adopted it through european influence.

Inventing something first isn't always a guaranteed road to success!



GUNPOWDER ...



The discovery of black powder dates to the 9th century AD, almost certainly an accidental byproduct of alchemical research (attempting to turn base metals into gold or discovering an elixir of youth), when Chinese records show that they were manufacturing it using charcoal, sulphur and saltpeter.

It was known by muslim scientists in the middle east, possibly as early as the 11th century AD, certainly by the 13th century, almost certainly transmitted along the Silk Road from China.

It seems likely that knowledge of black powder reached Europe either directly from China or via the Islamic world, some time in the 13th century also (saltpeter was called “chinese snow”)

This initial four century lead meant the Chinese were using cannons by the 12th century AD while the europeans didn't reach that stage until the 14th.

But the europeans soon surpassed them. By the end of the 15th century european made cannon were technically superior and were employed more effectively in combat (which is as much to do with Asian attitudes to warfare as anything).

One of the reasons for europe's slowness to develop black powder may have been a paucity of saltpeter. Human waste was not seen as a valuable fertiliser as it was in the east, but as something unclean and to be disposed of. Saltpeter was normally gathered as crystals found under dung heaps, so this was an important limitation.

Thus, gunpowder was *very* expensive in the west. As late as the 16th century gunpowder to provide 400 shots for all the Venetian Republic's cannon (both land and sea based models) cost more than a year's gross tax revenue!

Most european nations eventually instituted a system of government licensed contractors who had the right to go anywhere and dig up or dismantle anything (e.g. dungheaps or cellars) in order to collect the needed saltpeter,

THE SECRET FORMULA

A more common early mix is 15 parts saltpeter, 3 parts sulphur and 2 parts charcoal. Other mixes were used at different times, usually reducing the amount of saltpeter, which tended to be the most expensive component.

The materials are finely ground and *carefully* mixed, and, in this form, they are called “meal” (or *serpentine*) powder. Meal separates into its components over time and often has to be re-mixed before it can be used.

For this reason, in Europe at least, early gunpowder was often mixed on the spot from the components until a better form of gunpowder, *corned powder*, was developed.

and even developed ways of setting up saltpeter “farms” with composting heaps of manure in *attempts* to produce the volume required.

In fact, a method of manufacturing gunpowder *chemically* from Chile Salt-peter was not invented until the 1860's, in the US, and under the impetus of the Civil War there. Before that it had to be gathered from natural sources, mostly in India, and then refined (which gave the British Empire a considerable but little known military and political advantage until then).

GUNPOWDER POLITICS

Another factor in the speedy development of gunpowder weapons in the west was the political situation.

Western Europe consisted of many competing and antagonistic politico-economic units of small to middling size where survival depended on such things as improved technology.

And it was also a place where inventors could take their inventions across the border to another, more co-operative, principality if they were not favourably received in their first choice!

The artificer who constructed the giant cannon that breached the walls of Constantinople in 1453 had first offered to work for the Greeks, but had been rejected by the Emperor as too expensive! Surely an example of false economy.

In China, however, the existence of a unitary state which had no *civilised* (to Chinese eyes) competitors who to

THE EARLIEST CANNON ...

These were giant Bombards such as *Mons Meg* (50 cm bore, 5000 kg, firing a 250 kg stone ball) and the German *Pumhart von Steyr* (60 cm bore, firing a stone ball of 800 kilos) in the first half of the 15th century.

It is thought that the Bombards were so large and fired such large shot because the early gunpowder (still “meal” or *serpentine* at this stage) was also unreliable in composition and, therefore, propellant power.

Artificers relied on the *mass* of a shot rather than on its *velocity* to do damage until the introduction of better gunpowder formulae.

By the second half of the century, these giants were only a memory.

CANNON AND CULVERINS

Cannon had short(er) barrels and were intended for close range work – mostly siege work; *Culverins* had longer barrels and were intended for battlefield work, having somewhat longer ranges than cannon.

The longer barrel of the culverin, however, was *not* the reason for their increased range; it was due to the way bronze artillery pieces were cast.

Casting was done breech-down in a pit, and this meant that the metal in the breech of the long-barrelled culverins was under more pressure, and was therefore denser and stronger.

As a result Culverins could take a larger powder charge and *this* gave the increased range.

Culverins could take a charge 80% of the weight of the ball being fired. Cannon were restricted to a charge of 66% the weight of the ball being fired.

threaten its survival meant that there was less interest in innovation.

Asian thinkers saw war as a disaster to be avoided at all costs, so developing more and more destructive weapons did not have the same cachet.

In the west war was seen as a basic factor in international relations, to be exploited *regardless of the human cost*.

Therefore developing more effective weapons was a *much* higher priority.

... AND CANNON

The other important problem was not to do with the explosive per se, but with the best method of *using* it.

The Chinese originally used it in paper bombs (crude grenades, later fired from catapults) and “fire arrows” (bamboo tubes filled with gunpowder and metal scraps, fired from bows, not as rockets).

The next step was bamboo tubes spewing burning powder as a crude flamethrower, or, possibly, a sort of crude flaming projectile/fire bomb, recorded by the 12th century AD, which developed into crude metal cannon by the 13th century.

This four century development process then stalled, and did not pick up again.

THE WESTERN DRAGON

The first recognizable cannon appears in western european art in AD 1320 and is basically an iron pot.

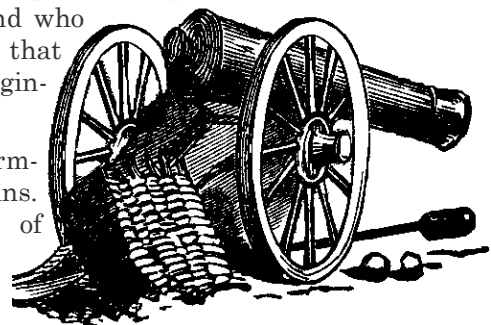
Within a 133 years this crude weapon had come of age. By 1453 the French defeated the English (and their famous Archers) in the last battle of the Hundred Years War because French cannon outranged them.

In the same year, the 1100 year old walls of Constantinople fell to massive siege guns cast on the spot by a renegade artilleryman who *had* offered his skills to the Christians, but was rejected because they couldn't afford him (a classic case of false economy!).

It was as much gunpowder and cannon as it was steam power and iron foundries that then spread european dominance throughout the rest of the world, even to Asia, and even to the home of gunpowder, China.

Gunpowder, or the *idea* of it, *may* have come from China via the Silk Road or the Islamic world, but it was European artificers who developed and improved the technology, and who quickly surpassed that of the Chinese originators.

Better powder formulae. Better guns. Better modes of employing them



CHEAP IRON OR DEAR BRONZE

The first cannon used in Europe were actually made in the same way as barrels were (hence the name for the main part of the cannon), wrought iron bars were welded together around a wooden form, then reinforcing bands were welded around the barrel so formed.

This was not a particularly reliable method of construction, the barrels had inherent weak spots all along the welds and the wrought iron used was very susceptible to the acidic nature of the gunpowder residue.

Worse, it was inconsistent in quality and would *eventually* burst, but when it did it did not burst *consistently*.

It *might* simply blow a hole where the weak spot was, but it was much more likely the whole thing would catastrophically explode in all directions.

Early wrought iron cannon simply were not consistent – they might catastrophically explode after a single shot, or after a hundred. You simply couldn't estimate it reliably.

This weakness was rapidly recognised, and cast bronze guns were developed.

These were much less likely to explode catastrophically, typically blowing off a *piece* of the muzzle or barrel, *much* more survivable than the catastrophic explosion normal in iron barrelled guns.

Unfortunately, bronze guns cost at least *ten times* more than iron guns. Though they *could* be recast if they *did* explode, or if the owner wanted to modernise his artillery park, or simply if he wanted to rework the weapon to make it safer.

It wasn't until better casting techniques and better quality control was available for iron that *more* (but not absolutely) reliable iron guns became available in the 16th century in Sweden and the UK.

These guns were still liable to catastrophic explosions, but *much* less so than previously.

And they were *still* 1/10th the cost of a Bronze gun.

This gave English monarchs a *huge* advantage against their continental enemies.

EXPLOSIVE IMPROVEMENTS

Meal powder (see *The Secret Formula* over) was not really suitable for large scale military use because of its tendency to separate back into its constituent components, so European artificers searched for a better solution.

Early in the 15th century AD they came across one – mix the powder with water (later with spirits of wine), compress into a cake then, with *extreme* care, grind the cake into granules.

Granulated powder, *Corned Powder*, would not separate into its components, the granulation improved the combustion rate of the powder, greatly increasing power, range and accuracy.

The fineness of the grains determined the use – coarser grains tended to be used in weapons with long barrels, finer grains in those with short barrels.

FEEDING THE GUNS

A 50 pound “Half Cannon” (i.e. firing a ball weighing 50 lbs, c. 22.7 kg) required a “crew” of 3 master gunners and 15 assistants. It could fire 45 shots per day and consumed 680 kilos of gunpowder in doing so.

Punto Bianco (“point blank” – the distance at which a white aiming mark at the center of a target could be seen along a straight barrel) was c. 228-273 meters.

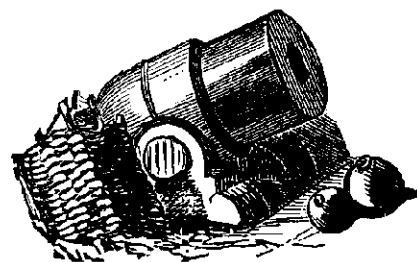
Maximum range, with barrel at 45° elevation, was c. 3185-3640 meters.

The “Half Cannon” weighed 3175 kg and required a team of 14-15 oxen or draught horses to move it.

It cost 781 ducats naked (unmounted) and 812 ducats with carriage (infantry pay was c. 1 ducat per quarter; an arquebus cost c. 1 ducat).

The new way of war was *not* cheap.

– various 16th century manuals.



MOUNTING AND TRANSPORTATION

The very earliest artillery pieces were mounted on crude wooden sleds constructed on site and normally transported to and from deployments by the simple expedient of slinging them from a pole or poles carried by teams of draught animals fore and aft.

Gradually these were replaced by more permanent “mounts,” still not much more than wooden sleds, and these were mounted on large wagons.

The *really* important development was of the *trunnion* (pairs of lugs cast in a cannon barrel at about the balance point), introduced in Europe in the 16th century. Trunnions allowed the weapons to be mounted on lighter, more mobile two wheeled field carriages (though to begin with “lighter” and “more mobile” were relative terms!).

PRINTING

“With my twenty-six soldiers of lead I shall conquer the world.”

– Johannes Gutenberg (c. 1400-1468)

Printing was a late development, even in China, where it first appeared as early as the 7th century AD (and certainly by the 9th) and depended on –

- a suitable material to print *on*, effectively *paper* (*parchment*, specially prepared animal skin, was too expensive and *papyrus* was too brittle and too rough).
- a large *and* literate enough population to make it economically viable.

These were in existence in China at that early stage, but not, yet, in Europe.

ASIAN PROBLEMS

China had a problem that could not be easily overcome, the nature of the written form of the Chinese language.

Unlike European languages where a small number of *alphabetical* characters could reproduce *any* word, Chinese consists of *ideograms*, *every word* required a separate symbol.

The capital cost of such a moveable type press was prohibitive, it was done, once, for a few official functions, but did not catch on and was scavenged for the metal type and abandoned.

The Koreans found a way around this by reinventing their writing system, abandoning the Chinese ideograms and adopting an alphabetical system based on ancient Sanskrit. The Japanese, much later, did something similar, supplementing ideograms with alphabets.

Of course, the Chinese *did* find a way of overcoming this problem, and the solution was quite effective and competitive with moveable type.

The Chinese cut a whole page of text and illustrations into a wood block and printed from this by inking it and pressing paper onto it, even developing mass production that made it competitive against moveable type presses as late as 1911, when the new Republican government banned the system in the name of “modernisation.”

THE SCRIBAL SYSTEM ...

A skilled scribe could produce two folio pages of text a week if all went well with the process.

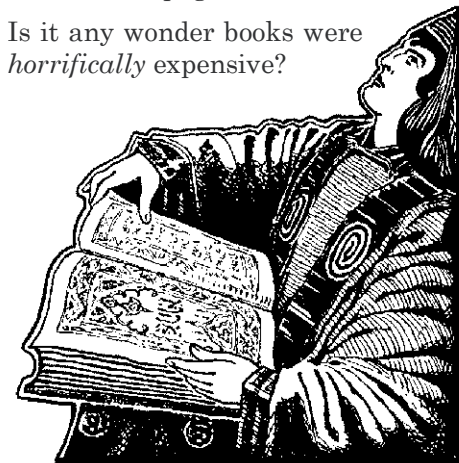
But that was only the *text* – the ornate, coloured, initial capitals and the illuminated margins were done by specialists once the text had been copied.

Then the book had to be bound by specialist bookbinders (once books had been invented, anyway – before they had they were glued together to form long scrolls called *codices*).

Most books were written on long lasting, but expensive, vellum or parchment – calfskin (though possibly sheepskin or goatskin).

But each calfskin took a month or more (depending on the time of year) to be prepared, though it did provide several folio pages.

Is it any wonder books were *horribly* expensive?





WESTERN ANSWERS

There is still considerable argument as to whether printing in Europe was an independent invention or was inspired either by *stories* of the Chinese methods (or by *contact* with Chinese technology), but it doesn't really matter (though the *limited* evidence available seems to support it having been an independent invention, and parts were completely, unlike anything the Chinese developed).

Paper was being made in Europe (Spain) as early as the 12th century AD, but then spread of literacy only began to reach the levels needed to make such a capital intensive industry viable in the 14th and 15th centuries ...

Thus, in the period from its invention in the 1450's to 1500 it is estimated that around 20 *million* books (called *Incunabula*) were printed in Europe, for a population of no more than 70 millions.

The cost of a copy of the Bible, for example, dropped from more than a years wages for a well to do Burgher (most well-to-do people owned only one or two Books or Gospels from the Bible rather than the whole thing) to a week's income, all within a century.

Within a twenty years the scribal dominance in reproducing texts that had lasted since the beginning of writing itself was no more, except on the peripheries of Europe and in parts of Asia.

In the next hundred years around 140 and possibly as many as 200 *million* books were printed in Europe, for a population, at the end of the period, of around 100 millions.

And the number of books printed continues to increase massively.

Today? The international book trade runs off around *ten billion* books a year (in excess of 400,000 titles), not including the 8-9000 daily and weekly newspapers and regularly or irregularly published magazines or many of the privately published volumes. It also doesn't include the tiny number of works (relatively speaking) "published" *only* in one of the many competing electronic formats.

THE GUTENBERG SYSTEM

The first European presses were based on a wine or olive oil press – a flatbed held the type in a frame. Paper was placed onto this and a platen screwed/pressed down from above.

It took about a day to set a page of type and, with the very first models, Gutenberg could print only 16 sheets an hour (of course, this was on large sheets, each of several pages).

Only one side at a time could be printed on, so the whole page of type had to be taken apart and then reset for each new sheet and then the printed sheets had to be redone on the other side.

Gutenberg began experimenting in 1438, commercial printing in 1450, and printed the famous 42 line Bible in 1453 (on parchment, not paper).

Unfortunately, like many inventors, he was unable to realise the financial rewards of his invention – at the moment the 42 line Bible was almost complete, his creditors stepped in and seized two of his three printing presses and all the copies of the Bible.

He struggled on for many years, and was finally awarded a substantial pension by the Archbishop of Mainz several years before he died, partly as a reward but mostly for political expediency (the Archbishop was beginning to understand the possibilities of *propaganda* that could be used either for, or against, him – and wanted Gutenberg to be *obligated*).

THE BIGGEST BESTSELLER EVER ...

Yes, you're all saying "The Bible!" In a sense, you're correct.

Between 1518 and 1525 *one third* of *all* the books printed in Germany (about 330,000 of a total of 1 million *per year*) were by one man.

Martin Luther (yes, the "father" of Protestantism).

In modern terms? The US prints around 2 *billion* books a year – so imagine a *single* author whose output represented *six hundred and sixty six million books*.

Year in. Year out. Seven years in a row. *That* is a best-seller!

BEFORE PRINTING

The earliest evidence of proto-writing, in the form of counting tokens with symbols may be datable to as far back as the 7th millennium BC.

Certainly the belief that writing almost spontaneously appeared from nowhere, more or less simultaneously, in Sumeria, Egypt and Harappa (in the Indus River valley) sometime between 3700 and 3000 BC is no longer accepted.

There is increasing evidence of a long developmental stage dating back centuries, if not millennia, leading up to the appearance of hieroglyphics in Egypt, cuneiform in Sumeria and the pictographs of the Indus Valley.

The Indus Valley script died out with the Harappan civilisation and left no successors (Sanskrit is entirely unrelated). Hieroglyphics lasted down to Roman times but also died out, though some of the simplified pictographs survived in the script used to write Coptic (now also extinct).

Of the three original forms of writing, only cuneiform survived – and only in as an alphabetic version which had over thirty letter signs, but no vowels.

The Phoenicians reduced the number of consonants and added vowels (22 letters). The Greeks copied the idea and modified the letters (24) for their own language. The Etruscans adapted the Greek alphabet (up to 26 letters) and the Romans, in turn, adapted the Etruscan (down to 23 letters, adding J, U and W in the medieval period).

Chinese ideograms are the oldest form of writing in east asia, appearing around 1600 BC – most likely the *idea* of writing, if not the actual scripts, travelled from the middle east to east asia along trade routes).

Once the *idea* of writing is learned of, the development of a script and of writing can be amazingly quick – Sequoyah developed an alphabetic script for the Cherokee in a mere 12 years, between 1809 and 1821.

It was so simple that anyone who could speak Cherokee could learn to write with Sequoyah's script in two weeks.

SCIENCE OR CRAFT?

Until the 18th century science (or what passed for it) took almost no interest in the practical world or in the practical application of their efforts.

Scientists did *pure* research and were usually not interested in solving practical problems. *That* was the province of mere *craftsmen* who, in turn, relied on a grab bag of technical tricks gathered mostly by trial and error, and which spread even more slowly spread.

Technological advances were *not* the result of systematic research into (or to develop) new ideas, new materials, or new ways of doing things.

ON THE CUSP OF CHANGE

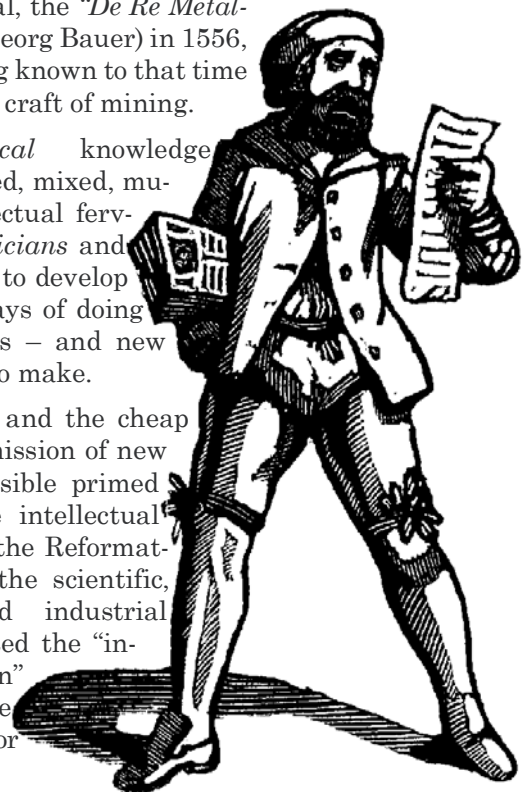
This only started to change (and *slowly*) with the invention of printing, and only in Europe (the Chinese never cottoned on to the possibilities of a mass market mass reproduction technology).

The majority of early printed materials were about religion or philosophy, and, while of *academic* importance in the spread of ideas, creating the intellectual climate that led to the Reformation, they did not have much *practical* effect on the everyday.

However, the stage was set, and change was in the wind. It began with the first “How To ...” manual, the “*De Re Metallica*” by Agricola (Georg Bauer) in 1556, covering everything known to that time about the practical craft of mining.

Suddenly *practical* knowledge spread, compounded, mixed, mutated in an intellectual fervour that led *technicians* and *practical scientists* to develop new and better ways of doing and making things – and new and better things to make.

In effect, printing and the cheap and speedy transmission of new ideas it made possible primed the pump for the intellectual ferment that was the Reformation, but also for the scientific, technological, and industrial ferment that created the “industrial revolution” and which laid the very foundations for our modern age.



TRANSPORT

Until the introduction of steam engine in the 18th century there was one immutable law of human civilisation: mankind travelled no faster than it had since the domestication of the horse and the invention of the wheel on land, and no faster than sails could propel you on water.

In effect the people, rich or poor, of the 17th century AD could travel no faster than the people of the 17th century BC.

The maximum speed that could reasonably be achieved, was 100 kilometers per day, and this was limited to water transport if it was to be economic.

Faster speeds were *sometimes* possible, but depended on favourable local conditions and also were normally prohibitive in cost.

The limitations of available transportation were a huge drag to economic and technologic development and progress.

LAND TRANSPORT

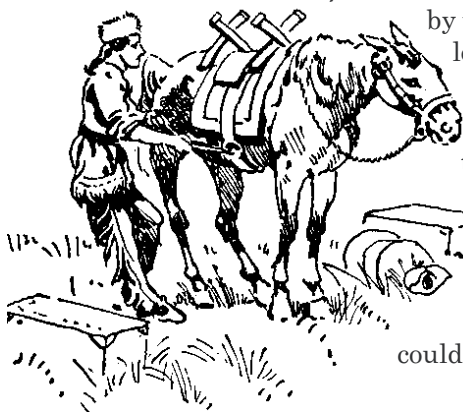
Land transport was especially expensive in pre-modern times as it involved substituting animal muscle and power for human, and this meant that both the animals and their human masters needed to be fed over whatever distance they were travelling.

Animal drawn transport could not be economically used over more than 250 kilometers for the simple reason that the draught animals would eat as much grain as the load they could carry.

And all this assumed the existence of good, all weather, roads surfaced to handle heavy traffic, something that was almost nonexistent for *most* times and places until, paradoxically, well after the transport revolution begun by the steamship and steam locomotive.

TYPES OF ROAD

There were basically two types of road common in ancient times: the dirt and the all weather road, and two possible purposes that roads could fulfil, civil or military.



Dirt roads were just that: dirt, graded if you were lucky, heavily rutted if not. All weather roads were mostly surfaced with gravel: even the famous Roman roads were of this type; stone flagstones as a road surface were used comparatively rarely.

Civil(ian) roads generally followed the easiest and most ancient routes, winding all over the place and only occasionally following the most direct route between two points they happened to connect.

Military roads, on the other hand, were very different. Wherever possible the followed the most direct route, even where considerable construction work was needed to make it usable, and they also tended to run along ridge tops wherever possible, to reduce the chance of surprise.

STEAMLESS RAILROADS

The earliest railroads used horse drawn carts on stone or iron rails, and early urban trams were often horse drawn on iron rails – there is a considerable mechanical advantage in such arrangements even if not using steam motive power.

So why weren't they invented and used earlier? By the Greeks or the Romans, or even by the Egyptians or Sumerians?

Mostly because they weren't *really* required. The trade the ancients carried on was quite limited compared even to that of the post medieval period *and* it was mostly carried by water transport.

Mostly, resources that weren't close to water transport weren't exploited unless there was no alternative.

By the early Industrial Revolution period all of those easily accessible resources had been exhausted, or were simply inadequate to meet the expanding needs of industry.

So the development of cheaper means of land transport suddenly became important in a way it never had been before.

And, coincidentally, the development of better tools and construction methods, cheaper irons made horse drawn railways economically attractive.

If the army they were designed for was basically an infantry based force they tended to be all weather roads, but if it was basically a cavalry based force they tended to be dirt (which is easier on a horse's hooves and cuts down on the cost and frequency of reshoeing with expensive iron horseshoes).

WATER TRANSPORT

Sea and river transport was much cheaper but, until the development of the theoretical basis for celestial navigation, it was too dangerous to sail for long distances out of the sight of land.

In the european world, these voyages were mostly limited to routes within the Mediterranean and Baltic seas, and, in asia, to routes such as China-Formosa, or Korea-Japan.

Everywhere else even the largest ships hugged the coast and normally put in to shore each night.

NAVIGATIONAL MATTERS

From the earliest times people had used the stars for navigation – or, more accurately, for *direction finding*. But to determine position accurately was impossible, at best you could estimate speed and direction and come to an educated guess.

Currents, the direction of flight of birds, winds, bottom soundings, and other practical observation methods supplemented any use of the stars, but did not really increase the accuracy of the position determined.

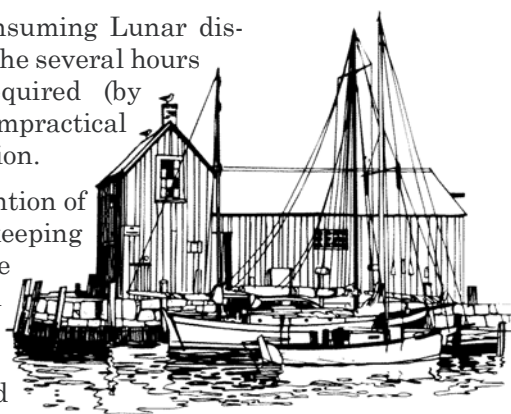
Even though the Chinese knew of the magnetic properties of lodestone, and used its use as a directional finder *on land*, as early as the 3rd millennium BC, it wasn't until the beginning of the 2nd millennium AD that anyone thought of (or, at least *mentions*) using it as a means of finding direction *at sea*.

The invention of some basic tools for determining latitude (north-south distance) really only began around the end of the 1st millennium AD, and the Sextant, the ultimate pre-electronics means of doing so, wasn't invented until 1731 (and, of course, required precision machining that could not have been done before the industrial revolution made it possible).

The Sextant even allowed the determination of *longitude* by using the compli-

cated and time consuming Lunar distance method, but the several hours of calculations required (by hand) made this impractical for regular navigation.

Only with the invention of an accurate timekeeping mechanism, the *chronometer*, could longitude be accurately determined and, again, this had to wait until precision machining could allow for the invention of a sufficiently accurate one in the 1760's.



CARVEL OR CLINKER BUILT?

The earliest known ships (from the Mediterranean) were *carvel* built – the planks were laid edge to edge and joined with mortice and tenon work and wooden dowelling. Only after the hull had been built was an interior frame added.

This method of construction was very strong – but it had two major shortcomings. It was slow to build and slow to repair. Still, this was the method of choice throughout the western eurasian civilisations till after the collapse of the western parts of the Roman Empire.

The Germanic and Scandinavian civilisations utilised a different method of construction, the *clinker built* method – overlapping the planks and caulking (sealing) the gaps with hammered in hemp rope and tar. This was *generally* fast, cheap, and easy to repair.

At first, they used this method with a minimal internal framework rather like that of the *carvel built* hulls of the mediterranean, but they eventually found that it was even faster to build a ship if the framework was built first and the hull planks then affixed.

East eurasian vessels (such as the Chinese *Junk*) were constructed differently – they were flat bottomed and work was started on a bed of sandbags and structural strength was provided by inserting internal bulkheads.

MATERIALS

A little considered problem facing pre-modern civilisations was the limited range of materials available to them for *any* sort of construction – from a nail through a pair of shoes to a waterwheel and even a mansion.

The most common materials were naturally occurring: wood, stone, leather and bone, supplemented by *small* amounts of metal (bronze, some brass, and iron/steel for construction).

Wood, leather and bone are all fairly obviously much less strong and permanent than stone or metal. But what were the consequences of this?

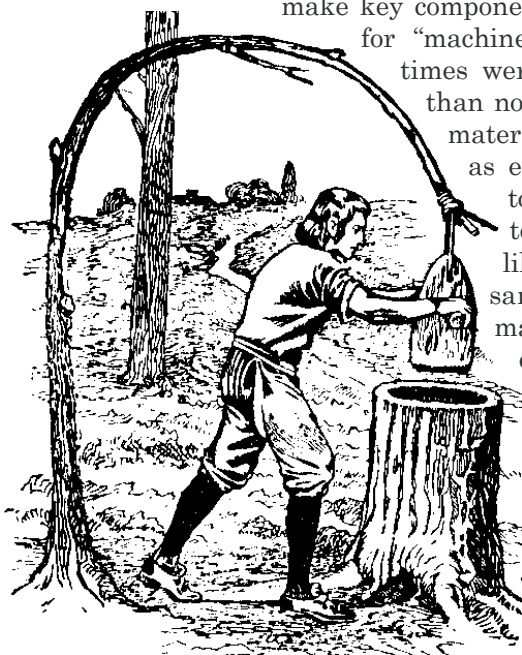
Well, for example, most of what passed for “industrial” machinery was constructed using wood as a key component (if not forming the whole of the machine), which, on average, meant that the wooden components that were under stress generally lasted no longer than 3-5 years, and often much less.

Even when not under stress, the work environment often meant that a life expectancy of 5-10 years was as much as could be expected for any other wooden parts.

The cost of the continual replacement and repairs was considerable. The key elements depreciated at a rate of 20% or more per year and the rest at a rate of 10-20%.

Worse. The tools that were used to make key components of what passed for “machines” in pre modern times were *also*, more often than not, constructed from materials that were just as ephemeral! And the tools to make the tools were most likely made from the same problematic materials, and so on down the line.

This meant the cost of *anything* man-made was *much* higher than one would expect based on modern day assumptions..



WATERMILLS

The main axle on which the waterwheel of a mill turned was cut much longer than was required to reach the gearing that ran the millstones.

The reason? Even greasing the axle on the points of wear meant that the whole thing had to be unmounted and moved in several feet each year to bring unworn parts onto the points of wear.

In general, the axle of such a mill could be expected to require complete replacement every 3-5 years. And, as the burning of forests for charcoal fuel for heating and industry proceeded apace, the availability of timbers that were long enough and strong enough became increasingly problematic.

The mill *stone* also required regular replacement, about every five years.

Yet the water mill was *the* major source of mechanical power right through to the Industrial Revolution. For example, when William the Conqueror had his officials record the extent and wealth of his new domain they listed more than *seven thousand*

So any form of machine or tool, and even most *structures*, were constructed from materials that had a very short expected useful life.

Even dwellings and other physical structures, unless constructed solidly of brick or stone, had the same problems. And even brick and stone dwellings needed constant preventive maintenance and minor repairs to keep them from decaying.

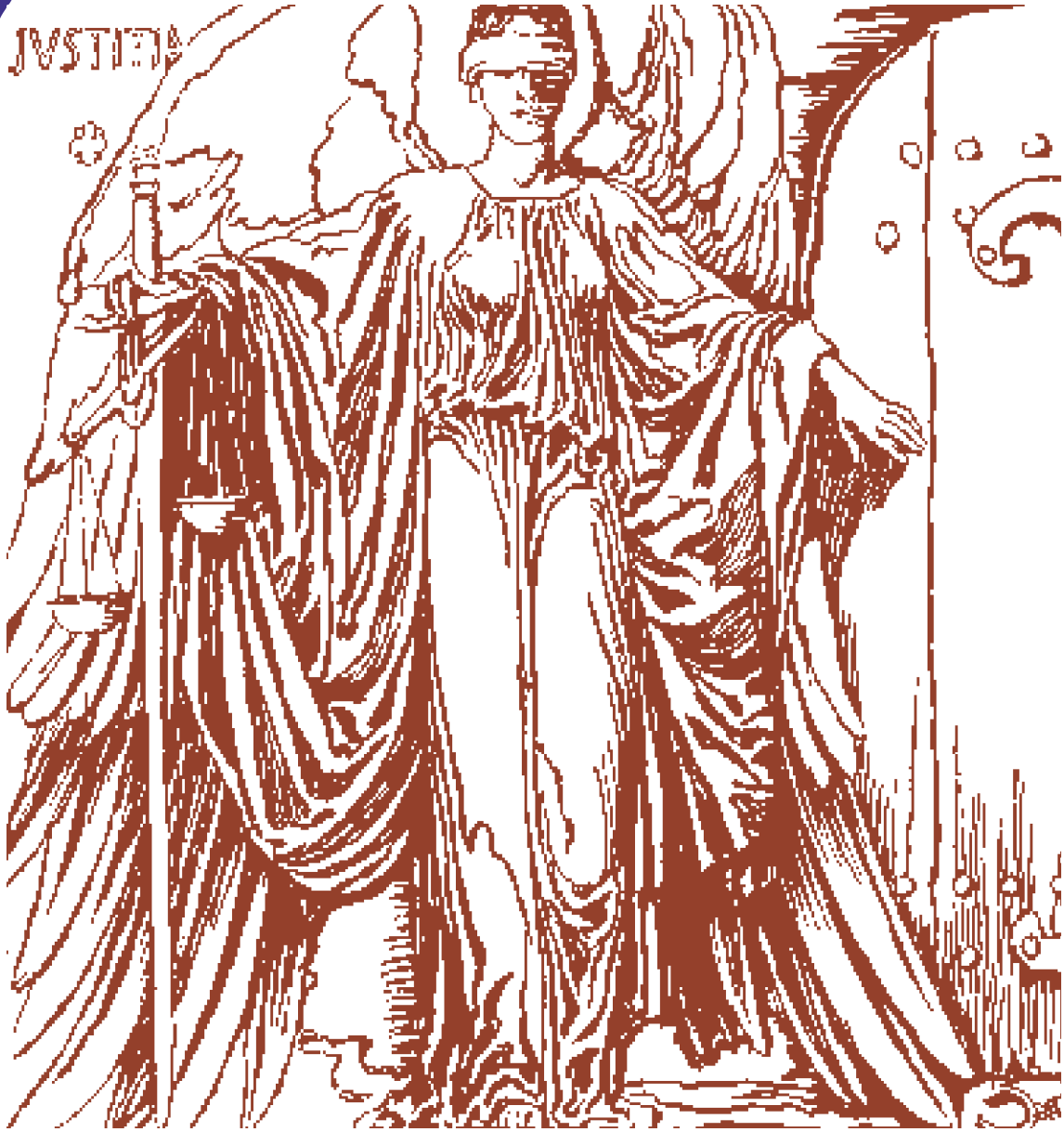
Unlike today, the cost of all this was a *constant* and *massive* ongoing drain on the productiveness of the economy.

Only the introduction of metal machines and tools, and of other modern, long lasting *or* extremely cheap materials has changed the situation, from the early industrial revolution onwards.

CONSOLIDATION

SECTION

6



“Civilization is a stream with banks. The stream is sometimes filled with blood from people killing, stealing, shouting and doing the things historians usually record, while on the banks, unnoticed, people build homes, make love, raise children, sing songs, write poetry and even whittle statues. The story of civilization is the story of what happened on the banks. Historians are pessimists because they ignore the banks for the river”

–Will Durant (1885-1981)

“Civilization is drugs, alcohol, engines of war, prostitution, machines and machine slaves, low wages, bad food, bad taste, prisons, reformatories, lunatic asylums, divorce, perversion, brutal sports, suicides, infanticide, cinema, quackery, demagoguery, strikes, lockouts, revolutions, putsches, colonization, electric chairs, guillotines, sabotage, floods, famine, disease, gangsters, money barons, horse racing, fashion shows, poodle dogs, chow dogs, Siamese cats, condoms, pessaries, syphilis, gonorrhea, insanity, neuroses, etc.”

– Henry Miller (1891-1980)

“Books are the carriers of civilization. Without books, history is silent, literature dumb, science crippled, thought and speculation at a standstill.”

– Barbara Tuchman (1912-1989)

IT FITS LIKE *THIS* ...

SOME PRACTICAL CONSIDERATIONS

While the preceding sections deal with many of the more practical problems involved with designing and defining a civilisation, not all of the problems that potentially face a world design process are covered.

This section is intended to deal with some of those problems.

UNIVERSAL EMPIRES

A common civilisation “type” in many role playing games is the “universal empire,” an all-encompassing, geographically compact, socially and technologically static, mega-empire that dominates a whole region, continent, world, sector or sectors.

Such empires are, almost routinely, said to be thousands of years old, and are, equally routinely, said to have remained unchanged in social structure and technology for that entire period.

Game Designers usually cite China as a “proof” that *their* universal empire is believable.

Sadly, this example, and the whole idea, doesn’t stack up against *reality*.

While Chinese civilisation is, indeed, very ancient, it is not the most ancient terrestrial civilisation and, in fact, did

not manage to “unify” what we in modern times call “China” until AD 1644!

Even if one looks at the *core* areas, China was not really unified before the 6th century AD at the earliest.

And the periods of unification rarely lasted more than 3-400 years, interspersed with long periods of disunity and division.

So much for the “Chinese example” of a “universal empire.”

The other, less often cited, example would be the Roman state, founded as a monarchy in 753 BC (according to legend), it managed to last until the mid 15th century (Constantinople fell to the Turks in 1453, but some outposts held out for another few decades).

Of course, it wouldn’t have been classed as a “mega-empire” for most of that period. Certainly, it was confined to Italy proper until around the 3rd century BC, when it was still a Republic, and didn’t really have a mega-empire until Augustus more or less formalised things under the Principate in the very last decades of the 1st century BC.

At its greatest extent it lasted for around 350 years before the western portion was progressively lost to barbarian incursions in the 4th and 5th centuries AD.

The eastern rump (often, incorrectly, called the Byzantine Empire) lasted for another 150 years before progressively losing territory to the expansion of Islam and other barbarians, but only really going downhill, and fast, from the 11th century.

So, so much for *Rome* as a “universal empire.”

Seems like “universal empires” just don’t have much of a track record!

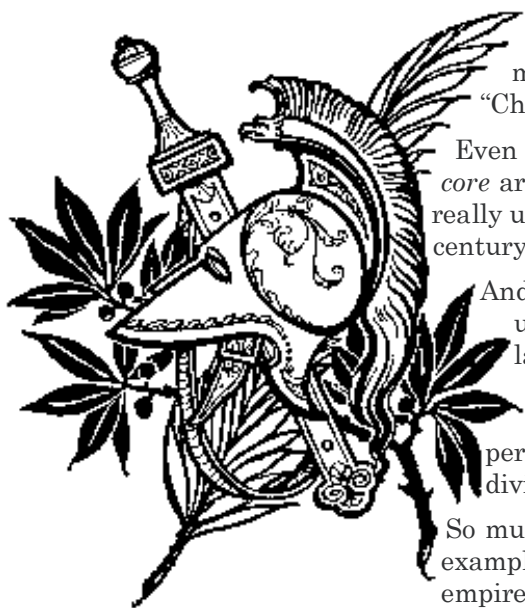
LIMITATIONS

So, what were the limitations that meant neither the Chinese nor the Roman “universal empires” had real staying power (at least compared to *fictional* empires of the same sort)?

TRANSPORT AND COMMUNICATIONS

The first thing that you’ll notice about both empires is that they are geographically compact. Communications and transport technology available had an important impact on their viability.

While they were in their expansionist phase, they had an edge, as their opp-



ponents had to *react* to them, and the slow speed of transport and communications meant that this put the *opposition* at a disadvantage.

However, once they had settled into their consolidation phase they gradually and increasingly found that the very advantages that they enjoyed in their expansionist phase were now accruing to their *opponents*.

Size, and the potential strength of the armed forces that a universal empire could field, was an advantage, but not an overwhelming one, especially as their enemies became more numerous, persistent, and sophisticated.

In fact, their very size could be an added problem.

The Chinese, even though geographically concentrated, inevitably found that moving armies over land simply wasn't fast enough, especially when being reactive.

The Roman Empire at least had the advantage of the centrally placed Mediterranean Sea which provided speedy and cheap internal lines of communication, though even that was not enough.

THE CUTTING EDGE

The other problem faced by all pre-gunpowder states is simply that the military technology available doesn't offer *anyone* a major technological edge. A sword is a sword is a sword, after all.

The usual advantage that a civilised state had against its less civilised (or simply less organised) opponents was mostly better training and logistical support.

The problem is that the "edge" that these factors provided simply weren't all that large, probably no more than 20-30% overall.

So civilised forces *could* be overwhelmed, fairly easily, by barbarian forces with a numerical edge that was brought to bear on them (which was often not the case because of poor command and control on the part of the barbarians).

In fact, the *real* edge that pre-gunpowder armies had over their barbarian counterparts was *strategic* – superior command and control and (hopefully) unity of command meant that even if



the barbarians had an overall numerical edge, the civilised forces had an enhanced ability to negate that by a variety of means (better/faster transport, better logistics, better/faster communications etc.)

SOCIAL STASIS

One common "trick" that game designers assume as a basis for creating worlds for fantasy (and other) milieu is the old "nothing changes because of social conservatism" argument.

Some sort of rigid caste system or exclusionary and limiting social structure is assumed to be the all-encompassing answer to keeping a society unchanging over many hundreds, and, possibly, many thousands, of years.

The problem is that there is *no* historical basis for this. None.

Rigid caste or social structures have, historically, not been all that rigid when examined closely, there are always "loopholes."

Able men (and, in some places and times, women) are always able to circumvent the class or caste strictures and raise themselves, or their children, up to a higher social or caste level.

PRACTICAL EXAMPLES

In India, usually used as a "prime" example of social stasis because of its all encompassing caste system, the historical situation was nothing like most people think. Whole clans (and the caste system was based on classifying *clans* within the overall structure) were able to move up the caste ladder by simply arrogating the status of the higher caste to themselves.

Of course, the clan had to be in a position to make such a jump "stick," which meant that they had to have acquired the social and/or political or economic wherewithal to empower such

a move. While such changes could take a generation or more, they *did* happen and were relatively common. And it *was* possible for a clan's social status to be effectively and permanently raised within the course of a person's normal lifetime.

The other option clans used to get around the *Hindu* caste strictures was to *abandon Hinduism* and adopt *Islam*, which is, of course, much more egalitarian. In fact, for many clans, this was one of the prime reasons for adopting Islam, its more flexible and egalitarian social structure.

In western societies, of course, even at their most restrictive, there was always a means of advancement for those with wealth or ability. Always.

At best, the social "haves" will be fighting a *losing* rearguard action aimed at limiting social mobility *not* at stopping it. This normally means that, while a lower class social climber will probably not be accepted (or not *fully* accepted), their *kids* ... or their *grandkids* are most likely to be accepted.

UNIVERSAL EMPIRES ... AGAIN

So, the case for social stasis by design doesn't work, either, unless you have a *Universal Empire* with no outside competition. But *that* option doesn't work, either, as has been shown above.

Which, of course, means that those fantasy societies that have remained socially static for centuries or millennia are, well, *fantasy*.

FANTASTIC SITUATIONS

That applies even to fantasy *races*. There is no reason to believe that any of the so-called nonhuman races are any more likely to adhere to anything more workable and permanent than human societies can.

In any case, most of the so-called "nonhumans" in fantasy games are capable of interbreeding with humans and producing viable and fertile offspring. Which means they are as human as, well, *humans*.

This, in turn, means that any claims that they are so vastly different that they would not follow basic human norms is, at best, unlikely and, at worst, downright unbelievable.

Even magic must have rules!

TECH STASIS

All fantasy world designers seem to make the assumption that their societies are even more static in a *technological* sense than they are in a social one.

Huge periods of their "backstory" history is, well, technologically unchanging or, at best, *vastly* slower than was the case in the only example we know of – the real world.

IN THE "REAL" WORLD

Taking the development of agriculture as a start point (c. 8500 BC in the Fertile Crescent) it took another 2500-3000 years to develop kiln fired pottery and, soon thereafter, metallurgy in the form of Bronze. Then it took another 2000 years to develop Iron.

But were the civilisations of the Neolithic and Chalcolithic (Copper Age) technologically static? Obviously not, they *did* develop kiln fired pottery and metallurgy, eventually (and much more, besides, even proto-writing).

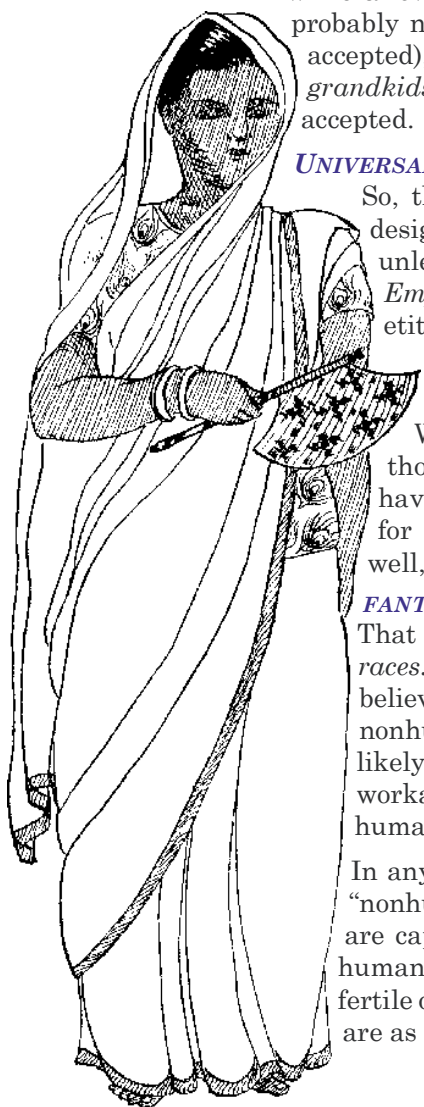
How about the Bronze age civilisations? Again, the answer has to be *no* – they developed (eventually) *iron*. And in the meantime they developed or perfected many other things.

BUT WAS IT REALLY STASIS?

Of course, while these societies *weren't* static, they were not exactly *speedy* in their rate of technological development.

The reasons for this are fairly simply and equally obvious – these early civilisations were *tiny* in terms of overall population, and the proportion of their populace that had the leisure time and physical/mental capital to *develop* new and improved things was an even tinier percentage of the overall numbers.

This means that you *can*, reasonably enough, have a quite slow pace of technological change. From stone age hunter gatherer to space age astronaut in eight and half millennia is slow by some standards of measurement.



But having “eras” of tens of thousands of years where technology barely changes, if it changes at all, well, no, that’s not possible based on what we know about how societies work and develop.

HOW SLOW IS SLOW?

Does this mean that all civilisations will advance smoothly and rapidly up the technology tree?

Not at all! In fact, it is common, historically, for societies to reject or abandon technological changes that, with benefit of perfect 20:20 hindsight *we* see as being a major, and usually costly, mistake.

Some societies have made just such decisions and, when they do, they often find that the long term consequences are devastating.

For example, China had a huge lead over Europe in both ironworking and gunpowder weapons – and blew it.

They abandoned or marginalised both technologies – and when European explorers finally rolled around to China, it was *Europe* that had the advantage – China is only catching up.

COSTS AND PRICES

Another illegitimate trick that many designers use is to arbitrarily link the price of goods with their game impact rather than the actual cost of production – and they often get away with it because players and game masters don’t know enough history to understand what has been done.

The classic example of this “trick” is the massive over-pricing of certain missile weapons in common fantasy games.

A COMMON PROBLEM

For example, in one extremely popular FRPG, a standard English Longbow sells for 75 gold pieces, while a standard Longsword sells for 15 gp.

Come again?

A simple chunk of seasoned wood and some animal gut bowstring costs as much as 4 pounds of iron/steel?

Given what we know about the cost of iron and steel in the medieval world!

In the real world the prices would be reversed – *more* than reversed.

The basis of this problem (and most like it) is a desire to “balance” the “game,” the sad news is that *life is unbalanced*.

The most lethal or effective weapons, or most useful technology is *not* always dearer than less lethal or effective weapons and more expensive technology.

LONGBOW TACTICS

In this particular instance, however, the designers have got it even more wrong than it appears on the face of it.

The thing is, the English Longbow has such a fearsome reputation as it does *not* for its use as an individual weapon targetted at a specific individual target, but as an *area effect weapon* targetted at an *area target*.

The average Longbowman spent his Sundays practising *not* to hit the classic circular bullseye target, but in a set close formation of other archers under the command of a master archer who would call elevation and deflection to the group for a simultaneous release at an *area*.

This is the way the Longbow was used at the classic battles against the French. It was *not* a case of an individual archer picking off specific French knights that he aimed at at all.

In other words, it wasn’t the *weapon* that was lethal as much as the *training* of the wielder and the *tactical* employment of it.

As an individual point target weapon?

Well, it was *OK*, but hitting a target at any real range was a *lot* harder than in Hollywood Robin Hood movies.

You were probably better off with a sword and shield, and if you could afford it, with armour as well.

At least that was the case on a one to one basis between combatants of no particular outstanding skill or ability.

THE ROMAN LEGIONS

Similarly, a Roman Legionary armed with a sword (either short Gladius or the long Spatha) was probably no better as a swordsman than a medieval knight.



He might even have been less well trained. *As an individual.*

The thing is, the Roman Legionary *did not fight as an individual*, and a formation of Legionaries would almost certainly outmatch a similar number of knights (as long as they were on foot, and fighting with sword and shield).

PROHIBITIONS

It is true that some societies, from time to time and place to place, attempted to restrict access to some weapons – with a notable lack of success.

The Knight's sword of medieval Europe was supposedly restricted to knights.

But there wasn't all that much advantage in a Knight's sword compared to a standard one, so what was the point?

The double swords of the Samurai were likewise restricted in Japan, but non-samurai could use swords, and non-samurai armies could and did win battles – the samurai tried to stack the decks, but it was really pointless.

Likewise, the Japanese attempted to legislate firearms out of existence, but the rest of the world wasn't interested in this legal theory and eventually reality forced its way on them regardless.

The Pope attempted to ban the use of the Crossbow against all but the Infidel, and failed miserably. The weapon was just *too* good to ignore.

Other societies and civilisations have tried to limit the spread of certain types of goods by sumptuary laws (limiting how much certain social classes can spend on clothing, weapons, transport etc.) These are universally ignored.

Worse, they almost always lead to corruption as those with the money, but not the status, bribe those in charge of enforcing the law!

Think *Prohibition*.

WHY?

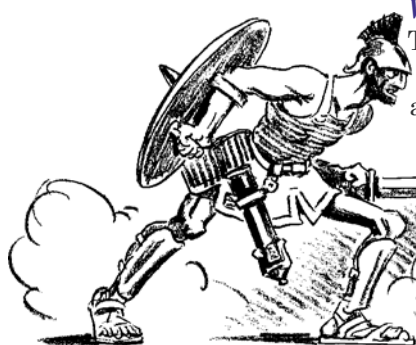
The sort of fiddling that you will usually encounter is an attempt to deal with the fact that, as this whole monograph has, hopefully, been showing, human societies are *not* static, and their

technology continues to progress, even if (by some standards) slowly.

Which is silly – the changes in question should be *part* of the role playing experience, there is *no reason* to “protect” players from it!

Let them take advantage of it (or be taken advantage of by it!) – which is rarely going to be cut and dried, just like it wasn't in real life.

So, be careful with costs and prices. Don't change them arbitrarily from what they were.



FANTASIES

SECTION

7



There are two sides to reality. There is what is, and there is what people believe. Seldom are they exactly the same.

– L.E. Modesitt, Jr. *The Magic Engineer*

ALL FANTASY SHOULD HAVE A SOLID BASE IN REALITY.

– MAX BEERBOHM (1872-1956)

That has been the purpose of this entire book:- to give a *basis of reality* for created societies and civilisations in role playing games. It doesn't matter, ultimately, whether those societies are for fantasy or science fiction or for historical games, *the same rules apply*.

In a very real sense, magic is simply another form of technology and will affect the fantasy world you are creating in similar ways to the way the real world was affected by scientific or technological developments.

By definition, for any game world that exists, magic has to have some internally consistent logic. It cannot simply be arbitrary and inconsistent – if it were, then the game would be unplayable because of that very fact.

MAGITECH

The obvious pattern of human historical advancement has been to develop technological means of improving our control of the environment and to make our lives easier.

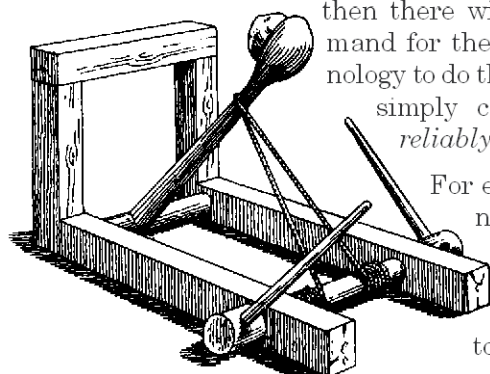
The existence of magic in a world does not *in any way* change this.

... IN WARFARE

If magic is amenable to some form of logical development and control, then magic will either replace much of the technological advances that took place in our world or will supplement them.

If magic is *not* amenable to some form of logical development and control, then there will be a continued demand for the development of technology to do those things that magic simply cannot do (or cannot *reliably* do).

For example, if magic cannot batter down castle walls, then there will still be a demand for *technological means* to do just that.



Catapults will lead to a better understanding of mathematics and physics and, since these *are* logical and consistent, will lead to the primacy of such technological means of battering down castle walls.

Of course, even for magic that is not powerful, consistent, or logical enough to do the job by itself, the use of magically enhanced or created missiles in mundane catapults is a certainty.

Or if magical ability isn't widespread enough in the population then there will either be an economic incentive to find and train *more* mages (if this is possible at all) or to, again, find a way to supplement this magical shortfall with mundane technology.

Noble leaders and warriors aren't going to be interested in excuses, they will want *any* effective way of taking that enemy castle. *Any way*.

As we have seen, things don't just stand still for hundreds, let alone thousands or tens of thousands of years!

Magical abilities will have important impacts in other areas of military endeavour – create food/water spells will have important effects on logistics. Armies (small ones, at the very least) will become more mobile than most pre-modern armies could be and will, likewise, be able to campaign during winter when, historically, the lack of fodder for horses was a major problem.

Such spells will also have an impact on the ability of castles and cities to withstand sieges, or of fleets to stay at sea

And these are merely *some* of the possible effects of logical developments of magic in the realm of mass warfare, beyond the usual *individual* focus of most fantasy magic systems ... enchanted swords, magically accurised missile weapons, (al)chemical weapons, scrying spells for improved intelligence, fireballs or other area effect spells that act as magical "artillery," and more!

... IN AGRICULTURE

All those “plant growth” or “crop enhancement” (and even weather control) spells that seem to exist in most magic systems will have a greater importance than might seem obvious.

If they are amenable to development and enhancement they will provide a *magical* but consistent means of enhancing crop yields.

Enhanced crop yields, as we have seen, mean better health, a stronger economy with more possibilities for specialists to exist, and a larger population.

All of these things mean that it is unlikely that such societies could fall into the grip of social and technological stasis for any length of time.

In fact, these possibilities mean that technological advancement will likely be faster (or magical advancement will be) in such societies.

CAVERNS AND FORESTS

What about the Pointy Ears and Big Beards? Does magically enhanced agriculture make them more feasible?

To a degree.

Elves *can* probably live in forests in much larger numbers than would seem possible on the face of it. With magically enhanced crops (based on, for example, Maize) you could expect to get 800 kilos per kilo of seed which makes even the small forest clearings that exist in most forests able to support modest populations.

Thing is, even with such a change, a forest won't support the numbers that will be needed to defend it against the encroachment of peoples with access to vaster areas of productive farmland.

Dwarves and their caverns could likewise be supported by magically enhanced underground crops (or by crops grown on small patches of level ground in and around their caverns), but aren't going to be competitive with *proper* agriculturalists.

In short, even with magic, Elves and Dwarves simply won't be able to compete with humans in the longer term unless they become *like* humans in their range and habits.

Coincidentally, such a change means that the likelihood of a continued existence of an unsophisticated, decentralised, basically feudal politico-military structure for a society is very low.

With increased revenues and larger populations, the trend towards a centralised bureaucratic state would seem to be inevitable.

Again, social and technological stasis is unlikely in the extreme under such circumstances.

... IN HEALTH

The existence of healing and cure disease spells also means the likelihood of considerable change if they are logical and consistent.

There will be an inevitable trend to develop them into a form capable of wide use throughout the populace – and this will have an major impact on infant mortality and population growth.

Faster population growth will have an impact on the development of improved magical and mundane technology, just as it did historically.

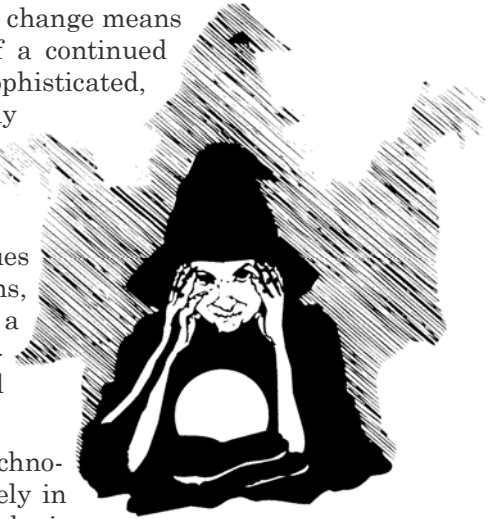
The availability of magical means for the combating of disease will also have important implications beyond mere population growth.

Any society which possesses (or which can gain possession of) such magical abilities becomes more or less immune to the sort of disease based conquests that destroyed the Mesoamerican and South American empires.

Of course, arguably, the Aztec and Inca equivalents of a fantasy world would have no exposure to epidemic diseases, just as was the case in the real world, and, therefore, no need to develop spells to counter it.

If spells are “miracles” provided by divine favour, however, all bets are off – and conquistador types aren't going to get the free ride that they did in the real world.

In fact, the interpenetration of geographical disease pools will likely have



a much reduced impact in a magical world than in the real world.

The arrival of new diseases (such as the Bubonic Plague that hit Europe in the 14th century) will be unlikely to have an impact in a world where magical aid can render such diseases impotent.

The existence of spells of regeneration and repair will also have an impact, though it will likely be more limited, there will be fewer physical disabilities amongst the populace as a result.

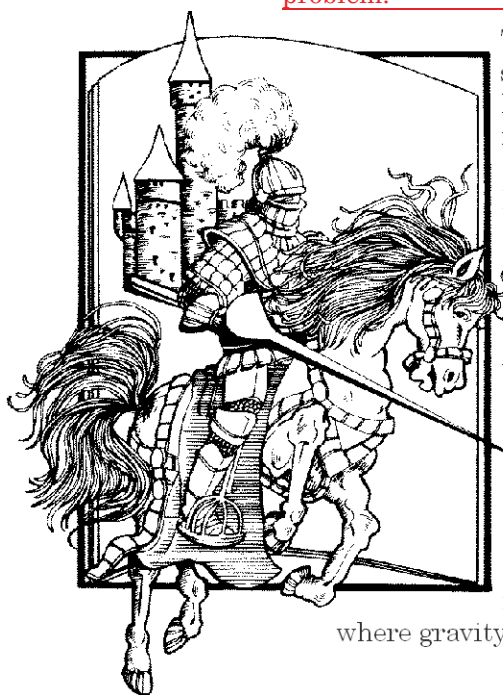
Fewer cripples, fewer blind or deaf people. Overall, magically enhanced medical practitioners may be able to utilise “technology” in some ways more advanced than that which we enjoy today!

... IN INDUSTRY

The existence of spells that make prospecting for metals (and, presumably, other raw materials) easier will have an impact on the availability of those raw materials – as will spells such as “create air” which will allow deeper mines even with primitive technology.

Variant spells that allow explosive gases to be transformed to non explosive gases, or which provide warnings about the buildup of explosive gases will also be helpful.

Of course, the availability of flameless “Permanent Light” spells make the issue of explosions considerable less of a problem.



Transmute spells such as “Rock to Mud” will make mining, even with pre-gunpowder technology, *vastly* easier.

The digging of adits (tunnels to drain water from mines by gravity) will become easy and economic, making mines that would normally be below the water table and, therefore, impossible to dewater possible in those situations

where gravity draining *is* possible.

The same spells would, presumably, make the separation of the ore from the rock matrix much easier as well: the *rock* being converted to mud but the *ore* being left. This would be applicable, at the very least, for those metals that appear in a metallic form in nature – gold, obviously, but also copper and tin.

Purify spells could also, one presumes, be developed to “purify” things other than food and water: purify <fill in the blank> ore would be an obviously helpful spell for miners! No need for nasty environmental pollutants in the smelting process, and probably not even a need for huge quantities of fuel for those processes, either.

Where heat *is* required, the use of summoned and chained elementals would be a useful and economic means of supply for industrial operations.

Steam engines, for example, could be a combination of a fire and water elemental in a magically warded structure, or wind turbines could be enclosed and powered by wind elementals in a similar structure.

Magically enhanced materials will lead to given architectural and engineering feats being possible much earlier.

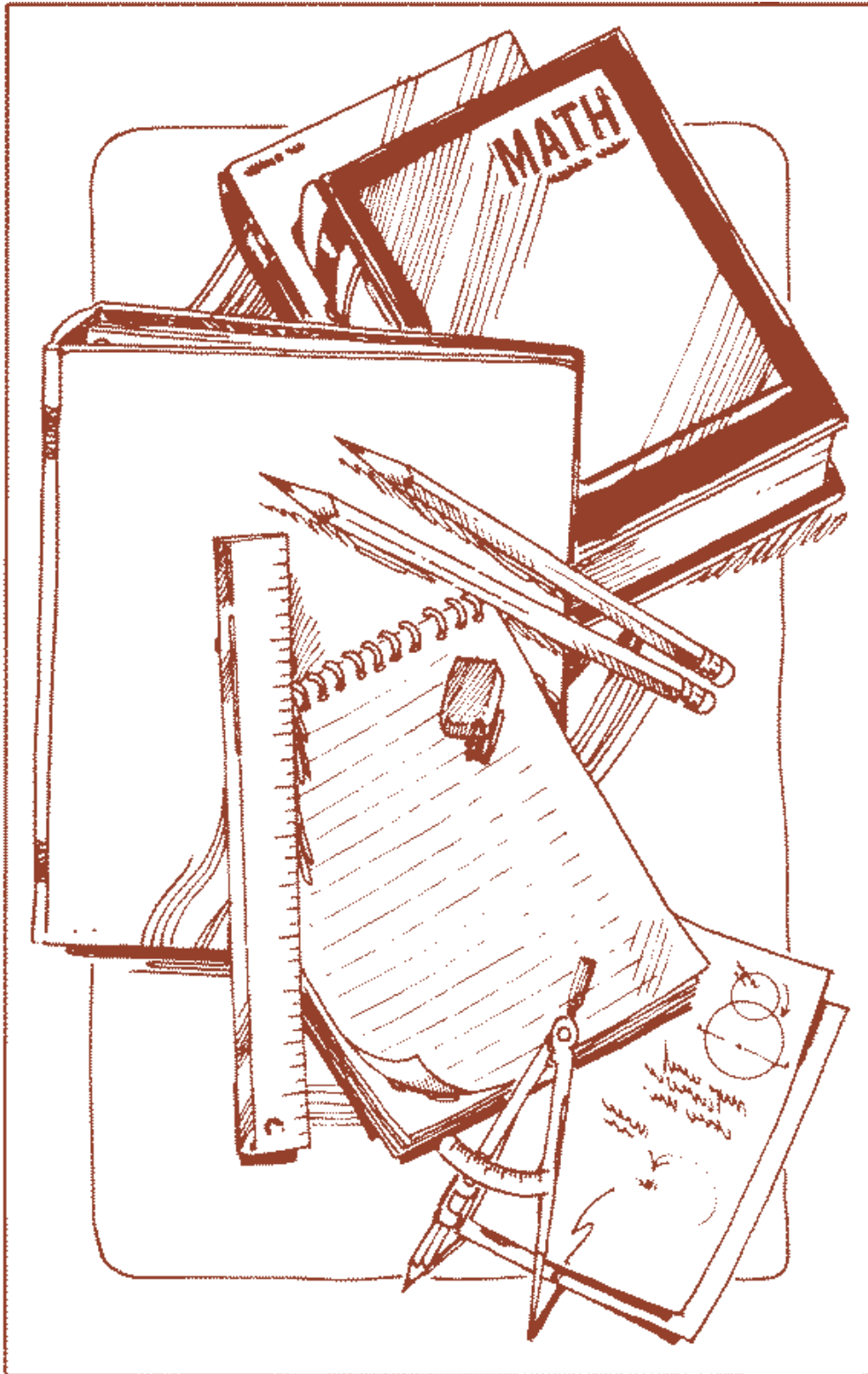
The use of magical automata will also have an important impact on the manufacturing of key items and the construction of key buildings, reducing their cost and making them more available as a result.

This will almost certainly have a knock-on effect reducing prices across the board, though, perhaps, not as massively as the mundane industrial revolution of *our* world did.

IN SUMMARY

In short, magic will enhance and accelerate *mundane* technological change unless it is completely unpredictable and totally illogical. In which case it will be *replaced* with (or will, at best, be *supplemented by*) technology at about the same rate of change that occurred in the real world.

BIBLIOGRAPHY



*For books are more than books, they are the life
The very heart and core of ages past,
The reason why men lived and worked and died,
The essence and quintessence of their lives.*

– Amy Lowell, “Boston Athenaeum”

SECTION

8

ANNOTATED SOURCES

FACT OR FANCY?

For those of you whose interest has been piqued by what you've read so far, the following pages contain an annotated bibliography for *some* of the more important books that were used, over the years, in the research for this book.

The list is not, and could not be, complete – much of the information that makes up the basis for FFnS was gathered in small bits and pieces, dribs and drabs, from many books on a wide variety of unrelated subjects. One fact here, a tidbit or two (or even three!) there.

However, if you are interested in learning more about how civilisations work, develop, and change over time then the books listed are a good starting point, especially *their* bibliographies.

PLAGUES AND PEOPLES

by William H McNeill, 1977, 1998, Anchor Books.

My copy of the original 1977 edition was so worn and yellowed (acid paper, unfortunately, like almost all modern paperbacks), that I shelled out the \$\$\$ for a new copy of the latest edition.

McNeill's thesis is that diseases have had a far greater impact on human history than (almost) any earlier historians had suspected, and his arguments have been influential.

The introduction contains an excellent layman's explanation of the evolution and ecology of diseases and the mechanism of their inter-species transmission, while the following chapters deal with the impact of disease in specific historical epochs.

A must read if you want a deeper understanding of this important, but largely ignored, aspect of history.

THE HUMAN WEB

by J R and William H McNeill, 2003, Norton Books.

Subtitled "*A Bird's eye view of World History*" and by the author of *Plagues and Peoples* (see above) and his son.

Just as PnP argues that the impact of diseases on human history has been much greater than most historians have understood, THW looks at the interconnectivity of human societies and experiences and their history.

Suffice it to say that the "web" motif is a recurrent underpinning – the basic argument is that civilisations have grown and prospered in a direct relationship to the exact degree in which they have integrated themselves into larger and larger groupings through trade and cultural contacts (and, of course, this is a development of the thesis that underpins much of *Plagues and Peoples* as well, but there it is limited to disease pools – here it is an underlying principle of *everything*).

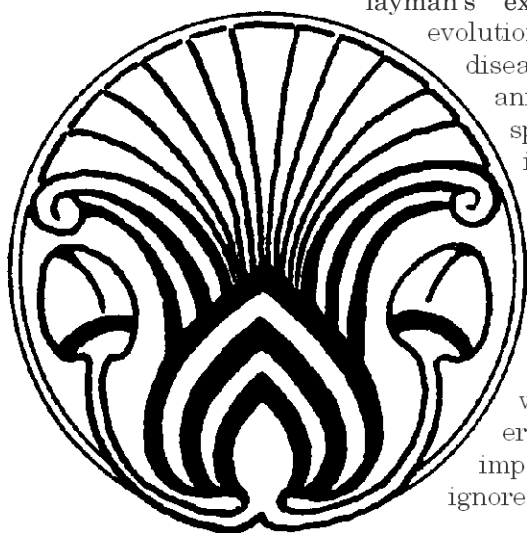
The intent is similar in some ways to that of Jared Diamond's books (reviewed elsewhere), but, unlike his, is not based on geographical determinism, but on a more structured historical thesis.

Which is not to say that the arguments are perfectly structured or completely convincing – there are some flaws but, overall, I believe that McNeill and McNeill are onto something that bears greater examination.

THE GUTENBERG REVOLUTION

by John Man, 2002, 2003, Review (Headline Book Publishing).

An interesting examination of the "discovery" or invention of printing by Johannes Gutenberg, arguing that the whole idea was home grown and owed little or nothing (directly, at least) to the east asian methods of block printing. Argues strongly for the genius of one man, Gutenberg, being the driving



force behind its development.

The book examines the milieu in which Gutenberg developed and implemented his ideas, his probable intent in doing so, and the way in which his invention did more or less the exact opposite of what he intended, and how it changed the world in ways no-one at the time could have predicted.

Printing has probably been the most seminal invention of the last several millennia for the simple reason that it accelerated and expanded the way in which new ideas and inventions could be disseminated and utilised ... which makes it the underpinning of the modern world in a way in which most people simply overlook. This book examines the early centuries after its development and the beginnings of those seminal changes – changes that are still echoing down to the present.

A fascinating examination of how inventions develop and how they develop in ways completely unexpected by their developers – or anyone else.

OUT OF THE FIERY FURNACE

by Robert Raymond, 1984, Macmillan Australia *.

The subtitle indicated the subject matter – *The Impact of Metals on the History of Mankind* – this is a companion book to an ABC (*Australian Broadcasting Commission*) documentary series of the same name that was presented on local TV here in Oz in the early 1980's.

While dated in some areas because of more recent archaeological discoveries and historical research, it is still an excellent popularisation of how civilisation developed from and in conjunction with the discovery of metal working technologies.

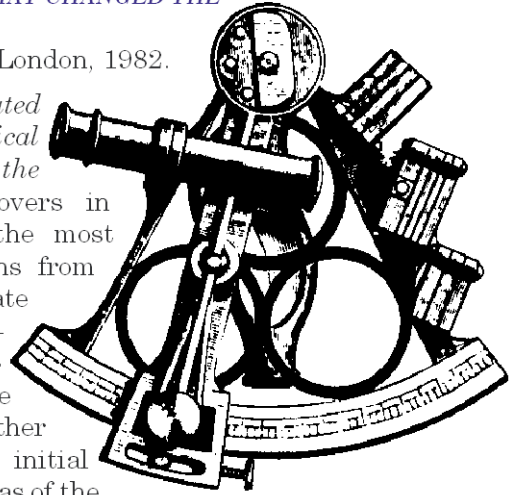
In a way, the book is an earlier version of Diamond et al and the recent spate of “theory of everything” books explaining historical and cultural developments – but limited to one particular technology and related areas.

* *The book was evidently reprinted by the University of Pennsylvania Press, 1986 (possibly reprinted, 2000), as a textbook for college courses. Check out Amazon.com or abebooks.com to see if copies are available.*

THE INVENTIONS THAT CHANGED THE WORLD

by Reader's Digest, London, 1982.

Subtitled *An illustrated guide to man's practical genius through the ages*, this book covers in reasonable detail the most important inventions from prehistory to its date of publication – often adding material as to how the invention was further developed from its initial stages into its final (as of the 1980's, anyway) form.



A useful reference work with a surprising amount of detail, though, of course, it does not cover inventions that were just being introduced or becoming important as accurately as the next book.

Well worth tracking down second hand if you can.

JAMES DYSON'S HISTORY OF GREAT INVENTIONS

edited by Robert Uhlig, Constable and Robinson, 2001, 2002.

A useful addition to the Reader's Digest book *The Inventions that changed the world*, updating things through to the end of the 20th century at the very least.

The book also contains information on some inventions not included in the former as well as additional information on some inventions that are.

These two books usefully supplement each other and are highly recommended, and this one should be easier to track down!

THE RENAISSANCE AT WAR

by Thomas Arnold, Cassel, 2001, 2002.

Part of the *Cassel History of Warfare* series, this book covers the developments of technology and tactics and how they affected the conduct of war during the Renaissance (1450 to 1600).

This is, of course, the period during which Europe went from a society in which medieval technology – knights on horseback, bowman, and peasant levies armed with farming implements (sometimes crudely converted into weapons, sometimes not) – was not only dominant, but virtually the only,

battlefield technology to one which was dominated by cannon and gunpowder weapons.

In the limited space allowed for books in this series, Arnold covers the changes that occurred during this important transitional period from the ancient to a more modern way of warfare remarkably well, and the bibliography is quite comprehensive.

WARFARE IN THE 17TH CENTURY

by John Childs, Cassel, 2001, 2003.

Another installment of the *Cassel History of Warfare* series, this one covering, as the title indicates, the period from the late 1500's to the early 1700's, but concentrating on the period 1601-1700.

During this period the *organisation* of warfare, at least in Europe, was recovering from its decline during the period after the collapse of the Roman Empire in the west and was becoming more modern in its forms and equipment.

This book, like others in the series, is an excellent survey and has an equally excellent bibliography.

WAR AT SEA IN THE AGE OF SAIL

By Andrew Lambert, Cassel, 2000, 2002.

Also from the *Cassel History of Warfare* series, this book covers the development of warfare technology, tactics and strategy in the naval sphere for the period from the late 17th century through to the early 19th century when steam finally began to replace sail.

In many respects the development of organizational regimes to handle the requirements of a more modern style of warfare was vastly more important in the naval arena than it was for armies on land.



Ships and their equipment required money in vast quantities and skilled manpower in considerable numbers could not simply be rounded up from the countryside like conscripts for the army could

be, they, too, had to be paid for at some premium.

The ability of nation states to organise the finances for such expensive toys, and the dominance of trade and industry that navies gave to a nation state was the determinant of who would be the dominant world power for over a century to come.

GUNPOWDER

by Jack Kelly, Atlantic Books, 2004.

Subtitled *A History of the Explosive that changed the World*, this book makes it plain that making gunpowder is *not* as simple as mixing sulphur, saltpeter and charcoal.

It examines the problems in acquiring those materials (especially the saltpeter, a problem not really resolved until the 1860's!) and in turning them into a reliable military (combat) and civil (engineering) tool.

It also looks at the origins of the invention, almost certainly in China (and probably transmitted to the west from there rather than invented independently), and how the Chinese managed to completely miss its utility and totally fail to develop this innovation in the way that western societies did and the long term consequences of this failure.

An interesting study both in how the importance of an invention can be almost completely missed by one culture and adopted and improved to the great advantage of another.

GUNS, GERMS AND STEEL

by Jared Diamond, W. W. Norton & Company, 1997, 1999.

Subtitled *The Fate of Human Societies*, this book made a *major* splash when it was first released – it wasn't the first book to ever make an attempt to explain why the world developed the way it has. Why the West dominates and the rest of the world is dominated.

It was different in that it didn't explain this by hackneyed old racist ideologies, but by looking at the matter holistically. That was what was different, and controversial.

The problem is that historians have all too often looked very narrowly at the rise and decline of human societies – looking at the immediate causes of war,

famine, disease without looking *beyond* the obvious and at the *underlying*. Climate change from massive volcanic eruptions, *resistance* to disease in a population, agricultural productivity and other matters.

Diamond makes an attempt, and an interesting one, at trying to look at these deeper reasons – and that is as much the problem as anything else. His academic background is in Physiology specialising in the evolution and ecology of birds, which, of course, raised hackles amongst historians – and you can probably guess how the story goes from there.

It is likely he is wrong in key areas, as some specialists have argued – but it is equally likely that he has some interesting new approaches to history, approaches that have not been examined before.

It cannot be too highly recommended.

THE YEAR 1000

by Robert Lacey and Danny Danziger, Abacus, 2000, 2001.

Subtitled *What life was like at the turn of the First Millennium – An Englishman's World* examines exactly what it says, dividing that world up by the months of the year and the events of most connected with those months.

This is, of course, especially relevant in a world that was still largely agrarian, and living very much on the edge of survival.

The picture drawn is one of a grim existence of grinding poverty and unremitting labour to secure the most marginal level of survival – and the fragile and almost nonexistent islands of learning and knowledge scattered amongst islands of darkness. Really.

LOST CIVILISATIONS OF THE STONE AGE

by Richard Rudgely, Arrow Books, 1998.

A good layman's survey of the recent scholarship showing that, despite long accepted (and long unchallenged, and equally unsupported) belief, the origins of civilisation were much earlier, and much more widespread, than hitherto believed.

It also shows, fairly conclusively, that older theories that writing came into existence fully formed in Sumeria (modern Iraq) is almost certainly incorrect – and that a developmental process can be traced that leads up to it from simple pictographic representations.

AFTER THE ICE

by Steven Mithen, Weidenfeld and Nicholson, 2003.

Subtitled *A Global Human History 20,000-5000 BC*, this excellent and *reasonably* accessible book covers the period *before* that of *Lost Civilisations of the Stone Age* (reviewed above) in considerable detail.

Showing the development of mankind from groups of wandering hunter-gatherers eking out a marginal (and not so marginal, in some places) and nomadic living to the beginnings of settled life, the domestication of animals, and agriculture.

It is somewhere between a popularisation and a full blown academic treatment, leaning slightly towards the latter, and can be heavy going in places, but does provide an excellent overview of the latest scholarship in the field of prehistory. Highly recommended.

CIVILIZATION AND CAPITALISM, 15TH-18TH CENTURY

by Fernand Braudel, Weidenfeld & Nicholson, 2002.

A magisterial study of exactly what it says in three volumes.

Volume #1, *The Structures of Everyday Life*, covers society and the economy at the very lowest level, that of the individual and family, covering all sorts of details that you would be hard pressed to find all together in the same book elsewhere.

Volume #2, *The Wheels of Commerce* examines the development of our modern market economy in an equal level of detail, and also containing much information that you would otherwise



have to struggle through dozens or scores of books to find.

Volume #3, *Perspectives of the World*, ties it all together in an informative and detailed overview of these three key centuries in the development of the modern world.

Personally I found the first two books the most use, as the third covers topics that many others that are mentioned here (and even more that are not mentioned for space reasons) already do, and, probably, the driest and hardest to digest of the three.

The first two are well worth checking out of the library if not purchasing!

GURPS WORLDBOOKS

No bibliography of sources on the subject of history and gaming would be complete without mentioning the large number of excellent historical world-books that have been published over the years by Steve Jackson Games.

Though intended for use with GURPS, GMs around the world, have found them to be useful and accurate guides for gaming purposes, oftentimes providing obscure bits of information not widely known or widely mentioned in more academic oriented sources.

There are too many to list, but their number include – *Aztecs*, *Middle Ages*, *Imperial Rome*, *Russia*, *Japan* and many more.

All are highly recommended, and make an especially good choice if you haven't got the time to do a lot of specific research – Steve has always had a reputation for going the extra mile for accuracy and its shows.

Inaccuracies are rare, if they aren't merely differences of opinion between competing theories in the first place!

EABA STUFF!

by Greg Porter, BTRC, 200x.

Soon to be released, *Stuff!* is intended to do for BTRC's EABA game system what the *Guns, Guns, Guns* and *VDS (Vehicle Design System)* do for the CORPS game system – and more.

Pre-release drafts have shown that *Stuff!* will cover "design" in the widest sense possible.

Not only are there rules for the design and construction of weapons and vehicles, there are chapters that allow you to design intelligent races and non-intelligent animals (or monsters) and, importantly, whole broad stroke *civilisations* (on a social, political and economic level!)

There are also plans to include some basic design rules to allow the GM to determine a ballpark figure for actual construction times and costs for anything you can design with the game.

While it is intended for *EABA*, like *Guns, Guns, Guns* and *VDS*, it will be easy to use the rules to do the scutwork of designing and then translate the end results into figures and formats more palatable for your house system of choice.

Look forward to it. Buy it when its finally ready (and, no, I don't get paid – this is an entirely unsolicited "plug").

PROFANTASY SOFTWARE

Finally, where would a civilisation designer be without mapping software?

My program(s) of choice are by Profantasy – *CCPro* for the detailed mapping work and *Fractal Terrain* for creating whole worlds at the click of a mouse button.

Dungeon Designer, City Designer and the assorted Symbol Packs are also especially useful for making your world more *alive* than the same old same old hand drawn maps.

Fractal Terrains even maps the climate bands and weather patterns of each world it creates, which is a great boon to would be designers as well.

No other program (or suite of programs) on the market offers the same degree of functionality and utility, though there *is* a learning curve involved (and an excellent mailing list that can provide online support).

Highly recommended.