SEEDS OF WEALTH

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Four Plants That Made Men Rich

PAN BOOKS

To all those who became friends
after they had read
Seeds of Change

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Notes appear at the end of each chapter

Introduction

Seeds of Change, which I wrote nearly twenty years ago, was the first work that sought to give plants role as an important causative factor in history. This was then a novel approach, somewhat imitated since. There were originally five plants and a sixth, coca, the source of cocaine and crack, was added to the paperback in 1999. Traffic in cocaine, of course, is now an enormous trade; its street value is said to be larger than the gross national product of the United Kingdom and is growing at least three times as fast.

The thrill of illegitimacy should not excite the reader of this book, which is dedicated, as the subtitle says, to plants that made men rich. The first is timber, which is important in the history of both England and the thirteen North American Colonies which became the first thirteen States. In England, timber supplies became increasingly insufficient at the time of the Reformation. As timber then mostly used as fuel – became scarce, more and more coal was dug. Because coal had been significant as a fuel, especially in London, for several centuries before Queen Elizabeth, easily procured surface coal became deficient. Because there was little deep coal not associated with water, pumps became essential, and they became fundamental in deep mines by 1700. Though with low efficiencies, these steam-driven pumps were common in England more than fifty years before James Watt, who, we are conventionally taught, was the practical genius who made steam-power widely available, thus being responsible for the motive force behind the coal–steam–iron Industrial Revolution. In fact, it is argued, the Industrial Revolution occurred in the United Kingdom fifty to on hundred years ahead of any other country largely because of the national shortage of timber, the first such shortage in a major European power.

But timber was still needed, and it was the British–American Colonies that supplied it. The Royal and Merchant Navies (before about 1870) and the iron and steel industry (until about 1820) were almost wholly dependent upon the wealth of wood in the thirteen colonies and for more than a centur before the Revolution. This dependence is demonstrated by ‘mast convoys’ as early as the reign of Charles I, and because even Nelson’s victory at Trafalgar was won by ships largely built of American timber.

The wealth of American timber was much more significant than this; it fuelled the westward marc in the 1800s and the occupation of the huge area between the Allegheny–Adirondacks and the great valley of the Mississippi. Earlier, ample timber encouraged the development of fishing and whaling and of ships both on rivers and at sea, of railroads, of wooden houses in new cities like Chicago, and timber was partly responsible for the cheap fuel philosophy which survives today, but in a different form. Houses of wood are still favoured over brick and stone, and the ability of the settler family to find everything needed in a well-timbered grant of land was essential to the American dream. Finally because the heavy use of American timber lasted till oil and natural gas were available, there was no

dominance of coal in the body politic in the later 1800s, a commonplace in England, in which country coal remained a basic fuel until the late 1980s. In contrast, until some time after the Civil War, little coal was dug in the USA.

The peculiar (and vital) difference remains that the early industrial greatness and wealth of Englan depended on an absence of timber while the opposite circumstance made possible an even greater form of wealth creation in the United States.

The second chapter, on wine, is about the wealth-creating potential of vines in place of more mundane crops like cereals. This has been true from before the time of Periclean Athens, through Roman and medieval experience, right up to the present. Today, in New Zealand, an entirely new win industry has achieved world-class status within a dozen years, an amazing achievement. From the earliest times to the present, to plant vines in the right place and manage them properly, and to make wine without breaking fundamental biochemical rules, was (and is) to multiply the nett profits from the same area of land by between twenty and two hundred times. The first multiple is probably true o 'ordinary' table wine as grown and produced in France, Italy, Germany or the New World. The secon ten times as great, is true of the vineyards where fine or great wines are grown and made, in Burgund Bordeaux, or choice places of comparable virtue in Italy, Germany, California or Australasia.

The chapter goes further. Here is a review, technological as well as economic, of the growing and making of wine from 600 BC to date, a bold claim for an essay only 20,000 or so words long. But the truth is that familiar, ancient methods were in use as recently as shortly after the Second World War and there have been more significant changes since 1945 than there were in the previous five hundred years. No-hassle vinification, the beginnings of genetic modification, new, simple, economical techniques, the use of satellite-tracking systems to assist the gathering of the grapes, all these are combined with those shifts familiar to most farmers in the Western world – tractors in place of anim power, pruning by machine, irrigation and constant sampling, all these only made possible by technology developed elsewhere. The amount of wine that is made in the world has multiplied many times in the last fifty years. So has the (now numerous) host of men and women made wealthy becau of wine. This last crowd, of course, includes those who create winespeak, a momentous, if abstruse, marketing tool.

Then there is rubber. The vital plant, *Hevea*, is one of the great gifts of Latin America to the world but other latex-producing species were originally 'hunted' not only in the Americas, but also in Afric and India. When *Hevea* plants were successfully transferred to new plantations in the Malay Straits, supplies of natural rubber came, at first largely, then entirely from plantation *Hevea*, alone able to meet the enormous demand created by the growth of electricity, bicycles and automobiles.

Before the First World War, there was a boom on the exchanges of the world comparable with the railway mania of the 1840s or the dot.com. bubble of the late 1990s. After the War, the trade became political, and the price of rubber a bone of contention between London and Washington, in a little-known dispute. There was a slump in prices before and after the 1929 crash, and a slow pre-1941 recovery. Then there was the long agony of the Japanese occupation and the communist attempt to disrupt the world's rubber supply. For a generation before and during the Second World War, serious efforts were made to replace natural rubber derived from the *Hevea* trees with synthetics. Though these synthetic alternatives are successful, there is one unique reason why natural rubber should remain an essential for one primary purpose; and it is a fairly safe bet that not one in a thousand will guess the reason before reading the story here. Rubber has generated wealth for many, and has largely created three important new nations, in descending order of fortune: Singapore, Malayasia and Indonesia.

The last chapter is about tobacco, a plant with a very negative contemporary image but which has had historically profound effects upon Anglo-American relations. The colony of Virginia prospered

because James I of England (reigned 1603–25) decreed not long after Shakespeare died, that his Old World subjects should not be allowed to grow tobacco, neither for sale nor for personal use. The ban was unique in Western Europe, every Continental being allowed to meet private needs in a private garden. King James also encouraged Virginia to save gold bullion, with which to pay for imports of 'Spanish' tobacco. Virginia was then of course a British colony, and imports from the colonies cause no drain on the gold reserves.

By 1776, tobacco in Virginia and Maryland was responsible for more than a quarter of the annual income of all thirteen Colonies. In tobacco-growing country this wealth produced a landlord class, including many of the signatories of the Declaration of Independence and outstanding leaders such as Washington, Jefferson and Madison. Little did the Stuarts, who encouraged the growth of Virginia by favouring American tobacco, ever imagine a democratic revolution resulting from their authoritarian initiative; another example of the law of unintended consequence.

Tobacco continued to be an important commodity in world trade, particularly in Anglo–American commerce, but the economic take-off only really occurred when the cigarette was invented in the 1840s, and the cigarette-making machine developed in the 1870s; marketing and advertising followed. By 1900, one firm in England and another in the United States had each become the most profitable corporation in their respective economies. Until the late 1940s, there was no respectable objective connection between the use of tobacco and cancer or heart disease and its use was considered essential to welfare in each of the two World Wars. The tobacco habit was supported in every way by wartime Allied governments. Between 1900 and 1945, cigarette use by women increased from a very few per cent to nearly 40 per cent of all adult women in the United Kingdom. Elsewhere, after 1945, particularly in Western Germany, cigarettes became a form of currency more trusted than paper money.

The story since 1950 has been one of strategic retreat by the industry, with 'safe', 'low-tar' and 'low-nicotine' cigarettes appearing in sequence. The wealth-creating factor remains, but the cost to those who sicken with cancer, heart disease or emphysema could probably be considered greater than the wealth accruing to those in the trade. But the greatest beneficiaries in most countries have been, since about 1920, the tax gatherers.

There is one unknown in the story. Is it the acidity of modern cigarettes that makes their use so dangerous? Would a return to alkaline smoke, universal before 1860, be therapeutic and reverse the causal connections with ill health?

There is much here about Anglo-American relations, commercial connections being as important as the politics, or more so. The critics can claim a degree of Anglocentricity. They are right. Without England, the United States would be like Mexico, and without the thirteen Colonies the United Kingdom would be a much poorer place. The wealth of which these are the seeds would have accrued elsewhere.

TIMBER

The Essential Carpet

I

There are huge areas of the world where, if humans ceased to exist, and if they had not already poisoned the Earth, trees would reclothe the land; this would not happen quickly, but it would be well under way within a century. Equally, it was often an all-pervading forest with which the Ancients wer confronted, although no one now knows much about the original mix of plant species nor about the disposition of those animals originally native to the virgin habitat. At a low level of human population, forests provided an environment which men and animals could co-habit without much friction, but as human numbers grew, forests and the relationship between humans and non-humans underwent changes, often brutal.

Wood was a vital resource for the material progress of mankind – more especially as populations increased and hunter-gatherers became farmers, and even more when the earliest urban civilizations were established. By 2000 BC, ample forests were as important as land for staple foods like cereals, and one great civilization – that of Egypt – significantly had to import a great deal of its timber, notably from Phoenicia (modern Lebanon). Fortunately the Phoenicians were addicted to trade and di not excessively exploit the Egyptian weakness in wood. In other ancient countries, sufficient wood was an essential raw material for every human activity needing heat, and for housing, transport, early devices for raising water and for spinning or weaving. Even if metals were used, the wood content of metal artefact would probably be greater than if the object were itself of wood. Rome, a capital city o a million people, grossly wasted wood for several centuries and more than partially deafforested the Mediterranean. Until the Middle Ages in England, there was little use of coal for heating, and until th late eighteenth century there was no way of using anything but timber (of the right sort) to smelt metals. Few today give enough weight to the importance of timber in history, nor is it widely known that nearly one-third of the world's population is still dependent upon wood for domestic fuel.

As this chapter shows, the English were the first people in modern times to run out of home-produced wood, with far-ranging consequences; their colonies in North America became essential, both before and after Independence, for the Royal Navy, for merchant ships, for iron and for the special woods for furniture and the many manufactured objects then made of wood, like blocks for ships' rigging, wheels of every kind, and harness.

Throughout modern history there has been an unseen conflict in land-use between short and long term, a clash made the more acute because population was (usually) expanding, more or less quickly. In the short term, land-for-food was obviously more important than land-for-timber, which equated t land-for-fuel or land-for-buildings or land-for-ships. But what happened to a country that could not grow its own food as well as its own timber? The answer was that it imported whichever was cheaper

not necessarily in money but in land-use. The Netherlands, then as now more densely populated even than England, imported wood, some from England before 1558, then from France, Poland and Russia after English exports ceased. England no longer exported wood for fuel and became short of wood for use at home. Uniquely, the English found coal to make up the deficiency, and imported naval stores from the Baltic and, later, from New England. England did not import any other consumables in such considerable quantity before the nineteenth century, except for exotica like tea and sugar, while tobacco was a special case.[1]

Of the countries geographically close to England, France had, in 1600, seven times the land area of England but only twice the population; the Netherlands had only 5 per cent of the area of France but 20 per cent of the French population, or, to put it another way, 35 per cent of the area of England and 40 per cent of the population. So the Netherlands was more densely populated than England, from which timber was exported before the mid-sixteenth century, and four times more densely peopled than France, which shipped timber abroad until the eighteenth century. Another favoured source of timber for European countries in deficit was, of course, the Baltic, the Northern part producing some of the hardest known softwoods, much prized for naval stores. Countries in the Southern Baltic, like Pomerania and Poland, produced valuable hardwoods. Trade with Russia was not highly developed until the time of Peter the Great in the early eighteenth century. In the Mediterranean, the great source of surplus timber was Turkey, and the shores of the Black Sea provided much that Europeans needed. But England, in serious deficit after 1600, was also a leading trading nation at the same date. Subject to the limitations of diplomacy and war, English timber merchants tended to buy timber wherever it was cheaper, but this was not really an alternative to substituting coal for fuel-wood. It should be remembered that the market for fuel-wood (including wood for charcoal-smelting) probably made up 90 per cent of wood used before coal became an alternative.

II

By 1666, the year of the Great Fire of London, which destroyed more than 400 acres of dense ancient building in the largest city in Western Europe, timber was already in short supply in England. When rebuilding was planned – in the middle of the Dutch War – weakness in timber resources became even more obvious. More than a million acres of mature woodland would be needed to rebuild the City as it had been. Even rebuilding in brick (and some stone), as Wren proposed, would have required more wood (as fuel) than was easily available; it was immediately clear to all that wood was critically short in England. John Evelyn's *Sylva* (1664) had already focused public attention on the problem.[2]

Shortage, as always, influenced cost. London merchants found that wood of building quality had risen in price tenfold in the century since 1560. Even domestic firewood had become so hard to find and so expensive that coal from the North-East had captured more than half the metropolitan fuel trade before Queen Elizabeth's death in 1603.

London had a population of 200,000 people in 1600, more than any other Christian city except Naples, at 300,000, more even than Paris, which had formerly had the largest population in Western Europe. In that same year Istanbul was, at 700,000, demographically second only to the largest Chinese city, Canton, probably, at 1 million, the largest city in the world. But all cities then larger than London were also naturally warmer; London was the only European city substantially heated by coal in 1600, and remained the only city (perhaps in the world) largely using coal for most of the next two centuries; it also became the first city to be lit by gas made from coal, brought by ship.

The largest use of wood in England after domestic purposes was in the iron industry, the largest

single industrial consumer of fuel in the Western world from early times. In 1700, the amount of iron made worldwide cannot have been more than 300,000 tons a year, and it was universally a cottage industry, using relatively large quantities of wood, burnt as charcoal. The ratio in England in 1700 was probably more than 100 tons of wood (equivalent to less than 20 tons of charcoal) for every ton of smelted iron, and more wood was used to make wrought iron. In 1800, probably only just about 2 million tons of iron were made worldwide which needed, in turn, about 400 million tons of wood burnt as fuel. By 1900, 150 million tons of coal were burnt worldwide to produce 25 million tons of iron and steel. In 1700, it was very different. In that year, a small ironworks might have had an annual output of only 50 tons of crude iron, and this effort (at a ton a week) would have needed the services of a dozen men and a water-driven set of bellows. Each week someone would deliver 20 tons of charcoal from a radius of a few miles, the practical limit for contemporary wagons before Macadam roads.

The final load of timber, the last of what had once been more than 1,000 shiploads a year, was exported from England in 1558, and later, as wood rose faster in price than did other primary products in the inflationary age that followed the influx of Spanish-American silver, there is no mention of any wood exports. Within fifty years, the supply of silver coin had more than quadrupled in Europe, with proportionate effect on prices, but as usual in inflationary times inflation itself affected different products at dissimilar rates of increase.

The connection between timber, iron cannon and naval supremacy had been the cause of a little-known triumph in the reign of Henry VIII. The great ‘Second Bronze Age’ – the age of essential bronze ordnance – lasted until the English produced iron guns that were safe for the user and much cheaper than the bronze alternative, which cost ten times more than iron guns. (This 10:1 cost-ratio was, intriguingly, the same as that between bronze and iron swords in about 1200–1000 BC.)

The English monopoly in cast-iron cannon lasted only till the end of the sixteenth century, about fifty years; by 1600, ironmasters in Sweden and the Netherlands learned how to make safe iron cannon cheaply, like the English. The French, through lack of expertise, or for reasons best known to themselves, preferred brass or bronze cannon until Colbert began to price such guns against cast-iron alternatives in about 1670. The same second Iron Age never occurred outside Europe and the Neo-Europes. In Asia and parts of Africa, bronze cannon were used until the late nineteenth century. But cast-iron guns were among the great unrecognized assets of Tudor England. Their virtues compared with bronze are generally little known today, but were as vital as the difference between bronze and iron swords

There had been a near-panic and a sudden new demand for iron (and therefore timber) after Henry VIII’s breach with Rome. Both cannon and shot had traditionally been imported from Liège in Burgundy and from Germany for a century before 1540. After that date, the Emperor Charles V, who Aunt Catherine had been divorced by Henry, refused to allow any export of ordnance to his erstwhile Catholic, now Anglican, customer-uncle. So the men of Sussex developed the casting techniques for iron cannon, and they also began to cast iron cannonballs to replace the more costly earlier wrought-iron or stone alternatives.[3]

Later, in the 1770s, the dearth of charcoal and therefore of iron in Britain arose at a time when a serious land-and-sea war in America was imminent and likely to become grave. Ordinary commercial and industrial demand for iron was increasing every year because of what would come to be called the Industrial Revolution. The chief American suppliers of timber, charcoal and iron were likely to be restrained from trading with the Imperial enemy. Because of the War of Independence, United Kingdom access to an iron supply then equal to British production had to be largely forgone, while European country after European country joined the ranks of America’s allies and friends. By the end of the war the Baltic trade was also denied to the British. France, Spain and Holland were at war with Britain, and there was an ‘Armed Neutrality’ between Russia, Austria, Prussia, Denmark and Sweden

As Britain used more iron and owned more ships than any other country in the world, the situation was, to say the least, critical.

By 4 July 1776, the day of the Declaration of Independence, it had already become obvious to the perceptive at home in Britain that there was a crisis in the production of charcoal, producing in turn a severe shortage of iron. The estranged colonies had been producing as much or more iron as the Hom Country, and the Colonies had many times as much growing timber per head of population – perhaps hunded times as much in 1776.

The coal solution to the shortage of timber (and therefore of charcoal) was unique to Britain. Every other nation in Europe lived and fought its wars for the next forty years, until 1815, on a largely wood standard. In addition to the early use of house-coal in place of wood, the English in the last quarter of the eighteenth century learned how to use coke in place of charcoal in the smelting of pure iron.[4]

III

When wood for fuel became short, England, almost alone in Europe, already had a domestic alternative to hand – coal. Although Roman soldiers had, it is now claimed, used surface coal to warm their quarters in the draughtier parts of Britain, the medieval English were the first serious coal-users in Europe. The first few coal-ships had arrived in the Pool of London before the Norman Conquest; London had then and later much the largest concentration of people in England, with about 10 per cen of the national population, and, of course, it was much the richest proportion – as it is today. This remained the case throughout the Middle Ages, and coal became a better bargain than wood for burning in London, both being brought in by water. Since the accession of Queen Elizabeth in 1559, firewood had become difficult to find and expensive to buy. But although efforts to burn more coal instead of wood were inhibited by royal and noble objections to ‘smog’ – recorded as early as the thirteenth century – it was inevitable that coal should replace wood in the City of London. James I ha enacted two regulations: first, for safety reasons, London houses should no longer be externally faced with wood, and second, bricks, tiles and glass should be baked in kilns using coal, not wood. James’s regulations may have saved fuel but they did not save the City from the Great Fire.

So London became ‘the Smoke’ during the seventeenth century as the result of the English shortag of wood. In 1605, over 60,000 tons of coal were burnt; in 1649, the year of King Charles’s execution, the tonnage had more than doubled, to over 130,000 tons; by 1700, the ‘burn’ had more than doubled again, to over 300,000 tons, leading to even more smog.[5]

Coal became the preferred fuel for brick, tile and glass works, for dye manufacture, salt evaporatio and other industries whose origins had been encouraged by Henry VIII before wood became scarce. Some of these new industries of course originally burnt wood, not coal, but entrepreneurs were move by the market to relocate near navigable water on which coal could be carried.

This new source of energy inspired many new enterprises, and the story of sea-salt illustrates the economic power of a high-calorific-value fuel. Before about 1550, salt was evaporated from the sea i flat, shallow pans in warm, sunny places, and England was a net importer of salt, though some sea-sa was produced in the warmer, sunnier southern counties. A century later, evaporation was so well established as an industry employing coal, and the total amount of salt made so great and its manufacture so cheap, that a considerable export trade developed.

Alongside the new export trade in crude salt, there was an equally valuable export of fish of variou grades and these two, salt and salted fish, would be connected for years before refrigeration began in

the 1880s. In the later 1700s, rock salt from Cheshire became another export from Liverpool and salted fish were also widely exported as one of the few sources of protein that could sustain long voyages.[6] Salt, which for centuries had been laboriously and not always successfully evaporated in th southern British summer, or imported, became a new source of wealth when coal was used in place o unreliable British sunshine.

The manufacture of brick and glass before 1600 had been tied to supplies of wood so that clay for bricks or silica and lime for glass had to coincide geographically with timber to make possible economic manufacture, as in Roman times; coal changed the topography of these and other trades. Coal – worth double the calorific value of the best fuel-wood, and with combustion much easier to control – could now be transported to any town on or near navigable water. Contractors set up brick kilns and glassworks near their customers, not, as formerly, near a supply of wood or charcoal. Although building-quality wood was still needed for housing, much as good lumber is still needed today in brick-and-tile houses, new houses from about 1620 onwards were increasingly of brick, ston and tile rather than of wood, wattle and thatch. Later, from 1700 onwards, those new and fashionable buildings arose in every city; building sites are often depicted in contemporary pictures and these nearly always include discrete kilns making bricks or tiles for local builders nearby.[7]

Coal-fired ceramics were more evenly fired with coal and included pots, mugs, cups, jugs, plates and saucers that were of pottery, not yet of porcelain, but glazed to deliver a waterproof finish, without which no vessel could be safely used for food or drink. Although pewter for the poor and silver for the better-off were in wide use as early as the reign of Henry VII, and noted as ‘normal’ by foreign observers, including an astonished Venetian ambassador, practical everyday ceramics preceded true European porcelain by two centuries. These ceramics were cheaper as well as better when coal-fired.[8]

Dyestuff manufacture was of course wholly based on animal or vegetable sources until the nineteenth century, and it was a local industry usually sited near textile manufacture. But following the introduction of coal by 1700, the coal-fired dyestuff industry was able to operate in larger units, a could brewing and lime-burning. Coal had the virtue of allowing new industries to grow naturally without always having to relocate because of wood supplies. It could be said that the use of coal was an impressive new economic factor in Britain’s favour, which encouraged new local industries.

Coal was dug in outcrops, as were stone, clay and lime. Mills were built on every river with sufficient flow; alum, lead, salt and marl were exploited, often in small units. All sorts of industries were built on rivers, which provided both power and the only economic freight transport for both raw materials and finished goods. Road transport did not improve, and a town without a nearby river or canal found itself at a great economic disadvantage. Other towns with water-power, and often near a source of navigation, as in the West Country, became new centres of the wool-cloth industry which expanded from its traditional homes in East Anglia and Kent. Wholly new trades grew up, sometimes brought by religious refugees from Europe; including ‘felt, thread, and lace making, silk weaving, engraving, the working of silver and the manufacture of paper, leather, needles and domestic glass’.[9] All these industries – new to England – were the product of the ferment of the Renaissance and Reformation. But not generally noted is the importance of coal in their development.

An important philosophic change followed the Dissolution of the Monasteries, which was completed in the 1540s. Educated men no longer exclusively served God and their neighbours as monks, whilst women previously in enclosed orders could now become wives and mothers. Natural abilities and acquired learning were now often devoted to Mammon, in the most economically significant way. Not since the Fall of Rome had so many pursued personal gain by peaceful means. Material distinctions grew up between England and the rest of Europe, where much economic

enterprise was still inhibited by religious or post-religious corporatism, and what would become *Etatisme*. England also benefited, because the young industries into which men went to make their fortune were more often than not coal-fired. Trade also attracted the adventurous, and the energy of individual Englishmen was unleashed. Adventurers were devoted to international trade in the Eastern Mediterranean, the Orient and Muscovy. Wool and cloth were even sold, at some personal peril, to the pirate-rulers of the North African Barbary Coast.

Equally, there was a development in the opposite direction. Whilst many Englishmen found opportunities in manufacturing as free men for the first time in history, few looked after failure, and the incapable suffered. Because the poor became a charge on individual parishes, the unemployed were discouraged from moving to other towns or villages. Displaced by agrarian changes, men often became vagabonds and beggars and starved, and Guilds used their powers to prevent entry into the better-paid occupations, protecting their own, as always. But as important as the social changes was the new commercial use of thousands of acres of woodland previously owned and managed by monasteries.

What no one now knows is the proportion of the economically unfortunate in, say, Shakespeare's England. These people had, of course, once been looked after by religious houses, or by their Manors. In the seventeenth century the surplus poor would go to the West Indies and Virginia, and those of the correct beliefs to Ulster and New England. But before 1600 there was little opportunity for emigration. The measure of the suffering of the poor is and was as unknown as their relative numbers.[10]

IV

By 1660, when James I's grandson, Charles II, succeeded the temporary Republic of Cromwell and restored the Monarchy, the English timber shortage had moved from chronic to acute. Coal had taken over from wood in London and in other cities close to water transport, but it was not yet favoured for baking high-class bread or drying malt for beer of good quality. These processes were more successful when near-smokeless charcoal was used, sulphurous coal affecting the taste of most foods. Not until the widespread manufacture of 'clean' coke from suitable coal was there available any fuel pure enough to use in the production of good food and drink. Making bread and beer of the highest quality was too important to be entrusted to any fuel except charcoal, which was preferred over any other source of heat – even coal-gas – in really high-class kitchens in some parts of Europe as late as the luxurious times before 1914.

In England, the only practical alternative to wood was coal, and the earliest coal used lay above ground or in shallow pits; such easily mined coal was soon exhausted, however. Most of the coal in England was some way underground, and the geology of English coal measures nearly always involved water, and water implied pumping. No significant tonnage of coal could therefore be dug without some means of powered pumping.

Before steam, there were alternatives, but none was powerful and none of much use for deep pumping. Early woollen mills were driven by human, animal or water power; there were treadmills for slaves or criminals in ancient times, pumping water, crushing ore, grinding corn. After AD 1200, there were windmills in flat country in Europe in those areas without flowing water, and watermills on many streams and rivers had been noted in the Domesday Book in 1087. But wind- and water-powered industries, naturally widely dispersed, were difficult to concentrate and were expensive in capital cost per horsepower (hp) generated.

The building of early steam prime movers was therefore originally made essential in England by the shortage of wood and the consequent need for deep coal and therefore pumps. The earliest pumps were

for draining mines, and these were installed from before 1700, the chief partner-inventors being Savery (1695) and Newcomen (1698).[11] These early pumps were 'atmospheric' and there was no effort to conserve heat, the whole, huge cylinder being cooled after each 'stroke' by a jet of cold water. As a result, both efficiencies and outputs were very low, the efficiency before 1720 being less than 0.5 per cent and the output about 1hp. Steam at only atmospheric pressure raised the piston to th top of its stroke, largely by counter-weight. Condensation was by cold water. The resulting vacuum allowed atmospheric pressure to force the piston to drop to the bottom of the stroke, raising the wate

The growth of steam-powered pumps in the seventy years before James Watt is almost unknown to non-specialists. In the 1720s Newcomen exported machines for use in France, the Rhineland, Belgiu and Saxony, and installed them in many places in Britain; perhaps a hundred, half abroad, half at home, were in place by the time of his death in 1729. Ironically, all the iron used in making these steam pumps was derived from forests, and so obviously was the wood used in their construction. They had a high wood content for an efficiency of only 1 per cent.

The limitation of the original design was almost crippling, even when manufacturing was refined and improved by John Smeaton. He had far greater production expertise, and was no longer depende as Newcomen had been, on carpenters, blacksmiths, wheelwrights, and even saddlers, who made the early leather seals. Smeaton used boring machines whose bores were far more accurate than was possible with the crudely wrought iron cylinders of the early Savery–Newcomen pumps. But howeve accurately machined the parts of a Smeaton pump, efficiencies could never be greater than 1–2 per cent because of the cooling of the cylinder at every stroke. None the less these crude pumps made possible the first deep-mined coal and increased the quantity lifted from virtually none in 1690 to more than 4 million tons in 1776. To this must be added perhaps 1 million tons from surface mines each year.[12]

Coal saved wood in a dramatic way. In 1690, less than 1½ million tons of coal from surface or undrained shallow mines were burnt annually in Britain and the use of coal saved about 40,000 acres of mature woodland. On a 100-year cycle, this would mean 4 million acres; on a 125-year cycle, 5 million acres. Even if non-native quick-growing softwood varieties had been planted for fuel-wood, about 1 million acres of woodland would have been needed to replace each million tons of coal burnt each year, on a self-sustaining basis. In 1776, with 3 million tons of coal being burnt, between 10 and 15 million acres of woodland were saved.

The weakness of the Smeaton pumps, even when superbly constructed, was philosophical, not mechanical. There was a single-acting piston in a cylinder which lost all its heat at every stroke. The loss of heat was of great importance, yet apparently unrecognized, although it breached known Newtonian laws about the conservation of energy, and it needed an abstract thinker as well as a craftsman to solve the weakness. The first man to do so was James Watt, an instrument maker employed by Glasgow University who was already halfway to being a natural philosopher as well as craftsman. He solved the problem of the loss of heat by using an external condenser.

After various – inevitably barren – negotiations on funding, Watt worked in partnership with Mathew Boulton of Birmingham, and the firm Boulton & Watt (along with the master patent) was in place from 1775 to 1800. Ultimately, the machines were double-acting, the motion rotational with th speed controlled by the now-familiar butterfly governor. Almost anything could be driven by stationary steam-engines: water-pumps, air compressors for blast furnaces, winding gear in mines, entire cotton mills, with elaborate and – to our eyes – dangerous unguarded belting to transmit power locally. The efficiency of the Watts machines made a great impact on a nation needing more power. As horizontal boring machines became more effective, and steam more efficiently used, Boulton and Watt engines were ultimately three times as kinetically efficient as Smeaton's best, and nine times as efficient as Newcomen's best steam pump. If he had used higher pressures ('dangerous', said Watt)

efficiencies would have risen further.[13]

By 1800, the United Kingdom of England, Wales and Scotland had a population more than twice that of the United States and half that of Revolutionary France. France was rich and the United States very rich in woodlands, and both economies were still driven by wood, wind and water, like those of every other nation in the world with the exception of the United Kingdom, which was partially dependent on coal. (Coal-deficient Ireland joined the Union in 1801.) In 1800, 6 million tons of coal were dug, distributed and burnt, equal to 120,000 acres of timber clear-felled every year, or a rotational area of at least 24 million acres. This area did not, of course, exist, since the United Kingdom produced all its own wheat, beer and beef and every other temperate food common at the time, and the margin was tight. Both wind- and water-power had reached their (then) very low upper limit, equivalent to a few thousand horsepower in England.[14]

Sugar, tea, coffee, rice, indigo and raw cotton and other traded goods were almost wholly transported in 8,000 British merchant ships, guarded and often convoyed in wartime by the Royal Navy. These operations had a high wood and wood-fuel content and an unavoidably warlike nature, while the British war effort also included a huge output of ordnance as well as of small arms, and gunpowder to match. This war effort in 1810 has been quantified at about 20 per cent of the output of British industrial effort, and together with sea transport and trade consumed nearly 40 per cent of the gross tonnage of available fuel. But Britain at this time was like the United States in the 1940s, capable of rapid industrial expansion, and there was no severe inflation before 1808. It was also of course true that any product with coal in its manufacture would be cheaper in Britain – and only in Britain – than if made using wood.

The United Kingdom used more coal much earlier than any other country in the world – it was mor than a century earlier, compared with most other economies. The UK use of coal in 1800 amounted to many times the use per head of any other country, as much as 90 per cent of all the coal burnt world-wide; more than half was used in industry, not in the home. But the use of the wood-wealth of the American colonies alone gave England the opportunity to trade all over the world, her merchant ship protected where necessary by a generally effective Royal Navy. Without coal and North American timber, the British could never have supported the new industrial manufacturing base and a rising standard of life as well as a rising population when timber ran short. Nor would there have been an increase in real national income per head greater than that in any other European economy during the eighteenth century, nor of course victory over Napoleon, nor the second British Empire, nor the splendours and miseries of the nineteenth century, with its wholly characteristic carboniferous capitalism.[15]

V

If there was one over-arching reason why the British-American Colonies were so materially prosperous, in contrast to the Home Country, and if there was a single explanation for the early wealt of the Colonies, it must be timber. With no commercially useful timber on the north-east coast of British America, history would have been very different throughout the Colonies. If there had been n indigenous species of soft or hard wood as good as or better than European equivalents, fishing, whaling, shipping, ship-building, exports of masts, timber, tar, iron and the lumber trade would have been unimaginable in the form that they took. British-Americans would never have been as rich as they were, often wealthier than the relatives they left behind.

Settled in a timberless land, colonists would have been as dependent on the ambiguous goodwill ar

dubious altruism of the Home Government as were other colonists of other powers in the New World. The only substantive export to Europe would have been Government-controlled tobacco, a trade only made profitable because it had been made illegal to grow commercial tobacco in England. Most indigenous whites would have been poor, as poor as poor whites were in Virginia when their land became exhausted by growing too much tobacco for too many decades.[16]

When they crossed the Appalachians, Americans found a wealth of timber. Most of the land east of the Mississippi–Missouri Valley was forested, and most of those who moved west before the Civil War settled in wooded areas. The virgin forest provided the settler-family with all its needs. A sort of sheltering tent, made of timber fronds, could be built in a few hours; a more permanent log-cabin could be constructed in a few days with ample standing timber all around.

On both sides of the Appalachian chain, log-cabin walls would be of whole or split logs, the floor and door of crude planks, the fireplace and chimney of clay if that were available, or later bought-in bricks to safeguard against fire. Clay or bricks had often to be hauled many miles.

The green wood of new log-cabins required fires burning for a long time, except in high summer, to dry out what had so hastily been put together without any seasoning. The gaps between the dried-out logs allowed in wind and cold, so they were filled with clay; later – often much later – walls were lined with properly seasoned, sawn and planed board. Fences were also made of timber, a good man being able to cut and split 200 rails a day from felled logs or in the same time cut and shape 100 stakes. Much later, because he was a quicker worker than average, the young Abe Lincoln was contemptuously known to citified Easterners as ‘the Rail Splitter’. Counter-intuitively, this would be to his political advantage.

Tree-trunks could be used to make bridges over brooks and streams, paths or ‘board roads’ across marshy ground, even drainpipes when hollowed. Because the virgin forest formed no permanent part of the plans of most pioneers, domestic animals were encouraged to forage in the woods, once the quarter-section had been fenced. Pigs especially benefited, almost keeping themselves; some went wild and reverted in appearance to the wild boars of Europe, whence ultimately came their genes. Fencing was at first glance quite a task, since the quarter-section of 160 acres allocated to pioneer settlers needed at least 2 miles of fencing, the minimum being an 880-yard square. Two miles of fencing, in turn, would have needed nearly 1,200 stakes and twice as many rails; presumably this load could have been halved by sharing the burden with adjacent neighbours. But every State had different local rules about livestock-fencing and local laws, different in a number of ways from the Common Law brought over from England. A unique American contribution was the picket-fence, a free-standing affair, about 3 yards long, which would render any area relatively stockproof except against horses, which could normally jump them, as was proved when picket-fences were used in an attempt to protect infantry against cavalry charges in the Civil War. Fortunately for the casualties of that brutal-enough conflict, barbed wire came later. But, in the ‘peaceful’ post-war West, horses learned to jump both wooden fences and the newly invented barbed wire, and had to be hobbled.[17]

Virgin deciduous forest was often responsible for building fertility in the soil, a natural wealth banked before any white men arrived, because of the annual leaf-drop. Some species, like beech, were more valuable for this purpose than others. Today, foresters know which are the valuable and the less valuable species for enriching the soil. This should have been a factor in valuing forest-land that settlers intended to turn into arable, but there is no literature on the subject.

More immediately important were the proximity of wood and the nature of the market for wood. Because there was so much of it about, felled timber was not regarded as having a greater value than as firewood, and most wood was burnt if not otherwise used. A cord of wood (8 X 4 X 4 feet, or about a ton), was the unit for fuel, and 40–60 cords per acre the norm. Proximity to a town produced an immediate local market for firewood but a nearby railroad or river would mean that locomotives or

steamboats would be the consumers. There were more valuable uses, however. Some bark went to tanneries; some large trees could be planked for lumber for building purposes, always provided the transport was available; white oak was needed for barrel-staves in which everything, from meat to tobacco to flour to pork, was packed in those days.[18]

A more valuable – and more ecological – solution was to establish a sawmill nearby, to add value t what would otherwise be firewood and therefore sold cheaply. But a sawmill would need good transport, several months to set up, capital and, above all, a supply of water-power – or sometimes, if more capital was available, a steam-engine. Despite these difficulties, sawmills were established, timber was seasoned, and many communities benefited. A man with a sense of husbandry might prov a role model, providing a degree of leadership and conducting himself in a way that was kinder to nature and to his neighbours than was customary.

In the absence of any market for wood as lumber or fuel, trees would be burnt in huge heaps, the resulting potash-rich ash being more valuable than the standing timber from which it was derived. No much is heard of charcoal-burning in pioneer Frontier areas, nor of its main outlet, iron smelting; thi presumably occurred at a later, more sophisticated stage than that of the pioneer-settler.

VI

North-East America was the first place in documented history where ordinary competent Europeans had no need to go hungry. In other words, every European in North-Eastern America, however poor, had plenty to eat for the first time. This was not immediately apparent, but even in New England, wit its thin, stony soil, the Pilgrims were eating better within a few years of their arrival than they had ever done at home.[19]

The Amerindians the Pilgrims met had no tradition of animal husbandry, for the best of reasons: there were no domesticated animals. If not hunter-gatherers, Amerindians in the North-East were simple growers of plants who used maize as the staple starchy food that all humans need, whether in the form of American maize (corn), European wheat or Oriental rice. Maize was, of course, the only American plant available to produce a staple alternative to cereals.[20] There was probably little man-cleared land, just a few natural groves in the forest, or along a river where floods or beavers building their dams might have cleared flat alluvial patches. It is easy to grow maize without any kind of cultivation; a small hole in the ground made with a stick for each maize kernel and a watch for pests suffice. Before the white man, there were relatively few animals to trample down the growing maize, fewer to eat the green plant, and none to prevent its spread through much of the Americas, from the S Lawrence to the Plate.[21] In places in pre-Columbian New England, there were just a few moose and other deer; turkeys on the ground, trout in the rivers and lakes. This was an epic sylvan scene, pastora in the best sense, and the small Amerindian population pressed not at all harshly on the environment which was home to species now extinct.

Of all the changes wrought by white settlers in New England, the destruction of forest habitat was the most damaging to the Indians. Building dams, millponds and races for timber extraction interfere with the natural flow of streams and rivers, and killed fish and threatened other species. River-engineering did as much damage as clearing forests to provide the white settlers with land. The Pilgrims managed the flow of streams and rivers, and their ‘improvements’ destroyed the habitat of fish, birds and mammals and also diminished the food supply of the Amerindians. The settlers, once tolerated by the natives, came to be hated. Possibly more detested than the settlers themselves were their methods of fishing, trapping and farming and their dependent and domesticated European

animals – cattle, horses, sheep, goats and pigs – which were unknown to the Indians. As white population pressure mounted against the natives, they regretted the kind welcome they had extended and warned the Europeans not to encourage yet more immigration, nor venture deeper into Indian lands. The Europeans (mostly British) ignored these requests and Indian wars, at first very small affairs, mere brawls, ultimately became commonplace. The original cooperative relationships ended and the whites pursued a policy of divide and rule.

Although this is the politically correct version of early New England history, it is selective. In fact most 'Indian' wars involved other white men, sometimes of the same nationality, sometimes the European enemies of the British, first the Dutch, then the French. Nor was slaughter by aggressive whites largely responsible for the mortality rate among Native Americans. Ninety per cent of all Indian deaths in the century after the *Mayflower* can almost certainly be charged not to warfare, but t the diseases that the whites brought with them. Smallpox, tuberculosis, measles and malaria were the great killers – unknown in the Americas before the arrival of the Europeans. Smallpox had first occurred from occasional contact with European cod fishermen and was already widely dispersed among Indians between the St Lawrence and the Hudson and east towards the sea, before the Pilgrim Fathers arrived in 1619. Where smallpox led, other diseases followed, until most Indians were wiped out; those that survived developed immunity, or the diseases themselves attenuated.[22]

Beyond the disease factor, it is also true to say that Stone Age Indians found their lifestyle impossible after only a few years adjacent to white settlements; and the great forests that had once supported a wonderful bio-diversity of life became as relatively barren as they are today. Turkeys, present in huge numbers before 1600, did not long survive the invasion from Europe, and it was dogs and gunshot that diminished their numbers, unless the white men inadvertently imported diseases fat to turkeys in their European chickens.[23]

British North America differed markedly from other European Colonies further South. First, there was no organized, splendid if savage, Amerindian culture, as existed in Mexico or Peru, which had perforce, in the philosophy of the time, to be destroyed by the Conquistadores. Indigenous natives in most of the British Colonies were of the Stone Age. They were primitive hunter-gatherers or subsistence growers of maize with no knowledge of animal husbandry. They had no draught animals to reduce the burden of drudgery. Colonial Amerindians were also thin on the ground, thinner still after being exposed to the diseases of the white men.

Second, British North America offered whites almost no opportunity to get rich quickly. There was neither gold nor silver and every export – fish, furs, timber, and so on – had to be farmed, grown or hunted. The introduction of European flora and fauna was equally labour-intensive. The consequent struggle for existence tempered the character of the white population in the long run.

Third, this was a place where Europeans multiplied extensively. The net increase in population meant a million whites in 1720, more than 2 million by 1770, and nearly 4 million by 1800, the last figure signifying an increase of nearly 300 per cent in fifty years. These statistics should be compare with a net gain of 80 per cent in the United Kingdom between 1750 and 1800, the highest in Europe, admittedly, but moderate compared with North American demographic increases.

A great increase in numbers was reinforced by a great increase in physique. British-Americans became larger, fitter and stronger than their European-British ancestors and collaterals, and survival amongst babies and young children exceeded European rates by a wide margin (a major factor in the large demographic gain). This survival rate was partly because American English, Welsh, Scots and Scots-Irish (more than 90 per cent of white immigrants before 1800) were not packed into large, crowded towns like London, where disease killed more than half of all infants before their third birthday. Since British-Americans were better fed, pregnant and nursing mothers and babies had bett resistance to perinatal and childish ailments. All this led to a feeling of optimism, or did a feeling of

optimism lead to the high birth-rate?

The region between the Appalachians and the Great Valley, now occupied by all or part of fifteen States, contained growing timber covering an area larger than the whole of France, Italy and Switzerland combined. This timber, if burnt, would have had a thermal capital value of 5 billion tons of coal equivalent, or a sustainable value (on a 100-year cycle) equal to more than 50 million tons of coal a year. In fact, the timber was used for houses, farmsteads, railroads, ships, bridges, wagons and furniture as well as for fuel, and some was simply destroyed to make agricultural land. The United States was launched into the Industrial Age uniquely with wood, not coal.

There are four contributions to mass-production (and increased wealth) that are now, 200 years later, identified as obvious, but their importance was resisted by those without the intelligence or experience to benefit directly from their adoption. Yankees assessed their value by trial and error, no by pure science; nor were their virtues widely voiced, being only first taught formally at MIT in the 1870s. The four are:

– the adaptation of power to machinery;
– the principle of interchangeable parts;
– machine-driven tools to make components; and
– original (appropriate) design so that unskilled labour can be used in assembly.

In every one of these developments in the Colonies (later the States), New England was a leader an ample wood played a major role.

Water-power was employed in New England in the lumber industry as early as 1628 and water-power (thanks to wood) energized many industries for more than 200 years. With the advent of steam cheap wood fuelled American steam for far longer than anywhere else.

Machine-driven tools were adopted more enthusiastically in New England than in Old England and often made cheaply and quickly out of wood, like clocks of the same date.

Interchangeable parts were developed as a principle by Eli Whitney prior to 1800, and before others in Europe: Wilkinson – textiles; Colt – revolver parts; Root – ironworks; Blanchard – copying lathes, and others.

The use of *unskilled labour* was forced on American manufacturers because of a shortage of *skilled* labour. The skills of machine-minding were unknown and had to be learned. Historically, skills of every new technique have to be learned, and in the process, existing proponents of the old technology become automatically ‘de-skilled’.

‘De-skilling’, which occurs and re-occurs throughout history, is often sad for the individual, but new skills were resisted less in New England than in the Mother Country, and the tradition of adaptability became one of the strengths of the United States. In parallel was an absence of frame-breaking Luddites, whilst throughout the Old World there had been powerful craft-resistance to new methods, and it was to the benefit of the new countries that there were few to resist factory novelties. However painful in the short term, even over a generation, the adoption of new processes ultimately favours workers far more than does resistance. The difficulty is to know which new technology is inevitable; only the market can tell, and sometimes only with hindsight. So only a few may benefit immediately, and it may take years for new efficiencies to profit economies and longer still to ‘trickl down’.[24]

The chief problem facing the Colonies and the young United States was not lack of resources, nor even a lack of people, but a need for good transport for the conquest of distance. The country was

enormous, even alarmingly so for people who travelled on land at the speed of a horse. There was nearly as much land in the thirteen original States as in France and Italy combined, but the new country was not compact, being than 1,200 miles long and a few hundred miles wide at the most, mo the shape of the leg of Italy than of France. It is a mistake, however, to believe that the need for transport systems was clearly recognized at the time. The Spanish-American Empire was challenged by the same problem of internal distance, and it was solved by neither the first European settlers nor their successors. The United States was lucky enough to be young at a time when steam, canals and railroads were about to become viable, and North Americans took advantage of every technological improvement on offer.

Before Independence, nearly all long-distance transport was by ship and boat, powered by sail or oar; but there are pleasant historic connections about the early development of steamboats. There wa a partnership between Robert Livingston, who had signed the Declaration of Independence, his brother-in-law John Stevens, who was an engineer, and Nicholas R. Roosevelt, great-uncle of the future President, Theodore. These three acquired a monopoly to navigate the Delaware River, but the steamboat never worked economically. Then Livingston became American Minister in Paris, and the he met Robert Fulton who was trying to sell Napoleon the idea of submarines and torpedoes to sink the Royal Navy.[25] These missiles only existed in Fulton's vivid imagination, however, and even before Trafalgar, Napoleon had gone off to conquer Central Europe. Fulton returned to the United States in 1807, and backed by the venturesome trio of capitalists, he built the first steamboat on the Hudson, a paddle side-wheeler which made the 150-mile journey to Albany in thirty-two hours. But the Fulton river-boat was badly designed, and even when rebuilt did not last long and never made money. Monopoly was called in to save the commercial situation, and there followed attempted monopolies on many rivers, including the Mississippi, before they were ruled unlawful by Chief Justice Marshall and the Supreme Court in 1824. Before this vital ruling, the first technically successful (non-Fulton) steamboats had been built on the Ohio, with a shallow draught, high-pressure boilers and engines mounted on deck. By 1830, there were over 200 such steamers on the Western rivers, later to become the travelling palaces of legend, complete with professional gamblers, loose morals and steam organs. These river-steamers were 90 per cent wood and they burnt their own weig in timber about every 1,000 miles. By 1860, there would be ten times as many wood-fuelled steam vessels on the same rivers – 2,000 of them – and wood, not coal, was to be found at almost every poi along their course.

In the same order as in England, but later, canals and railroads became the one answer to the American internal transport problem after 1790. No one today can imagine the difficulties involved i moving heavy inland freight far from rivers before there were canals or railways. It was largely a freight problem, because anyone in a hurry could ride a horse. After the arrival of canals and railway the use of roads for freight was not viable until the perfection of the internal combustion engine. Every experience since the great Persian roads built before 500 BC had confirmed the dubious nature of any claim to economic benefit for roads for freight, in contrast to military or political advantages. Fine for runners or horse-riders, and for moving soldiers, ancient roads, even the superb Roman road were of little use for freight wagons. Because Roman harness was so inept and wagons so inefficient, and because draught animals had to be fed, the cost of a wagon-load of grain doubled every 100 mile After about AD 1200, European harness and wagons had improved, but roads – very expensive in upkeep – had declined in quality and ultimately some had to be supported by tolls. American draught animals and vehicles did not suffer from any harness-imposed limits, but there were similar problem to those in Europe. In the United States, horse-drawn freight transported by road cost ten times as much as horse-drawn freight transported by water in 1800 – forty times the cost of steamboat-transported freight in 1830. Before railroads, canals became of greater importance than roads and

some of them evaded or defeated the Appalachian barrier. But many of those supported by individual States suffered from financially unsecured paper and later could not compete financially with railroads, and investors paid a high price for the eight States that defaulted.

Other canals had uses other than transport; one was the La Salle, which allowed the rapidly growin city of Chicago to dump its sewage into the Mississippi River, via the Illinois River, thereby keeping its own lake shore clean for fish. The nominally more fragrant reason for the La Salle Canal, going south, was to link the Lakes to New Orleans, whilst the Erie Canal, going east, joined the Lakes to New York.

The Erie was the most commercially successful of the canals, allowing lakeside States to deliver grain to New York via the canal and the Hudson River. To the surprise of those without any historica sense, it was revealed that grain from lakeside Ohio was cheaper delivered by canal to Charleston, South Carolina (more than 1,200 miles) than by road from inland South Carolina (100 miles). One effect was to inhibit Southern wheat culture.

The Erie Canal repeated the experience of the Emperor Nero (d.ad 58) and his canal parallel to the Tiber, or that of the medieval Venetians, who imported grain from Cracow by water – over 5,000 miles – instead of less than 250 miles by road via Austria-Hungary.

Before the building of the Erie Canal (1825), New Orleans was the natural outlet for the huge basi drained by the Western rivers. By 1830, New Orleans found itself losing much important bulk trade, largely grain and lumber from the then North-West. It was not until the river States were developed that the Mississippi (‘Ole Man River’) regained economic importance. There was also a political pric to pay before 1860. Because of the Erie Canal, commercial interests in the old North-West tended to align themselves with the East in slavery debates and this was in the end a higher cost than any earnings lost from freight not passing through New Orleans.

Even after the arrival of railroads, river and coastal steamers were still vital in the East, not only o the Hudson but from New York north to Boston, south to Chesapeake Bay, and water transport competed vigorously as far as cost was concerned. Timber-fuelled steam-power was also essential fo the economic movement of bulk cargoes on canals. Most American canal barges were much wider than horse-drawn narrow-boats in England. They were of wood, with tugs fuelled by wood, as were th river steamers.[26]

All inland water transport has by definition to be relatively slow, even compared with slow early rail movement, and inland waterway freight has to be largely free of the major constraint (or tyranny of time. Given an absence of time constraints, canal and river transport was still far cheaper than rail in 1860. But no one should imagine that water transport was run by cost-reducing philanthropists. Before railroads became an important deflator of costs, both river and canal rates were ten times wha they were twenty years later. It was steam that reduced both railroad and inland water costs, and railroads were half the British cost because of cheap American timber for construction as well as for fuel.

Lower internal transport costs in the huge new country helped double the economic growth rate of the young United States. Between 1800 and 1840, economic growth had been running at a rate not ve different from England’s. After 1840, it increased so much that American growth rates were nearly double those of England in 1860. Recovering from Reconstruction, the US growth rate was three time that of the United Kingdom in 1880. This was largely due to the reduction in transport costs followin the triumph of wood-fuelled steam, which was of greater importance in a huge country like the Unite States than in the smaller United Kingdom. The American West that Thomas Jefferson (d. 1826) had thought would need a millennium to fill with a population big enough to exploit its bounty, was almost wholly settled before the centenary of his death.

The same sort of progress in productivity was made at sea. In 1860, American export freight rates were one-twelfth the rates for the same goods in 1800; this reduction was due to improvements in the size and efficiency of wooden ships, still driven by wind, steam having a more immediate effect on inland waterways than on the oceans. By 1860, freight by steamers on rivers or canals was just over 1 per cent of the cost of freight by wagon in 1800. River rates came down by four times, if a raft floati down to New Orleans in 1800 is compared with a steamer doing the same trip in 1830. The raft was broken up, never to be returned; the steamer came upstream at less than half the speed it travelled downstream. River-freight productivity doubled again between 1830 and 1860, whilst railroad productivity increased by even more after the Civil War. But even when railroads were fully developed, they could not compete with a bulk cargo, free from the demands of time, travelling on th great rivers flowing to the Gulf. This is still true of river-freight today.

The first American railroads, like those in Europe, were to be found in quarries and mines; as in Europe, wagons were first hauled by horses, mules or cables. Other early railroads were powered by sails mounted on trucks; some even used a horse on a treadmill, as was tried and (predictably) failed at the Rainhill Trials in 1830 in England. American railroads began more quietly than in England and the railroad was usually conceived as a freight line. Then it was found that advantages in speed compared with water-routes made passengers important. Turnpike roads and competing canals were not normally allowed to hold up railroad development, as in the Old World, and there was usually enough empty land not to necessitate the expensive financial compensation which made railways so costly to build in England.

'Free' land played an important part in American railroad building. Twenty million acres (31,520-plus square miles), an area larger than either Scotland or South Carolina, was 'given' to railroad promoters before 1860. This was to encourage rapid build-up of traffic, the 'free' land being settled b farmers and others. In exchange, there was the right of Governments, State or Federal, to enjoy preferential freight rates.

Three features of nineteenth-century American railroads went beyond European experience. First, there was the force of competition, often remorseless and usually without scruple. Second, there were marvellously inventive financial tricks, including much 'watering' of stock. While these features became more general after the Civil War, they were by no means rare before 1860. Third, there were no real early interconnections by rail; in 1860, for example, rails from New York to Buffalo were in six systems, in three different gauges; passengers were required to change carriages, while freight ha to be trans-shipped. Neither a common national gauge nor a zonal time was established until the 1880s.[27]

Nor did American trains find it odd to travel along highways; this usually happened in towns, with the locomotive's warning bell clanging and the whole procession advancing at the pace of a horse. Abraham Lincoln proceeded thus, in (imaginary or real?) peril, through the streets of disaffected Baltimore, on the way to his First Inaugural in Washington, DC, in March 1860. Even today, trains ca be found passing through the middle of Main Streets in Middle America, while the fabled daily Twentieth Century Limited, scheduled to run the 960 miles between New York and Chicago at an average speed of 60 mph, crawled through the streets of Syracuse, as recently as 1936, at a legal limi of 15 mph.

American railroads were far more wood-reliant than the railways of any other country, even those of Russia. Early American rails were often made of wood, shod only by a thin strip of iron; ties (sleepers) were of wood, of course, as were even the larger bridges, the longer viaducts and many drainage and water-supply pipes. Wood was the fuel of almost every US railroad locomotive until after the Civil War, and by then the United States had twice the rail mileage of the United Kingdom, much smaller, of course, but hitherto the most developed railroad country. The United States probabl

burned ten times as much wood as the United Kingdom burnt coal, but green softwood of course has less than a third of the thermal value of coal.

The Civil War, the first railroad war in history, showed engineers what could be done with timber under the stress of battle. Near Fredericksburg in Virginia, a wooden viaduct replaced a structure bur by retreating Confederates; it was built over the Potomac Creek in nine days. The wood for the viadu came from local standing timber, amounting to over 200,000 cubic feet, or the product of at least 500 acres. How green the timber was, and how warped the bridge – made of unseasoned wood – became, has not been recorded.

After the Civil War, in places west of the Mississippi–Missouri basin and east of the Rockies, timber had to be hauled so far that iron was sometimes preferred for bridges, and masonry for viaducts. But there were disadvantages: wrought iron was never as flexible as wood, and masonry wa often much more expensive. On the other hand, neither metal nor masonry was easy to burn. In the wilder parts of the Frontier, wooden structures were sometimes destroyed by rivals or criminals or ju dismantled by the cold or hungry. Lastly, the age-old rule applied: iron smelted with wood, even in 1860, often cost more in timber than wooden material of the same strength as iron. Over time, of course, iron would be cheaper, because it would probably last longer. But before and after 1860, mos iron in the United States was smelted with wood, a condition no longer true in England. During hungr winters in the 1880s, settlers even took to stripping wood for fuel from bridges and viaducts, an enterprise not esteemed by the railroads.

American railroad coaches were derived from lavish, comfortable, long canal-barges for passengers. They were too long to be manageable or safe on a conventional ‘fixed chassis’ when running on the rough-and-ready, light, cheap and cheerful track of the 1840s and 1850s, so four-whee bogies were evolved to prevent the derailments that were inevitable with a long, rigid wheelbase. British railway coaches derived from stage-coaches and were usually built with compartments with six, eight or twelve seats, according to class, and with four or six wheels on a rigid chassis running smoothly on high-class permanent way. The American open coach, which was replicated in railroad cars after 1870, encouraged strangers to talk, and was inclusive of people; the much smaller British compartments were associated with much more formal behaviour.[28]

Nearly every railway coach before 1860 contained about 90 per cent wood, which in Britain was nearly always imported timber. Whilst there was little comfort in British trains, American railroads provided WCs a generation before any European country other than Russia. Both Russian and American railways, because of long distances and slow speed, were also the earliest providers of diners and sleeping-cars. There were few gangways in British coaches before the 1880s, and gangway with access to all carriages and dining-cars were not generally found, even on the best trains, until th 1900s. Fire risks were ironically increased by improvements in lighting; the progression was from candle-lamps to whale-oil lamps to vegetable-oil lamps to kerosene lamps to piped gas. Piped gas provided fuel for the worst sort of fire in accidents: the only safe lighting – by electricity – was not installed, even in new rolling-stock, much before the twentieth century.

Freight vehicles answered the trading needs of the countries involved. America soon developed 40 ton freight-cars with double bogies; Britain relied on 10-ton four-wheelers; America had automatic couplings by 1860; Britain was still using screw-couplings and buffers – designed in the 1820s – mor than a century later. At least three types of shock-free wheels were made of wood and patented on bo sides of the Atlantic. Locomotive fuel was originally coke in Britain, wood in America; coke gave wa to much cheaper coal when the brick arch and deflector plate were invented in the late 1850s in England. As with iron-casting, anthracite from Pennsylvania was the first American substitute for wood in locomotives, anthracite being first successfully burnt in very wide grates on the Reading Railroad in Pennsylvania. But this alternative was not generally available except in the East.