

THE MODERN WORLD: A JOINT CREATION OF CHINA AND THE WEST

Professor Robert Temple

People often speak of the modern world in which we live, and presume that it is a creation of the Western world. But this is not correct. More than half of the basic inventions and discoveries which led to the creation of this modern world are Chinese, and are not Western at all. Indeed, China has produced more fundamental inventions and discoveries than the rest of the world put together. Because so few people realize this, the view of China's place in the modern world is wrongly conceived. Most people in both East and West believe that China is emerging into the modern world. But China is not emerging into anything, it is *re-emerging* into something which it helped to create in the first place. Nor is China a developing country: it is a *re-developing* country. For two thousand years, China was developed while most of the rest of the world was undeveloped. It was richer, it was stronger, it was bigger, it could feed itself better, it could build more things of greater magnitude, and it could explore when it wanted to: Australia was first discovered by the Chinese, who landed near the city now called Port Darwin before any Westerners found their way to that continent, for example.

The position of China in the world has been artificially suppressed for a long time. For the hundred years before 1978, this was largely because of prolonged struggles, including an invasion by Japan, and other military and civil upheavals which disrupted the normal progress of industry, technology, economics, and society. The wholly artificial process of China's suppressed state has now come to an end. But the rest of the world is reacting with a mixture of shock and apprehension to the appearance on the international scene of a new world power which many foreigners think is sudden and perhaps undeserved. However, any foreigners who know enough facts of history will realize that China is merely returning to its natural position as a leading world power. China is sufficiently large and sufficiently important that this process cannot justifiably be criticized.

It is only natural for a re-emerging China to show signs of returning as well to technological eminence. It is not enough for China to join the WTO and to be seen to be important in international diplomacy, trade, and economics. China must also regain its status as a leading source of technological innovation. But as China seeks to pursue that goal, it is important to consider the question which has now come to be known as 'the Needham Puzzle', named after my old friend Joseph Needham (Li Yuese), who died a few years ago. This 'Puzzle' is this: why did China, which invented more than half of the inventions that led to the modern world, fail itself to create that modern world on Chinese soil? Since China was technologically in advance of the rest of the world in many ways, including agriculture, for two thousand years, why did the Industrial Revolution not take place in China? Why did the Renaissance not happen in China instead of in Florence in Italy? Why did the Westerners put together the separate

elements and create the modern world instead of the Chinese doing so, especially since more than fifty percent of those elements were Chinese in origin? Does this indicate that the Chinese lacked some ability to synthesize a whole from many separate elements? Was something wrong with Chinese culture or society which can explain this enigma?

There is no single answer to these questions. Instead, there are several answers. And I believe some of them have not been given before, although they may be rather large and obvious once we consider them.

I want to start by calling attention to one of the largest and most obvious of all the reasons why China failed to create the modern world on its own soil, and failed to have an Industrial Revolution. This reason is so obvious that I am amazed that no one ever seems to have mentioned it before. Perhaps I am not informed of discussions of this question which have taken place without my knowledge. But I have never come across them.

The reason to which I wish to call attention is the collapse of the Ming Dynasty, a prolonged process which culminated in the year 1644. Let me start by calling attention to one amazing fact: Between 1585 and 1645, the population of China seems to have declined by as much as forty percent because of disease, bad weather conditions, bad government, economic distress, and the collapse of law and order. This figure has been suggested by the sinologist Mark Elvin, based upon his extensive studies of the source materials. If such a population decline occurred in China today, it would be equivalent to the deaths of 520 million people, without any of those deaths being replaced by new births. The population of China would thus decline from 1.3 billion to 780 million. Since a decline in population size of these proportions occurred at the time of the collapse of the Ming Dynasty, it is clear that China was in no condition to do more than attempt to survive, and the creation of an Industrial Revolution was out of the question.

Most of you will have read the wonderful stories by Pu Songling. He was born at the end of the Ming but lived most of his life during the early Qing. If you think about it, there is a strange feature in his stories. You will recall that so many of those stories mention large empty houses all over the countryside, in which ghosts live. Have you ever thought about why Pu Songling is always mentioning empty houses with ghosts? Well, the reason is that he grew up in a China which was indeed full of empty houses in which all the inhabitants had died. This was a true description of the world he knew. During his youth, it was common for entire households of ten or twenty people to die, without a single one surviving. There were too many bodies for burial to be possible. One contemporary writer, Chen Qide, says that the worms from the bodies filled the houses and crawled out of the doors into the roads, and no one dared to go inside the many houses filled with corpses. Between 1640 and 1642, thirty percent of the population of Huzhou Prefecture, a densely populated area, died from disease within only two years.

At this time, China was swept by many plagues and epidemics, including smallpox. In 1641 there was an epidemic in Tongxiang County of Jiaxing Prefecture in Jiangnan, when between 80% and 90% of all households were

infected. But disease was not the only killer. Millions of people throughout China died of starvation. Terrible weather conditions afflicted China, causing drastic crop failures and loss of income. There were alternating droughts and floods on a huge scale. In 1638, the Grand Canal dried up. In 1640, the Yellow River dried up. People were so hungry that there were instances of cannibalism, for rather than starve to death they decided to eat their neighbours or even dead members of their own families. In the north of China, the intense cold also meant that the growing season was two weeks shorter than it is today. The intense cold extended further south, and lakes of the Yangtze Basin froze over in the winter. At the same time, terrible pestilences of locusts occurred, which destroyed what crops there were remaining in the fields.

At the time when all this was happening throughout China, what was going on in Beijing? There were no less than 40,000 officials and relatives of the Emperor in the capital who were supposed to be supported by public funds, as well as 3,000 court ladies and 20,000 eunuchs in the imperial palace. Because the money ran out, these people turned to extreme forms of corruption and embezzlement to survive. In 1643, when the Chongzhen Emperor insisted upon viewing the contents of his Treasury in the Forbidden City, the guards at first pretended they could not find the key, but as the Emperor insisted, when they finally opened the door, it was discovered that every one of the imperial treasures of the many storerooms had been stolen by the officials, and all that was left was one small red box containing a few faded receipts.

Does this sound like a government or a nation which could possibly sustain an Industrial Revolution? But there were other terrible things going on at that time as well. Law and order disintegrated entirely, and marauding gangs of bandits and even government soldiers were rampaging around the country breaking into houses and looting them whenever they pleased. No one could obtain protection. There was no justice at all. Peasants were roaming around the countryside with no homes and no food, but even in their penniless condition they were nevertheless robbed and beaten, and the women raped. Some became criminals and more became the victims of criminals. The silk industry in the Yangtze Basin had collapsed, causing enormous numbers of workers to lose their jobs, because there was a serious economic recession in Europe, and the Europeans were not buying Chinese silk anymore.

Even at the beginning of the Ming Dynasty, an enormous burden had been placed upon the people by the creation of a permanent army of three million soldiers to defend China against the northern barbarians. That meant that there were three million men plus their families all of whom had to be fed by the people. At the time of the collapse of the Ming, the people were feeding the same soldiers who were robbing them, as the social situation deteriorated into total chaos and anarchy.

The final collapse of the Ming Dynasty led to the foundation of the Qing Dynasty by the invading Manchus. The Manchus reinstated order in China and brought back some prosperity. The bad weather stopped, and people recovered. The second Qing Emperor, Kangxi, was a truly remarkable man with a deep interest in science and technology who would have made an excellent Fellow of the

Academy of Engineering today. But later emperors of course became corrupt, and the Qing Dynasty, like all others, subsequently degenerated.

However, although life became better under the early Qing Dynasty than it had been during the end of the Ming Dynasty, there was another problem. That problem was that the Manchus, as foreigners, wished to enslave the Han people. All Han Chinese males were required to have their heads shaved as a sign of their status as slaves. In the early Qing Dynasty, official barbers toured the countryside shaving the heads of all the Han Chinese, and these barbers were given the power of life and death. If any Han Chinese man refused to let a barber shave his head, the barber had the legal right to execute him immediately without a trial.

Chinese people do not like to be humiliated in public. What would you feel like if some foreigners came into this conference today and insisted that you all had to have your heads shaved, and if you refused you would be killed? You would not be happy. Most of you would probably rather have your heads shaved than die, but you would then feel humiliated and you would be ashamed to look in the eyes of your friends. You would all have lost face to such an extreme degree that you would feel like suicide because the shame would be so great. What would your wives say when you went home, and what would your children say? The sign of your public humiliation would be visible for everyone to see, since your shaved head could not be concealed.

I suggest that the mass humiliation of the Han Chinese people in China during the four centuries of the Qing Dynasty, and their reduction to the status of slaves, produced such demoralization that it was impossible for them to find the energy or the self-confidence to create an Industrial Revolution.

Thus, from about 1580 until modern times, China was sabotaged from within and was unable to function normally. This can be seen if we look at the list of inventions and discoveries made by the Chinese. The last significant original invention in China was published in the year 1584 by a Ming prince named Zhu Zaiyü, who was 48 years old. It was the brilliant invention of the equal temperament system for music, which was subsequently adopted all over the Western world, and most Westerners think mistakenly that it was invented by the composer Johannes Sebastian Bach one and a half centuries later, but we know that Bach got this system from China either through the writings of a Dutch mathematician named Simon Stevin or a French scientist named Marin Mersenne. It is interesting that all the classical and romantic music for which the West is famous after Bach is based upon this Chinese invention, which made possible the modulation between keys. No piece of Western music today is based upon any other system than that invented by a Ming prince, so that all Western music could be described as Ming music. This was the last significant legacy which the Ming Dynasty ever gave to the world.

But it is no coincidence that the last major Chinese invention prior to modern times was made public in 1584, at the very same time that China was descending into chaos and anarchy, with a total economic and social collapse. For it was at the same time when we could say that native Chinese culture as a viable and

freely functioning national entity in China effectively ceased to exist. A true Chinese culture free of foreign domination did not then reappear again until the time of Sun Yat-Sen.

It seems to me therefore that these large and obvious explanations for the 'Needham Puzzle' have been for too long ignored. There is no need to postulate that there may be something wrong with Chinese society and culture apart from the facts I have just mentioned. From 1584 to 1911, social conditions made it impossible for China to create any kind of 'modern world', even if the Chinese had wanted to do so.

The 'modern world' was therefore created elsewhere, in Europe in fact. But although the Chinese did not do this themselves, the technological elements out of which this 'modern world' was created were more than 50% Chinese. But the Europeans who used those elements did not realize this. They thought they had invented most of them. For instance, the Europeans were completely ignorant of the fact that paper and printing, gunpowder, and the compass were Chinese inventions. They used guns and cannons and bombs and grenades without knowing that the Chinese invented all of them. Even today people all over the world speak of the revolution in communications made possible by the invention of moveable type for printing, which they all believe was invented by Johann Gutenberg in 1458. But Gutenberg did not invent moveable type. Moveable type was really invented by Bi Sheng between 1041 and 1048, four hundred years before Gutenberg. No 'modern world' would have been possible without the widespread use of moveable type for printing in the alphabetic Western languages, but the Chinese origin of this invention is still largely unknown all over the world. And Gutenberg himself certainly did not tell people that he was not the real inventor, since he probably enjoyed being told he was a genius. But it was not Gutenberg who was the genius, it was Bi Sheng who was the genius.

Having explained why there could be no Industrial Revolution in China after 1580, we come to the question as to why there was no Industrial Revolution in China *before* 1580. After all, the Industrial Revolution was made possible in Europe by the preceding European Agricultural Revolution, which was brought about entirely by the importation of Chinese inventions and agricultural techniques and their dissemination by Jethro Tull and others. And this Agricultural Revolution, which everyone admits was a necessary precursor to the Industrial Revolution, had happened in China in its totality by the second century BC, in other words by the Early Han Dynasty, more than 1700 years prior to 1580. During all of those seventeen centuries, why did China not go ahead and have an Industrial Revolution? Perhaps *this* is the true 'Needham Puzzle'.

Let us turn our attention first to economics for a possible or partial explanation. Today in China everyone is aware of the power of money. Money is everywhere, and the lack of it is also everywhere. Universities have to make money today to earn their operating budgets, research institutes have to make money in order to continue functioning, people are buying their own homes, which costs money. People are buying cars, which cost money. Everything is expensive. And in the cities, plenty of people are earning a lot of money, and they are all buying things

in a big 'consumer boom', which keeps the economy of China growing. So everyone here today is very familiar with money, having it, lacking it, and its power. Therefore no one can be surprised to hear the statement, well known to everyone present, that *science and technology cost money*.

But what was the situation prior to 1580? Was there money available for science and technology? In those days there was no 863 Programme. Here we see part of the problem. Who was paying for the science and the technology? The country was controlled by an emperor and the officials. They were willing to pay for military inventions, when they were very much needed, so military inventions thrived from the tenth century onwards. Gunpowder had been discovered by mistake in the ninth century, by alchemists, but by 1040, gunpowder had been adopted as a true invention of war and its formula was published. From the tenth century to the sixteenth century, when there was so much fighting in China, we then saw the invention, dissemination and mass use of gunpowder, flame-throwers, flares, bombs, grenades, land mines, sea mines, rockets including multi-stage rockets, hand guns, large guns, cannons, and finally repeating guns. You can see many of these in the Weapons Museum in Xiamen and in other museums around the country. All of the weapons of war which I have just mentioned are Chinese inventions. None was a Western invention. Certainly in China military technology was massively funded by the government and was massively implemented and adopted. So as far as military technology is concerned, there was definitely an Industrial Revolution in China many centuries before the Industrial Revolution in the West, but it was restricted to the field of military technology only. And this also included techniques of mass production and factory assembly lines, which were not invented by Henry Ford in twentieth century America but were in fact invented in China for the production of weapons hundreds of years before he was born.

Why did this Military Industrial Revolution not extend into non-military areas? Because there was no money to fund it. The emperor was not interested. The officials were not interested. And there were no investment banks, no investors, no entrepreneurs, no stock markets, and no one of any social standing or prestige engaged in business activities. Merchants in China in the old days were looked down upon as socially inferior. They might be rich, but they were not scholars, and so they had no face. They could not advance in any careers other than the restricted scope of trading. They could never hope to be respected because they could not recite the Confucian texts or quote ancient poetry. They were social outcasts, lacking in dignity. Such people were not in a position to fund an Industrial Revolution. They may have had the money, but they did not have the position. And they simply did not make those kinds of investments. When merchants first created the salt industry in Sichuan, it was seized by the emperor during the Early Han Dynasty. The fermentation and brewing industries were seized from the merchants who developed them by the Emperor Wang Mang who reigned between the Early Han and the Later Han. During the Northern Wei Dynasty of the fourth and fifth centuries AD, the penalty for brewing your own beer at home was death. When distilled alcohol was invented, and the first brandy and whisky were made in China, the merchants were prohibited from selling it. Whenever merchants showed initiative in opening up a new technological area of activity which made money, the government took it away

from them. There was no incentive to continue. Success was rewarded by seizure and penalty. No private person or business was allowed to make any money from technological innovation. Therefore, funding for technological innovation was not available except from the emperor or the officials. And as we all know, most of the emperors were very stupid, unimaginative men. Only once in a while did a clever emperor such as Kangxi appear, but as soon as he died, a stupid emperor would take his place. The system was rotten. And there was also massive corruption at all levels of the government for most of Chinese history.

We can see therefore that the economic climate for invention was very poor. But nevertheless, the clever Chinese went on inventing things anyway. What was lacking was an industrial deployment of all of this wonderful technology. Invention after invention appeared, in an endless series. The Chinese have a wonderful genius for invention, surpassing that of all other peoples. Perhaps this is because the Chinese are more intelligent than other peoples. Or it has been suggested that the difficult concentration in early youth needed to learn to read and write Chinese characters creates mental habits which are useful for the process of invention. I have read this in a modern book written by a Western sociologist about the Chinese. However, I do not believe it. If this were true, the Japanese should have invented lots of things as well, but apart from better swords for their Samurai warriors and the advances in metallurgy necessary to create them, I can think of not one Japanese invention before the twentieth century. Where are all the Japanese inventions of the past? There are none. And yet they concentrate hard on learning to write in characters as well. So I think that that theory is disproved. This leaves us with the theory that the Chinese are cleverer than other peoples. And personally I think this is true. But of course the Chinese are not allowed to say it, because it would be boastful. It is OK for a foreigner to say it, who is not part Chinese. So I say it.

What about psychological factors? Are there any of these involved in the 'Needham Puzzle'? I believe that there are. Chinese people are much less inclined towards individualism than are Westerners. Chinese people care more about what other Chinese think of them. Westerners often do not care what anyone thinks of them. Anthropologists in the West often speak of the differences between 'shame cultures' and 'guilt cultures'. A 'shame culture' is one where people are restrained by fears of shame. Chinese people are very restrained in this way. They dread being made to be ashamed in front of another Chinese person. Some Chinese friends of mine have spoken to me of their fears that if they did certain things 'they could not dare to show their face'. Not daring to show one's face is a feeling of shame. Other people's opinions of you really matter, indeed they matter more sometimes than anything else. Knowing how sensitive Chinese people are to shame, that is why I earlier stressed the shaving of the heads under the Qing Dynasty, and the shame which it inflicted on millions of people. And shame was the greatest of all sufferings for them, for I do believe that many Chinese people would rather starve or die than to be deeply ashamed.

But the other kind of culture, the anthropologists say, is a 'guilt culture'. Such a culture is completely different. In one of those cultures, which the Western cultures were until about fifty years ago, people are restrained by feelings of

guilt, not by fear of shame. What other people think is not what is important. Instead the feeling is an inner fear of guilt or sin, or having broken rules which you know inside by your conscience, or which God will see because he sees everything, even more than neighbours can see. Because God can see into the secret recesses of the human heart, and knows everything. Therefore, when a Western person in the past did something wrong, he felt guilt rather than shame. He might feel shame also, but it was much less important. This was because until about fifty years ago, Western cultures had very strong religious traditions, both Christian and Jewish, and both of these taught the concept of guilt very strongly.

But today everything has changed in the West. Religion is no longer very strong except amongst a minority. Guilt has largely disappeared. But alas, there is no shame to take its place. We all know the name of a prominent person in America who had no shame at all. I do not need to name him. Although I believe that he was an extreme case, and had a deep personal psychological problem, he represented in an extreme way the problem with which the entire Western world is currently struggling: lack of reasons to behave well, and lack of reasons to restrain oneself. One could even say that what Westerners need today is a good dose of Chinese shame, to make them behave better.

But let us return to the problem of China before 1580. We see a China which was very much a shame culture, not a guilt culture. It had always been a shame culture, and I believe that it always will be a shame culture. That is the Chinese way. I only make an observation, not a criticism. But what are the consequences of a shame culture when one is considering technological advances? In a shame culture, there is plenty of incentive to invent things, because people will think highly of you. You will become famous amongst your friends for being clever and useful. So Chinese society has always encouraged that. To invent something in China, one feels the opposite of shame, one feels pride and joy. In the same way today, when a young person qualifies for entry into Tsinghua University, he feels such pride and joy, his parents are bursting with pride and joy, his friends are all impressed, he gets a high reputation. That is just the same social encouragement which has always existed in China for invention and discovery. If you invented something useful like the wheelbarrow, the chain drive, the belt drive, efficient horse harnesses, the crank handle, the segmental arch bridge, - and all of these were invented in China, - it was like getting into Tsinghua ten times. So great would your reputation be amongst your family and friends! Everyone would praise you, and your heart would be joyous.

But what about the widespread adoption and use of such technology? Here there was a problem. Chinese people do not like to have sole responsibility for decisions, because if anything goes wrong they will experience shame. So they need to take their decisions on a consensus basis in a group, and then no single Chinese person will get the shame if something goes wrong. Each individual is protected by the group. A group can survive shame, because the shame can be diffused. But an individual in China can never survive shame if he or she bears it alone.

But what groups were available to inventors in traditional China? Where could an inventor go to spread the risk of shame so that he would be safe? There were

no High Tech Zones in those days. There were no research institutes. There were no technological universities. There were no technological ministries or bureaux. An inventor was on his own. Having received the praise from his family and friends for making the invention, he dare not risk the shame of attempting to deploy it on his own initiative. If friends wanted to copy the invention and use it and spread its use, that was OK. He would not be blamed if anything went wrong because he had not initiated anything. If he went to see a merchant to ask for some money to spread the use of his invention, no merchant would give him any money. There were no patents or intellectual property rights to protect his invention. If the merchant liked the invention he would just copy it for free and use it. But he would not be foolish enough to try to manufacture and sell it, because the merchant in the next town would just steal it and the merchant in the next town after that would just steal it again, and so on. So we see that the fear of shame and the lack of economic security join here, and make exploitation of inventions almost impossible in traditional China.

From time to time an emperor would take a fancy to some new invention, as happened with the first mechanical clocks. But then the mechanical clock was forgotten in China, and during the Ming Dynasty when the Westerners showed one to a Ming Emperor, he thought it was a Western invention, not realizing that the Chinese had invented it centuries earlier and then forgotten and lost it, and that the concept had spread to the West from China, although the precise mechanism differed.

There is another psychological difference between Chinese and Westerners which is more profound than the shame and guilt dichotomy, and goes back further in time. I refer to the extreme individualism which has been traditional in the West since the times of the ancient Greeks. There is no such tradition in China. Sometimes extreme individualism can be productive and can drive forward technological implementations, especially within a business context. However, extreme individualism has its disadvantages as well, just as anything which is extreme cannot be entirely good. Amongst the ancient Greeks, the most famous philosopher, Aristotle, agreed with the famous Chinese philosopher Kong Zi, in recommending restraint and moderation in all things. All deep thinkers in all cultures agree on that point. I think everyone here today probably shares that opinion. But the extremes of individualism should never be forgotten by the Chinese when trying to understand certain aspects of the West, both contemporary and historical. These psychological factors can be just as important as economic and social factors.

I think that we have examined enough of the aspects of the 'Needham Puzzle' for now. In fact, I do not believe that Chinese people need to worry too much about the 'Needham Puzzle'. It should not make them worried about their future. There is nothing wrong with the Chinese people that is any worse than all the things that are wrong with everybody else. Different peoples have different failings, and different strengths. It is part of the wonderful diversity of our planet. But surely if there were anything seriously wrong with the Chinese people, they would not have accomplished the greatest miracle of all: that they are still here, in China, with a thriving civilization and culture, thousands of years after they started. Where are the Egyptians? The Greeks? The Romans?

The Babylonians? They disappeared. The people who live in those countries now do not have the same cultures, and often are not the same people. So many ancient empires have vanished. But the Chinese have survived. And because they have survived, they should be proud of their past achievements. But much more than the monuments of the past, the Chinese should be proud of the inventions and discoveries of the past. For these intellectual monuments are greater than the Great Wall, more spacious than the Forbidden City, more beautiful than the West Lake, more elegant than the gardens of Suzhou. And although physical monuments can be destroyed and taken away from you, as has often happened, intellectual monuments cannot, as long as memory of them survives. That is why the most important tradition of China is its scientific and technological tradition.

In closing, I want to list some of the Chinese inventions and discoveries, and give the periods of time which elapsed between the recorded invention or discovery in China and its adoption or recognition in the West:

The cultivation of crops in rows rather than at random. 2,200 years.

The iron plough. 2,200 years.

Trace harnesses for horses. 500 years.

Collar harnesses for horses. 1,000 years.

The rotary winnowing fan. Never adopted in the West.

The multi-tube modern seed drill. 1,800 years.

From these you can see that China was two millennia in advance of the West in agriculture.

Quantitative cartography. 1,300 years.

The so-called Mercator Map Projection. 600 years.

Mounted equatorial astronomical instruments. 600 years.

Cast iron. 1,700 years.

The crank handle. 1,100 years.

The so-called Bessemer steel process. 2,000 years.

The so-called Siemens steel process. 1,300 years.

Deep drilling for natural gas. 1,900 years.

The belt drive or driving-belt. 1,800 years.

The chain pump. 1,400 years.

The suspension bridge. Between 1,800 and 2,200 years.

The first cybernetic machine. 1,600 years but possibly 3,000 years.

Essentials of the steam engine. 1,200 years.

The segmental arch bridge. 500 years.

The chain-drive. 800 years.

The first plastic, namely lacquer. 3,200 years.

Petroleum and natural gas as fuel. 2,300 years.

Paper. 1,400 years.

The wheelbarrow. 1,300 years.

Sliding callipers. 1,700 years.

The fishing reel. 1,400 years.

The stirrup. 300 years.

Porcelain. 1,700 years.

Biological pest control. 1,600 years.

The umbrella. 1,200 years.

Matches. 1,000 years.
Brandy and whisky. 500 years.
The mechanical clock. 585 years.
Block printing. 700 years.
Printing with moveable type. 400 years.
Playing-cards. 500 years.
Paper money. 850 years.
The spinning-wheel. 200 years.
Circulation of the blood recognised. 1,800 years.
Circadian rhythms in the human body recognised. 2,150 years.
The science of endocrinology. 2,100 years.
Deficiency diseases recognised. 1,600 years.
Diabetes discovered by urine analysis. 1,000 years.
Use of thyroid hormone. 1,250 years.
Inoculation (against smallpox). 800 years.
The decimal system in mathematics. 2,300 years.
A place for zero in arithmetic. 1,400 years.
Negative numbers. 1,700 years.
Extraction of higher roots and solutions of higher numerical equations. 600 years.
Decimal fractions. 1,600 years.
Using algebra in geometry. 1,000 years.
The so-called Pascal's Triangle of binomial coefficients. 427 years.
The magnetic compass. 1,500 years.
Dial and pointer devices. 1,200 years.
Magnetic declination of the Earth's magnetic field recognised. 600 years.
Magnetic remanence and magnetic induction. 600 years.
Geobotanical prospecting. 2,100 years.
The First Law of Motion (so-called Newton's). 1,300 years, but 2,000 years before Newton.
The hexagonal structure of snowflakes. 1,800 years.
The seismograph. 1,400 years.
Spontaneous combustion. 1,500 years.
So-called Huttonian (modern) geology. 1,500 years.
Phosphorescent paint. 700 years.
The kite. 2,000 years.
The first manned flight. 1,650 years.
Relief maps. 1,600 years.
Contour transport canals. 1,900 years.
The parachute. 2,000 years.
Miniature hot-air balloons. 1,400 years.
The rudder. 1,100 years.
Batten sails and staggered masts. Never adopted in West.
Multiple masts and Fore-and-Aft Rigs. 1,200 years.
Leeboards. 800 years.
Watertight compartments (bulkhead construction) in ships. 1,700 years.
The helicopter rotor and the propeller. 1,500 years.
The paddle-wheel boat. 1,000 years.
The canal pound-lock. 400 years.
The large tuned bell. 2,500 years.

Tuned drums. Unknown in West.
 Hermetically sealed research laboratories. 2,000 years.
 Musical timbre understood. 1,600 years.
 Equal temperament in music. 50 years.
 Chemical warfare/ poison gas, tear gas/ smoke bombs. 2,300 years.
 The crossbow. 200 years.
 Gunpowder. 300 years.
 The flame-thrower. 1,000 years.
 Flares and fireworks. 250 years.
 Soft bombs and grenades. 400 years.
 Metal-cased bombs. 246 years.
 Land mines. 126 years.
 Sea mines. 200 years.
 The rocket. 200 years.
 Multi-stage rocket. 600 years.
 Early guns, cannons, mortars. 450 years.
 The true gun. 50 years.

I have not listed everything. Some things such as land sailing I left out because they were not very important, but some things such as cupro-nickel alloy I have left out because more research needs to be done on it. So although the above list is not complete, I have used it to take an average of the time-delay for the adoption of a Chinese invention or discovery in the West. There are 96 listings above, even though they sometimes represent more than one invention per listing, of which three were never adopted in the West and 93 were. If using only the conservative time figures we add up all the time delays (113,734 years) and divide that figure by 93, we get the average time delay of 1,223 years for a transmission time of a Chinese invention to the West. That figure gives some rough indication of the order of magnitude by which China was temporally ahead of the West. But we must not forget that this average time-lag was not between an invention in China and its re-invention in the West. What we are talking about are merely *delays in transmission and adoption*. Few if any of these Chinese inventions and discoveries can be said to have had any independent invention or discovery in the West. They were all transmitted either by direct diffusion, such as physical objects actually being transported, or by what Joseph Needham (Li Yuese) called ‘stimulus diffusion’, where a description alone and not an object was transmitted, as happened with the mechanical clock.

I cannot go into any more details of the history of Chinese science and technology now, nor can I explain in any greater detail its adoption in the West. The above list will have to suffice as an indication of the fantastic extent to which China contributed to the critical mass of fundamental inventions and discoveries which led to the creation of the modern world. It is immediately obvious to anyone that the contribution was overwhelming, like a tidal wave of genius which engulfed the West. And during the years after 1580, when China was unable to create the world which we now call modern, the Westerners went ahead and did it, using Chinese ingredients as well as Western ones. But I believe we can safely say that more than half of the ingredients were Chinese in origin. Imagine a large international building built of bricks of two colours: red and blue. The red are Chinese, the blue are Western. If we imagine the modern world as being such a

building, than more than one side is red, and less than one side is blue. But neither can stand without the other, for there is no building at all unless it is both red and blue.

This is the world of today. This is the world in which we all live. Let us all, whether we are red or we are blue, whether we are yellow or we are white, see clearly that there is only one way ahead: a multi-coloured way. And as we go ahead together, the Chinese can be proud of their contributions so far, and of those many wonderful contributions yet to come.