Verwood u3a History Group: topic for September 2024

ANCESTRAL POWERS: Empire and Science in World History

Empire and science shaped the modern world. Ancient empires laid the foundations of our politics and government. Science transformed our civilization. Their common factor is ***power***. Thus from ancient times empires were some of the greatest political entities ever created, while as Francis Bacon the 17th century English philosopher of science said, "knowledge itself is power". In this two-part topic we'll discuss the history of empires and of science from the ancient world to the present day. We'll explore parallels between ancient emperors and modern leadership, and consider new thinking about the origins and nature of science.

PRELUDE: Francis Bacon – power, empire and science

PART 1 – Empire and emperors in world history

1 Arenas - the geopolitics of empire; the geography of Eurasia
2 Meanings - the idea of empire; definitions, imperial ideologies/hard and soft geopolitics
3 Origins – the first empires; Mesopotamian/Assyrian, Zhou/Qin Chinese, Indian/Mauryan/Gupta, Persian/Archaemenid, Macedonian/Greek
4 Origins - continued
5 East and west – Han Chinese, Roman/Byzantine
6 Mobility – cavalry and caravels; steppes grasslands; nomadic states; Mongols; Chinese nomadic empires; European oceanic empires; ancient African empires
7 Early modern empires – Ottoman, Spanish, Habsburg, Russian, Mughal
8 The fate of empire – British, German, Soviet, US, Putin, Japanese; lost empires; ancient American; ruins.

Below is a chronological list of the Eurasian empires we will be discussing. It may help to refer back to this as we go through the topic. We will also look at empires in the Americas and at Africa.

A chronology of Eurasian empires

Akkadian/Mesopotamian 2334 – 2154 BCE
Egyptian/Old Kingdom 2686 – 2181 BCE
Assyrian/Mesopotamian 2025 – 609 BCE
Chinese/early dynasties 2070 – 206 BCE
Achaemenid/Persian 550 – 330 BCE
Macedonian/Alexander the Great 336 – 323 BCE
Mauryan/Indian 322 – 185 BCE
Roman 27 BCE – 476 CE
Byzantine/Eastern Roman 330 BCE – 1453 CE
Chinese/Han dynasty 206 BCE – 220 CE
Gupta/Indian – 320 – 550 CE
Japanese 540 CE –
Umayyad Caliphate/Islamic 661 – 750 CE
Abbasid Caliphate/Islamic 750 – 1258 CE
Carolingian/Charlemagne/Franks) 800 – 888 CE
Holy Roman Empire/German 962 – 1806 CE
Chinese/later dynasties 618 – 1912 CE
Mongol 1206 – 1368 CE
Ottoman/Turkish 1299 – 1922 CE
Mughal/Indian 1526 – 1857 CE
Austrian/Habsburg 1282 – 1918
Portuguese/oceanic 1415 – 1997 CE
Spanish/oceanic 1492 – 1976 CE
British/oceanic 1583 – 1997 CE
French/oceanic 1605 – 1962
French/Napoleonic I 1804; Napoleon III 1852
Russian/Romanov 1721 – 1917
German/Hohenzollern 1871 – 1918

SESSION ONE

PRELUDE: Francis Bacon – power, empire and science

These sessions are about the histories of *empire* and *science*; their common factor is *power*. Security is a basic human need. Throughout history humans have faced two main threats to this: *nature* (unexpected illnesses, crop failures, natural disasters); and *other people* (especially strangers). Both threats involve ***power***. Do other people and nature have power over us? Or can we gain power over them? The connection between these two aspects of power is illustrated in the career of **Sir Francis Bacon** (1561 – 1626).

Bacon knew all about power; he both gained and lost it. Born into a rich and powerful English family, but as one of eight children, he inherited nothing from his father's estate. Even so, he worked his way to the top of English public life, becoming a lawyer, MP (including Melcombe in Dorset), judge and in 1618 Lord Chancellor. But in 1621 he was convicted of taking bribes and although he escaped imprisonment he was disgraced and barred from parliament or public office.

Bacon also knew about empire. As leading figure in British public life under he was involved in the struggle with Spain for colonies in the Americas. He served on the Councils of the Virginia, Newfoundland, Northwest Passage and the East India Companies. After his fall he turned to writing, becoming a famous, much-quoted essayist.

But Bacon's great passion was science. He is sometimes credited with inventing the modern scientific method. He didn't, but he did strongly advocate the scientific method of experimentation and observation. However he believed that it was enough to just accumulate data through observing nature. Later thinkers realised that scientists also needed to develop hypotheses, make daring leaps of intuition, and have the courage to challenge accepted theoretical frameworks or "paradigms ". In short, there was more to science than just data collection.

Rather than being a great scientist, Bacon was a great visionary who saw the potential of science to transform society. He proposed creating teams of full-time, trained researchers and experimenters – today we'd call them research institutes – which would usher in a golden age of scientific discovery and human progress. This provided the model for the world's first scientific academy, the *Royal Society* (1660), created after his death.

In other words, Bacon's real greatness was as a prophet. He anticipated the 18th century Enlightenment with its key modern ideas of science, reason and progress. Earlier thinkers like Aristotle believed that history moved in cycles, with periods of improvement then decline. Bacon's own contemporaries like John Donne saw around them only stagnation and decay. But Bacon, far ahead of his time, was the supreme optimist.

Which brings us to Bacon's most famous quote: "*knowledge is power".* What a clarion call for discovery and progress! After Bacon, science and technology enabled the Europeans to conquer the globe. Science seemed to merge with empire, and their combined power seemed limitless.

But alarm bells began. In 1818 Mary Shelly prophetically warned about scientists like her fictional Victor Frankenstein assuming god-like powers. Then came real-life horrors: industrialisation, world wars, the holocaust, the atomic bombing of Hiroshima, global environmental crises. The hopes invested in science and empire seemed to be undermined by the terrible, unintended consequences of their untrammelled power.

Some historians argue that Bacon, the great advocate of science in society, is implicated in all this. It didn't help that when writing about science he uses language comparing nature to a woman who must be "*hounded"*, "*vexed"* and even "*tortured"* into submitting to the mastery of man. Others defend him, quoting his words, "*nature to be commanded, must be obeyed"* and claiming that he valued the European voyages of discovery as much for their new knowledge as for their conquests. And his famous aphorism actually says that "knowledge *itself* is power"; it isn't a *means* to power.

Are Bacon's critics right? The histories of science and empire seem to intersect in his career, and although he didn't create the link between them, the fact remains that science *did* become the handmaiden of empire. Either way, Bacon's reputation has never quite recovered. Once acclaimed as the "father of modern science", he is now seen as compromised, implicated in the modern critique of both science and empire.

Whatever our view, it's clear that the histories of empire and science are of more than just academic historical interest. They raise huge issues about the nature of power, knowledge and progress. We'll discuss these issues as we proceed. It is right that history should inform the present. To quote the novelist William Faulkner, "*the past is never dead. It's not even past."*

As for Bacon himself, legend says he died of pneumonia caught after impulsively leaping out of his carriage in the dead of winter to get a plucked chicken so he could stuff it with snow to see if it would preserve it. He said, '*I have taken all knowledge to be my province".* American Daniel Heitman says that despite his many faults and limitations, we should respect his audacious ambition of aspiring to "*a mind without borders."*

1 ARENAS – EURASIA, EMPIRE AND GEOPOLITICS

Geography is important to history and in these sessions I propose to apply ideas adapted from geopolitics. This can be defined as "*the impact of geography on policy and politics*". Historians use it to help explain how political power is projected over territories and peoples. When applied to empire, this includes how rulers get their people to obey them and also how they interact with other states and empires, friendly and unfriendly.

Geopolitics is also interested in how the balance of power changes, as states rise and fall, a pattern observed throughout the history of empire. This involves looking at all the relevant factors: not just geography and politics, but also economic, military, technological and cultural. Other less predictable factors include popular uprisings and migrations.

A key idea is that states such as empires have geopolitical *imperatives* and *constraints*. *Imperatives* are the pressing geopolitical goals and ambitions considered essential to an empire's future and well-being. *Constraints* are geopolitical obstacles or weaknesses which limit their ability to act as they would like*.

**"What Are the Fundamentals of Geopolitics?" Geopolitical Futures https://geopoliticalfutures.com/learn-with-gpf/what-are-the-fundamentals-of-geopolitics/ December 9, 2022*

Beginnings: Eurasia as the arena of early geopolitics

Jonathan Holslag makes the point that the geography of Eurasia strongly affected where and why the first civilizations, state and empires arose. Civilization began on the continent of Eurasia, in three key geographical zones. These are the *Middle East*, the *Indo-Gangetic Plain* (central-northern India) and the *North China Plain*. These regions were the seedbeds of the first city states, kingdoms and empires from the 4th millennium BCE onwards. This big region, lying roughly between the middle east and the Pacific, became the world's first *geopolitical arena*. How did this happen?

Within Eurasia, there was one particular zone which was particularly conducive to human settlement and it was here that the first agricultural communities, cities and empires emerged. This zone follows *the Alpide Belt,* a chain of mountain ranges which runs right across Eurasia from west to east. It extends from the Atlas Mountains in north Africa to Java in south-east Asia. It includes *the Atlas, Pyrenees, Alps, Balkans, Caucasus, Zagros, Hindu Kush, Tian Shan, Himalayan, Annamite, Cardamom* and *Barisan* mountains.
The point is that the lands that lie close to this mountainous zone have temperate, subtropical climates and rivers, making them well suited for permanent human settlement. By contrast, the regions that lies to the north and south of this mountainous belt have either snow, or desert or tropical rain forests, much less conducive to human settlement (see map below).

The Alpide Belt, mountain ranges which define the main zone of settlement

Across Eurasia *mountain ranges* also acted as major natural barriers between communities, civilizations and empires. *India*, for example, was separated from the rest of Asia by the formidable barrier of the Himalayan and Hindu Kush Mountains. They protected its ancient civilizations from invasion from the north. Further, mountainous rains and melting snows flowed down and fed the Indus and Ganges rivers. The mountains also blocked the cold, dry winds from

the north and summer monsoons from the Bay of Bengal and the Arabian Sea, causing rain to fall in northern India. All this helped make the north Indian plain ideal for the growth of agricultural settlements, civilizations and empires.

China too was shaped by highlands. Himalayan rains and melting snows from Tibet carried rich sediments down onto the north China plain. In this fertile zone, enclosed by formidable mountains to the west, deserts and vast steppes to the north, seas and impassable jungles to the east and south, Chinese agriculture and civilization flourished.

The Himalayas, natural barriers of ancient Indian and Chinese empires

Human settlement begins

Within the zone defined by the Alpide Belt, civilization began in a very specific location, *Mesopotamia*. This name comes from the ancient Greek words meso, meaning "between" or "in the middle of," and potamos, meaning "river". This is region of fertile valleys lies between the *Tigris* and *Euphrates* rivers. It became home to many civilizations and empires over thousands of years, including the *Sumerians, Babylonians*, and *Assyrians*. Geographically it

basically corresponds to modern-day *Iraq*, plus bits of Iran, Turkey, Syria, and Kuwait.

It all began here: the first farming communities, city states, writing, specialised occupations, bureaucracies and religions. Also watered by the River Jordan, it has been called the *fertile crescent.* The very first identifiable empire in history, arising from the *Sumerian* civilization, was the *Akkadian*, and *Sargon* was its emperor.

There were other fertile, flat lands in Eurasia and here too early civilizations and empires emerged. The most prominent were the *North China Plain* and in warmer climates the *Nile Valley* and the *Indo-Gangetic Plain*

Also conducive to such developments were the *European Plain* and the *Mekong Delta.* There were also habitable *coastal plains* in what are today Japan, Korea, Oman, Kenya, Georgia, Azerbaijan, Greece, Italy and Senegal, and the *fertile plateaux* of modern-day Afghanistan, Armenia and Macedonia.

In the colder regions to the north, there were the *Eurasian steppes*, a vast, level ecoregion of temperate grasslands, savannas and shrubland. The steppes grasslands extended from Hungary to Manchuria ((the *Pontic-Caspian, Siberian, Mongolian* and *Manchurian)*.

The Eurasian steppes, a vast belt of level grasslands and nomadic peoples

Here nomadic peoples kept herds of cattle, sheep and goats and perfected the skills of horsemanship (other steppes fauna includes pigs, bison, deer, antelope, yaks, wolves, foxes, falcons, and eagles). The steppes saw the rise of the Silk Road, large but short-lived tribal confederations, and ultimately the Mongol Empire. The relationship between the mobile nomads and their sedentary neighbours was complex and as we'll see shaped the history of empire in profound ways.

Connectivity begins

Connections across Eurasia such as trade routes were slow to develop. The obstacles – the vast size of Eurasia, the low density of population, natural barriers, all meant that long-range connections were slow to develop. Yet Eurasia was gradually connected, north-south as well as east-west. A big part in this was played by the *rivers* and *seas* – the *Baltic, Mediterranean, Black Sea* and *Red Sea*.

Narrows between seas, such as the *Kattegat, Gibraltar, Bab-el-Mandeb* and *Strait of Malacca*, would later become strategic pinch-points. The *Kattegat* strait controlled access to the trade of the Baltic and has been fought over by Denmark, Norway, Sweden Russia and Germany. The *Bab-el-Mandeb* strait connects the Red Sea and the Indian Ocean and became the gateway to the Suez Canal after 1869. It has been contested by the Portuguese, Ottoman, British and French empires, the Axis powers in World War II, was involved in the Suez Crisis and Arab-Israeli wars, and the present crisis of Houthi rebels in Yemen trying to disrupt western shipping including oil shipments.

The *Straits of Malacca* connects the Indian Ocean with the South China Sea and the Pacific making it a vital passage for global trade. They have been fought over in numerous historical periods: by the Indonesia and Indians (11th century), the Sultan of Malacca and the Portuguese (16th century), the Dutch and the British (17th century), the Japanese and Allied forces (Second World War), Indonesia and Malaysia (1960's) and the Americans, Russians and Chinese (the Cold War).

In the 15th century the Chinese Ming emperor Yongle made what was for China a rare bid for naval power via the Straits of Malacca. He built a huge fleet and sent it through the Straits on several expeditions, both to deter potential threats to their security, and to project Chinese power beyond its frontiers over the seas and rulers to the west. (Actually, not so much a rare

bid, more a unique one. The next emperor called it off, grounded the fleet and even destroyed the official records of its existence).

East-west connectivity across Eurasia overland was revolutionised by the nomadic peoples of *the steppes,* once they mastered *horsemanship* and the essential tack invented. This took time; although horses were domesticated around 4,000 BCE, saddles were not recorded until around 700 BCE (by the Assyrians) and stirrups possibly by 500 BCE. The effect on the mobility of the nomads was transformational. Mounted warriors gained what was virtually frictionless mobility. As we'll see later, the Mongols showed how massed nomadic cavalry could become an unstoppable military force.
The new connectivity made possible *mass migrations*, *large-scale invasions*, *long-distance trade* (including the Silk Roads) *cultural links, the spread of religions* (like Buddhism, Christianity and Islam) and *diplomatic links and treaties.* These are the stuff of geopolitics; through them Eurasia became the world's first *geopolitical arena* from the third millennium BCE.

Elsewhere
Although our initial focus is on Eurasia, we must not dismiss as unimportant human settlements and empires in other hemispheric regions, notably Africa and the Americas. Egypt was of course both an African and a Middle Eastern empire. But the fact remains that, as we've seen, Eurasian geography was in crucial respects more conducive to early large scale permanent human settlement. For a long time it had both higher levels and greater density of human population. Also the surviving evidence for early African and American states and empires is often limited to material remains revealed by archaeology. This makes it extremely difficult to say anything about their politics and geopolitics. We will look at African and early American empires in later sessions.

Next
First we need to consider what empire is. This will be the question for next session.

SESSION TWO

MEANINGS – THE IDEA OF EMPIRE

Coin of Augustus, the first Roman Emperor (r.27 BCE – 14 BCE). A silver denarius, 7-6 BCE. The inscription on the heads side reads [CAESAR AV]GUSTUS DIVI PATER PATRIAE
("*Caesar Augustus, son of a god, father of the country*"). Augustus was one of the first ancient rulers to see the power of putting his portrait everywhere he could.

Where did the words "*empire*" and "*emperor*" come from?

In 44 BCE Julius Caesar was assassinated. His political enemies suspected him of plotting to overthrow the centuries-old Roman Republic. In his will Caesar named his great-nephew, a man called *Gaius Octavius,* as his adopted son and heir. Octavius renamed himself; henceforth he would be known as *Gaius Julius Caesar.* This turbo-charged his political career. By 27 BCE he had fought his way to victory in a long and bitter civil war and made himself ruler of Rome. The Senate awarded him a new title, *Augustus*, "the exalted one". Confusingly, this is the name by which he is known to history.

It was Augustus who effectively invented the words "*emperor*" and "*empire*".

As the above suggests, Augustus was not born to rule. He battled his way to power and he knew that he had to keep the Roman army on side. To cement their partnership, he adopted for himself yet another title: ***imperator***. This was a military title, meaning "one who commands and gives orders" (the Latin for command is *imperium*). It was traditionally used by Roman soldiers about a general who had proved himself worthy of command in battle. By adopting it,

Augustus transformed it from a military into a *civilian* title. The word caught on and from Augustus onwards *imperator* was used to mean a supreme ruler who exercised *civil and political* power. *Imperator* translates as ***emperor*** and also gives us the word ***empire***. Both words derive from *imperium*.

Augustus' adoption of a military title is a good example of his political acumen. However ironically Augustus' policy was strongly against further military conquests; he argued that the Roman empire was already big enough. The other great irony of course is that the great-uncle to which Augustus owed so much, Julius Caesar, had been assassinated in 44 BCE because his political enemies wanted to stop him becoming dictator of Rome.

What were they called before?

Thus the words *emperor* and *empire* were born. What words had been used before this? One was the Latin word ***rex*** – king – derived from the ancient Indo-European word ***reks***, which also gave the Sanskrit *rajan*, the Irish *ri*, the old German *reiks* and the Dutch *rijk*, plus the English words *regal* and *royal*. The Persian word for ruler or king was ***shah***; someone even more powerful than that was called ***shahanshah,*** "king of kings".

The Egyptians called their rulers ***pharaoh*** which meant "royal building or palace". The Chinese used the word ***huangdi***, and the Japanese ***tenno***: both words mean "divine or heavenly ruler".

The Greeks had two words, ***archos*** meaning ruler, leader or chief; hence words such as "monarchy", "oligarch", "archangel" and "patriarch"; plus ***basilieus,*** originally a religious official, which also came to mean a ruler. In the Catholic world "*basilica*" was used for a church given special privileges by the Pope, such as St Peter's.

It was the Anglo-Saxons, inventors of the English language, who gave us our word "***king***", or ***cyning***: from *cyn*, kin or lineage, and *inga*, the people, thus meaning "member of the family who rule the people". Kings whose power extended beyond their own kingdom were called ***Bretwalda***. (Some of them optimistically called themselves *Imperator*).

The Islamic emperors used the Arabic word ***caliph,*** meaning "successor", because they were regarded as the successors of the Prophet Muhammed. In 1571 Russia's ruler Ivan the Terrible adopted the title ***Czar*** or ***Tsar***, a Russianized version of Augustus' adopted family name ***Caesar***.

What happened to empire?

From the dawn of civilization to 1900 empires were the biggest states in history. Today there is just one left: only the Japanese still have a hereditary emperor as their head of state. He is Naruhito, 64, who succeeded to the Chrysanthemum Throne in May 2019. He is descended from the sun goddess, Amaterasu, and is head of Japan's national religion, Shinto.

Empire virtually ceased to exist during the 20th century. During the first quarter of the 20th century, all the great surviving land empires were dissolved. The Chinese (1911), the Russian (1917), the Habsburg, the newer German (1918), and the ancient Turkish Ottoman (1924), all gone for good. Within another fifty years all the great European oceanic empires had virtually disappeared as well: the Spanish, Portuguese, French, Dutch and Belgian. The British reckon the final end of their empire as 1997, with the handover of Hong Kong to China (they took it in 1841; a treaty of 1898 gave them a further 99 years).

Empires have been replaced by ***nation-states***, which date from the 18th, 19th and 20th centuries. Nation-states are based on a shared ethnicity, language, and culture, and basically date from the 18th and 19th centuries. There are currently 205, of which 193 are members of the United Nations Organization (est.1945). The biggest nations, so-called superpowers, have vast territories, on the scale of historic empires: America, Russia, China and India, with a second rank of medium regional or emerging powers like Brazil. If the EU, a unique political and economic union of 27 countries, was a single nation, it would be the world's third biggest in population, wealth and military spending, and the seventh biggest in area.

<u>Two Cambridge historians on empire:</u>
Thus, empire has gone out of fashion. Here are two opinions about it:

Richard Drayton: *"All empires are expressions of inequality hidden behind a mask of community. Panic about scarcity or security, channelled through a racial or cultural idea of self and others, has generated over millennia that combination of ruthlessness and hypocrisy of which every empire is an expression. There is a myth of shared virtue, usually for the consumption of the empire's elites, but which may attract peripheral collaborators without whom no expansion is possible. The experience of violence and inequality generate a terrible momentum. The planning, justification and execution of that brutality which is the basis of each empire lead to a hardening of racisms and a decay of compassion."*
(Why do empires rise? In *Big Questions in History* ed Hilary Swain, 2005)

Dominic Lieven: *"There are moments when I believe that empire needs not only to be defined in words but also seen, felt and imagined. For me, the essence of empire is best encountered when sitting overlooking the Golden Horn at Istanbul of standing on the steps of the Throne of Heaven in Beijing where the Chinese emperors made their great annual sacrifices. In those surroundings it is hard not to sense the power, magnificence, confidence and beauty of imperial monarchy, together with the sense of history and destiny that fuelled great empires."*
(In the Shadow of the Gods: the Emperor in World History, 2022)

As these two extracts show, historians have very different feelings about empire! They also differ in their approaches to studying it. Dominic Lieven, author of *The Shadow of the Gods: The Emperor in World History*, 2022, who has studied empire for fifty years, takes the view that since history is about people in the past, we should focus on the history of *emperors*. He views empire as their collective biography.

By contrast, Jonathan Holslag (*A Political History of the World: Three Thousand Years of War and Peace*, 2018) takes a more geopolitical perspective, focusing on the origins, rise and fall of empires and other states and how they relate to one another. In these sessions we will combine both approaches,

Six key features of empires and emperors
The rest of this section is based on Lieven's book, *In the Shadow of the Gods: the Emperor in World History*, 2022. Dominic Lieven says that an *empire* is defined by ***scale***, ***diversity*** and ***power,*** while an *emperor's* basic roles are ***dynastic***, ***sacred*** and ***political***.

1. *Scale*

Empires were vast. Governing them was a challenge given the limitations of pre-modern travel, transport and communications. It made emperors distant figures who had to rule with a light-touch. In practice they had to rely on local elites to govern communities on their behalf.

The fundamental task of the emperor was to extract a share of the agricultural surplus out of the people they ruled. They took this in the form of taxation or tribute. They had to squeeze enough out of their subjects to pay for the huge armies, palaces and monuments on which their power depended. They were the the means by which emperors both protected and coerced their own population and impressed and fought other rulers. Tax was a trade-off. A

balance had to be maintained. The emperor had to raise enough, but excessive tax levels could ruin the people or spark mass revolt.

From the Greeks onwards it was believed that for an emperor to rule a vast empire he had to be a despot. While smaller city states could be more relaxed and democratic, they were generally too small to defend themselves. Fashions in the size of states changed. In the 19th century nationalism arose and it was believed that medium-sized nation states were better; they could be more intensively governed and developed than vast sprawling empires. In the late 19th century the fashion changed back; improved communications technology – notably the telegraph and railways – allowed bigger nations to be governed intensively and to develop their resources. The bigger the nation, the more power it would have. Modern superpowers are in effect nation-states on the scale of empires.

Between 1870 and 1945 these contradictory developments helped to destabilise the world geopolitical system. Nationalism gained widespread popularity; almost like a modern religion, it gave meaning and purpose to many peoples' lives. But nationalism undermined the great multi-national empires which were faced with breaking up into its smaller component nations, as the Habsburg empire did in 1918 and the Ottomans in 1923. This collided with the counter-trend towards greater territorial size as the only source of great power status. These tensions culminated in the world wars. It continues to disrupt our world today.

Paradoxically, the larger and more complex empires became, the more they obliged their supposedly almighty emperors to delegate their powers. They had to rely on able chief ministers, trusted subordinates and efficient bureaucracies, while still relying on local elites to carry on everyday government and administration. The potential for disloyalty grew ever wider. Even members of the emperors' own dynasty could not be trusted.

2. *Diversity*

Empires were diverse. Emperors and kings were both monarchs Both had to protect the interests and status of their dynasty. The rituals they performed were similar. Both embodied in their person the sovereignty and legitimacy of their domains. Both ruled, chose and managed ministers, conducted war and diplomacy.

But what made empires different was that while a king ruled over a *people*, an emperor ruled over *kings*. This also meant they also ruled over several or

many different peoples. Thus as well as having greater scale and higher rank, empires also had greater *diversity*.

Hence the Achaemenid Persians called themselves, "*Shahanshah*" – "King of Kings" – and claimed equality with the emperors of Rome. The emperor Charlemagne (crowned 800 CE) who aspired to revive the heritage of the Roman empire, claimed leadership over the whole of Christendom, though he had to share this with the popes.

More ambitious still, King Zheng of the ancient Qin dynasty who first united China in 221 BCE, gave himself the new title of *Huangdi*, meaning "majestic god-emperor". He claimed this was a break in world history; that there was no ruler on earth who was not ultimately under his authority; that his civilization was the greatest and was uniquely blessed by Heaven; and that all humans and their rulers who aspired to live a civilized life and follow correct principles should respect him and follow his guidance. This, says Lieven, was a true vision of *universal empire* in its purest form.

The diversity of peoples in an empire meant that they could never be just about "hard" power – armies, wars and coercion. The word "*imperator*" may have had military origins, but in reality cultural and ideological power were also essential. Emperors had to project not just their power but also their *legitimacy*, their *right* to rule. It mattered how these messages were received. To ensure their survival, emperors needed to create their own ideology, an ***imperial tradition***.

Lieven points out that all the great empires were grounded in either a universal religion or a "splendid civilization". The greatest of them, such as China or Rome, aspired to be "universal" empires, where their civilization was acknowledged as the only worthwhile one; therefore even kings outside their political orbit and not under their direct control were still expected to show them respect and accept their guidance.

The rise of nationalism in modern times was fundamentally incompatible with the diversity of empire. Nation states are based on a common identity, derived from a sense of ethnic, linguistic and historical and cultural commonality. This spelled doom for the great multi-ethnic empires like the Habsburg and Ottoman which both ended in or soon after 1918. Lieven says, "*the ethno-linguistic criteria that define most modern nations seldom meant much to either elites or masses in the pre-modern world*." Emperors took pride in the diversity of the peoples they ruled over. But this was doomed by nationalism.

3. *Power*

Empire was about the concentration of power: power over enormous territories and a huge and diverse population; power to command the massive resources these provided; power over the elite; and ultimately power over a formidable army. Empire is fundamentally about projecting great power both within and beyond the frontier. Nearly all empires were founded by military leaders. Yet all this power and responsibility rested ultimately on one person, one emperor.

The origin of the emperors' power was that they were hereditary monarchs. But the hereditary principle had an Achilles heel: the problem of succession. It could never guarantee a competent successor. Why then did it continue as a system for so long? The short answer is that it seemed to nearly everybody the only truly reliable safeguard against its worse opposite, popular anarchy. The long civil wars that ended the Roman Republic discredited republics so absolutely that they were rejected for nearly two thousand years. "Democracy" remained a dirty word and its reputation only began to recover from the later 18th century CE (with minor exceptions, such as the Venetian and Dutch Republics).

Empires were expected to last; *longevity* was part of the definition. To achieve this required more than military power. An empire had to acquire *legitimacy* and this could only be done by generating ideological and cultural power. Unless they established an enduring imperial tradition, empires could not fulfil their historic destiny. Lieven's choice of title, "*In the shadow of the gods*", is significant in this. Emperors were believed to be links to whatever version of "Heaven" existed at the time, from the ancient Chinese Sons of Heaven right up to Napoleon ordering the pope to officiate at his coronation in 1804. Emperors were "*Priest-Kings*", sacred beings. Their performance of the correct religious rituals was believed to be essential to upholding the cosmic order, just as their secular power was considered essential to the maintenance of the earthly order.

In modern times, nationalism largely did away with need for monarchies. Nations didn't need priests as leaders; nationalism itself in many ways filled the spiritual void. Yet there was a way in which monarchies could survive: by becoming purely symbolic figures and identifying themselves closely with the nation. Two of the last emperors to be created were King William of Prussia who became German emperor in 1871, and Queen Victoria who became Empress of India in 1877. Significantly both titles were conferred by popularly elected parliaments.

Being an emperor: the job description

What did emperors do? Lieven puts this question at the heart of his approach to empire. He reminds us that despite their vast powers, diverse roles and the intense demands placed upon them, emperors were still human beings.
He sees an emperor as having three main roles:

1. *Dynastic*

An emperor was the head of a royal family. The strength of this commitment varied with the emperor and with tradition in the empire. Habsburg emperors traditionally gave the dynasty high priority. By contrast, the Tamur and Ottoman empires put the interests of the emperor before those of the dynasty. This is shown by the Ottoman tradition that the Sultan's heirs should fight one another to the death for the succession; the victor was expected to kill his brothers. Similarly in the Roman Empire the dynastic tradition was relatively weak. This was because Augustus, who won the civil wars of the Republic to become Rome's first emperor, was keen to pretend that little or nothing had really changed. He kept many of the political forms of the Republic (like the Senate) and downplayed the trappings of emperorship. This had the effect of weakening the Roman imperial tradition and contributed to its demise.

2. *Sacred*

Emperors were sacred beings. This goes back to the deepest origins of kings and emperors during shamanic times. Lieven says that this helps explain why hereditary monarchy endured: "*In most pre-modern societies, political theory was a branch of theology*." Heaven or the gods made everything happen. From India's Buddhist emperors to the Muslim Caliphs, all emperors were believed to mediate between the human and the divine orders, including the world of the ancestors. Monarchs were agents of both orders and were essential to the preservation of each.

The period between 500 BCE and 700 CE saw the emergence of all of Eurasia's great religious and ethical "*cultural zones*": Buddhism, Hinduism, Confucianism, Christianity and Islam. Zoroastrianism was also significant under the Persian empire and influenced Christianity. All the great empires adopted one or the other of these. Thus, says Lieven, emperors were "*blessed by one version or another by Heaven*."

This was one of the great legacies of empire to the modern world: *the religions chosen by emperors defined the world's great cultural-religious regions*. The

Roman emperor Constantine's conversion made the west Christian. The Mauryan emperor Ashoka entrenched Buddhism as a world religion centred on South-East and Eastern Asia. The Chinese created a unique Buddhist-Confucian synthesis. In the 16th century the Safavid Shahs of Iran/Persia adopted the Shia variant of Islam, with huge consequences for today's Middle East.

As sacred beings, emperors had a sacred aura; the word "charisma" means "touched by the gods". This was important to their legitimacy, although it sometimes brought them into conflict with the official priesthood. Yet ironically emperors also seemed to feel the need to build huge monuments, to leave their mark on *this* world.

Their supernatural aura also makes it difficult to see the inner lives of emperors. Although, as members of the elite, their words and deeds are recorded in surviving sources, their deeper thoughts and feelings remain inscrutable. Emperors were advised that they could have no true friends. Favourites could provoke resentment within the elite. Though rarely alone, being an emperor was a lonely occupation.

This problem extended to who they should marry. European monarchs expected to marry other royals, but this limited the field and risked inbreeding; the enlarged "Habsburg jaw" of the 16th century Emperor Charles V was hardly surprising. They were famous for acquiring and enlarging their vast dynastic domains (spanning Spain, the Netherlands, Italy, Austria and Czechoslovakia) by carefully planned strategic marriages rather than military conquest. Marrying into the aristocratic elite could provoke jealousies. Therefore the early Tsars of Russia took to marrying wives from the lower gentry. The Chinese emperors and Ottoman sultans took additional wives in the harem and their sons were recognised as heirs; these children were sometimes "adopted", i.e. abducted, by official wives.

Nearly all emperors were men. One notable exception was Maria Theresa who inherited the Habsburg crown in 1740. Lieven describes the positive media comments when Jacinda Arden, New Zealand prime minister, had a baby while in office in 2018. He notes that Maria Theresa gave birth to sixteen children. Thirteen survived, ten into adulthood. Her reign was full of crisis and war. At a low point in the wars she said she would lucky if she had a town left in which she could give birth. She also survived smallpox.
Frederick the Great of Prussia exploited the doubts about whether a woman could successfully rule the Habsburg empire to attack and seized the valuable

province of Silesia. It was an act of cynical opportunism and naked aggression which plunged Europe and the Habsburg empire into crisis and a 20-year series of wars. Prussia was embarking on its long-term path of domination in Germany.
Maria Theresa never recovered Silesia.

Nonetheless she proved Frederick and the doubters wrong. She was a remarkable ruler. She never gave up fighting and held the empire together. Her skilful and courageous leadership steered the empire through years of crisis, bitter wars and complex diplomacy. Her reforms strengthened the state and helped ensure that the Habsburg empire remained a great power until 1918. Her daughter, Marie Antoinette, was less successful. She married King Louis XVI of France. In her letters, Maria Theresa urged her daughter be less frivolous and lazy, but this did not save her from the guillotine in the French Revolution.

It was easy enough for men to exclude women from the throne or the army or the bureaucracy. But empires were dynastic. At their heart was family life. It was harder to deny the rights of an emperor's wife or mother. If a child succeeded to the throne his mother had a strong natural claim to guide him. Wives and mothers inevitably had access and influence over an emperor, including the distribution of patronage. They could be displaced by a mistress; the most secure wives were Christians for whom divorce was not an option. In the Ottoman and Chinese empires an emperor's mother might have precedence over a wife, while mistresses of the harem had official status and their children potential legitimacy.

3. *Political*

An emperor was the chief political officer of the empire, The demands of political leadership were considerable. It was a gruelling role, requiring self-confidence, stamina, resolution and toughness. They had to make difficult decisions and remain calm in adversity. It also required emotional intelligence and a degree of humility, and an ability to recognise, inspire and manage competent and able subordinates. David Runciman says that self-knowledge was vital. Confucius agreed: "*He who conquers himself is the mightiest warrior*." There was a danger of arrogance and megalomania, in coming to believe in your own propaganda.

The memoirs of Louis XIV of France (reigned 1643 – 1715), an emperor in all but name, are a gold-mine of advice. He wrote them for his heir. Set high and ambitious goals, he advised, then focus your time and resources on achieving

them. The interests of the state must take precedence over your own pleasures or inclinations. Be fixed and resolved on your ambitions but flexible about how you achieve them. Circumstances constantly change and you must adapt accordingly. In foreign relations and wars, your tactics must be cautious and rational, but your strategic goal must be the status and glory of France. Weigh all available evidence before reaching a decision. Choosing able ministers is “the principal function of a monarch.” Encourage your advisers to give you honest advice; promote and reward the ones who tell you things you don’t want to hear. Don’t hesitate to appoint strong, ambitious and intelligent ones. It is essential to be as knowledgeable and well informed as possible; this requires hard work and having as many channels of information open as possible. But most important of all, monarchs must “learn to examine ourselves very strictly”: in other words, above all else, know yourself.

Monarchs are constantly bombarded by applicants for patronage, It is always tempting to say yes for an easy life and to win a reputation for being generous. But the state’s coffers are finite and there is never enough to satisfy all in search of favour. One of the monarch’s hardest tasks is to defend the treasury but in a graceful way to avoid offending the proud aristocrats who were always first in the queue for favours.

A few emperors however reigned as mere figureheads, e.g. the later Abbasid Caliphs, the Japanese emperors, and the British and Dutch monarchs of the 19th century. But most Emperors were expected to lead, to rule as well as reign. At a minimum this meant dealing with top appointments, foreign policy and military policy. In time of war, even the most sage-like Confucian emperor might be asked to set out the overall military strategy. In well-established dynasties much could be safely delegated to a chief minister, though even if they were highly competent there could be whispered criticism. This varied due to the emperor’s personality, the dynastic tradition, and being able to find a suitably able person. The worst case was the useless emperor who nonetheless insisted on playing the autocrat.

Unlike modern political leaders and chief executives, most empires lacked a large, complex government bureaucracy to support them. The Chinese empire led the way in developing these, then the Roman, then the16th century Spanish. The Caliphs, early Ottomans and Mughal empires had nothing to match them.

A powerful army was a basic essential, to ward off foreign enemies; but they could also pose an internal threat. Rome was the worst in this respect. The

army constantly interfered in politics; there were coups and civil wars which in the end wrecked the empire. The basic reason was that the dynastic principle was weak. It was strongest in medieval and early modern empires where emperors and the aristocratic elite shared the same warrior values and were closely allied. Emperors were expected to honour their military heritage. The problem was that pursing military adventures could result in either exalting an emperor's glory and legitimacy or bring complete disaster. Some emperors found in the military camp a freedom and camaraderie lacking in the palace and royal court. Successful military experience could help the emperor learn how to manage crises and make rapid political decisions.

The emperor had to play his role in "*the theatre of empire*": "*courtiers were both spectators and participants in a splendid and choreographed ballet, with the monarchs at its centre*." At formal and informal occasions the emperor was expected to "*radiate majesty, awe and benevolence*." It was all very hierarchical: precedence was all.

Some empires however, notably the Chinese and Ottoman, were much less public in how the emperors conducted themselves. They would disappear into the harem for weeks. In public they were immobile, statue-like and formal, more like a god than a person. Buckingham Palace is designed for show. The Japanese emperor lived in modest buildings with a garden hidden by trees.

As mentioned above, one tricky balance emperors had to strike was extracting a share of surplus agricultural produce from the agrarian masses of farmers and farm workers. Empire depended on this basic fact. Hence the importance of developing a sense of legitimacy, a sustainable relationship between ruler and ruled grounded in justice. Excessive tax demands in time of crisis or a poor harvest could endanger this delicate balance and provoke rebellion. The surplus was actually extracted by the elite through whom the emperor governed. They had to be willing to hand over a share to the emperor. The people often felt that even if he was a distant and remote figure, a good emperor would protect them from the excessive demands of the elite which they experienced on a daily basis. It was a delicate balancing act.

These relationships were complex and based on mutual self-interest and calculation. Hence the importance of promoting the legitimacy of an empire and of the emperor maintaining a close partnership with his landowning elite. Although most empires were founded by military leaders, over time religious and cultural values came to the fore. The Confucian and Buddhist emperors of Asia were more sages than warriors. In the long term, the survival of an

empire depended not just on the size of its army, but also on creating a strong idea of empire, an enduring imperial cultural tradition.

The lessons of empire

The above discussion of empire and emperors raises timeless questions of power and government, and in a sense power is fundamentally the theme of these sessions. However empire itself was not timeless. Today, modern democratic nation-states have become the political norm. Churchill's witty defence of democracy remains the standard one: he said that it is the worst form of government, except for all the alternatives. There seems to be little room in modern democracies for the hereditary principle, sacred leadership or the diversity that characterised empire.

Yet modern democracy has its shortcomings too. It doesn't guarantee good government. Critics point to problems such as crowd-pleasing leadership leading to short-termism, extreme partisanship and intolerance of diversity, public disillusion and voter apathy. The debate about the best form of government is not over, and may never be.

Next session, we'll discuss how the first empires began, developed, rose and fell.

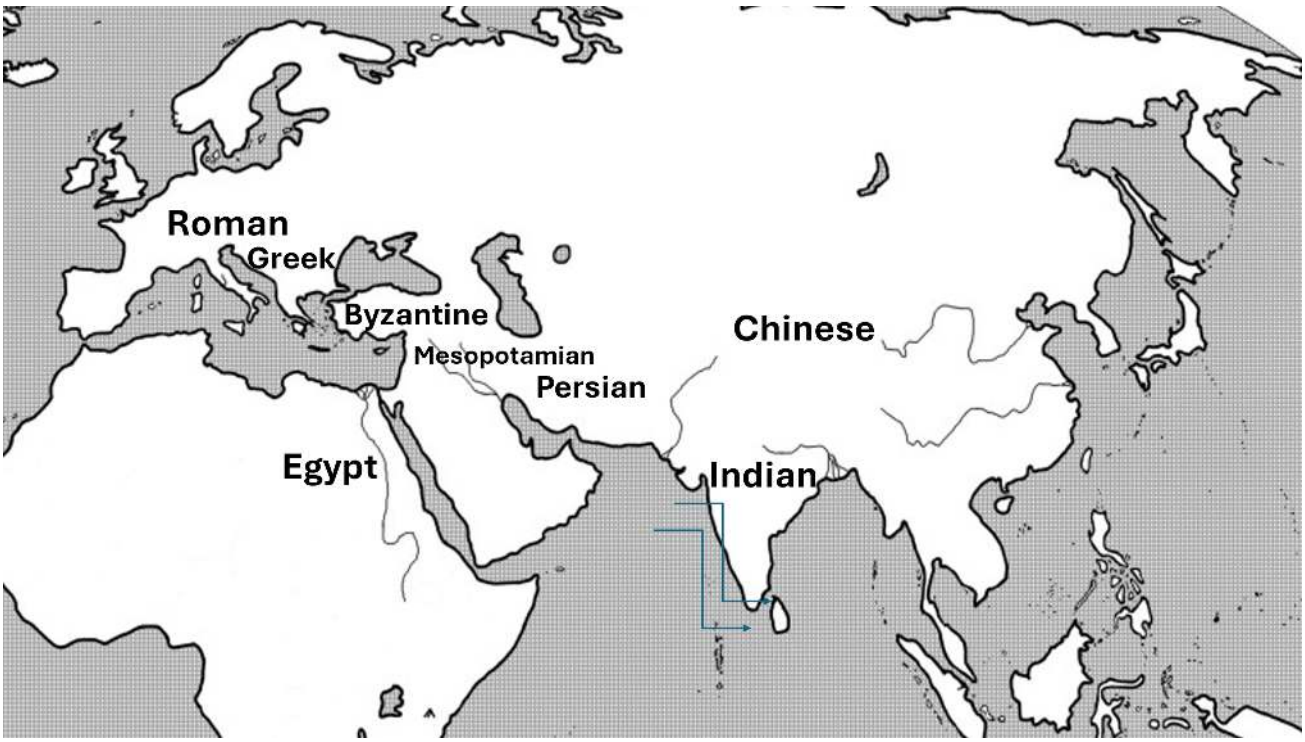
SESSION THREE

EMPIRE – ORIGINS: AKKADIANS TO GREEKS

The next three sessions will focus on the origins and development of the earliest Eurasian empires, including:

- Akkadian 2334 – 2154 BCE
- Egypt [Old Kingdom] 2686 – 2181 BCE
- Assyrian 2025 – 609 BCE
- Persian [Achaemenid] 550 – 330 BCE
- Alexander the Great [Greek/Macedonian] 336 – 323 BCE
- Indian [Mauryan] 322 – 185 BCE
- Roman 27 BCE – 476 CE
- Byzantine [Eastern Roman] 330 BCE – 1453 CE
- Chinese [early dynasties, Xia, Shang, Zhou, Qin] 2070 – 206 BCE
- Chinese [Han dynasty] 206 BCE – 220 CE
- Indian [Gupta dynasty] 320 – 550 CE

The map below is a reminder of these empire's general geographical locations.



In this session we will discuss how empire began, including the ***Akkadians, Egypt, Assyrians, Persians*** and the ***Greeks***.

AKKADIAN 2334 – 2154 BCE

The earliest recorded empire is the ***Akkadian*** *in Mesopotamia, and its ruler* ***Sargon the Great*** *the earliest emperor.*

The land of Mesopotamia (Greek for "between the rivers", the Tigris and Euphrates) and the region of Sumer in particular can claim many historical firsts. The earliest recorded agricultural communities (*Jericho*); the earliest cities (*Uruk, Ur, Eridu*); the earliest written language (*cuneiform*); the earliest surviving work of literature (*the Epic of Gilgamesh*); and, putting them all together, the earliest known *civilisation*.

However the two rivers run parallel for over a thousand miles, dividing it into a patchwork of valleys and oases, making it difficult for one power to control. The Sumerians, based on Ur, dominated the south, the Babylonians the centre and the Assyrians the north. The first ruler to succeed in unifying the Mesopotamian city-states was ***Sargon the Great***, of the Akkadians around 2300 BCE. Crucially, Sargon was the earliest recorded ruler of a state consisting of a number of diverse peoples. He is therefore reckoned to be ***history's earliest emperor*** and ruler of its ***first empire.***

Sargon's early life is shrouded in myth. One story is that he was the son of a priestess who was placed in a basket and out in a river, as in the later Biblical story of Moses. He seems to have held a high position in the court of the king of Sumer, from whom he seized power. He then embarked on bringing the other states of Mesopotamia under his control. He made Akkadian the language of government and appointed family members as governors of the regions. He established trade routes and forged diplomatic alliances. Sargon founded the city of Akkad and encouraged Akkadian art such as bronze stature and reliefs. Akkadia grew stable and wealthy. His grandson expanded the empire further, but it fell due to internal strife and external invaders in 2154 BCE.

Although there was never a "Mesopotamian empire", Jonathan Holslag says there was a "Mesopotamian imperial culture" which Sargon did much to encourage. Monarchy was assumed to be the natural form of government. A Mesopotamian proverb said. "*A people without a king is like a flock without a shepherd, a crowd without a supervisor, water without a pipe, a house without a master, a wife without a husband*." The Babylonian ruler Hammurabi produced the earliest known law-code (c.1750 BCE) which was adopted by

the later Assyrian empire (see below), as was the Sumerian's *Epic of Gilgamesh*. Thus Mesopotamia, the first civilization, was also the seedbed of the idea of empire.
Despite its antiquity, a surprising amount is known about Mesopotamian civilisation. The reason for this is their use of cuneiform writing on clay tablets. Hundreds of thousands have been found by archaeologists. The British Museum had 130,000; experts come from everywhere to study them. Many are fragmentary. A 19th century apprentice printer called George Smith who worked near the museum was the first to decipher them. Cuneiform was written with a quarter-cylinder piece of reed, like a chopstick. Clay was mixed with water so the bits of debris, grass and twigs etc, floated off. The clay was then pounded with the feet to make it malleable and uniform and shaped into a tablet (roughly mobile phone-size). . The letters were made by pressing horizontal or vertical marks into the wet clay. The tablet could then be baked to preserve it or recycled by mixing it with fresh clay and water. Baked tablets are pretty tough and last in a way that bamboo or paper do not.

The oldest ones found are accounts, records of quantities of things like beer. These were vital to big empires; it was the birth of bureaucracy. The first writing systems recorded images of things. True writing began when the symbol came to stand for how the word for the thing *sounded*. Then literature was possible, like the *Epic of Gilgamesh*. From around 2000 BCE or earlier, stories of Gilgamesh were told across and beyond Mesopotamia, possibly based on legends about a real king of Uruk of that name. They were recorded on Sumerian clay tablets and surviving fragments were assembled to make up the current text of the "epic", the world's oldest work of literature. Its theme is the transformation of Gilgamesh from pride and arrogance to nobility through a journey of self-discovery and acceptance. He is the first literary hero.

In the *Epic,* Gilgamesh is a powerful but arrogant king. The gods send the wild man Enkidu to fight him, but they become friends. The set off seeking glory and adventure, encountering the monstrous Humbaba, guardian of the sacred cedar trees which they cut down, angering the gods. The love goddess *Ishtart* proposes marriage to Gilgamesh, but he spurns her. Furious, she sends the *Bull of Heaven,* who Enkidu kills; the gods then kill him. Gilgamesh seeks out Utnapishtim, the only mortal who the gods made immortal for saving humanity from a great flood by building a boat. Immortality is what Gilgamesh craves above all. He finds the plant of youth but serpent steals it from him. But after further trials, he meets Siduri, a tavern-keeper: she tells him:

"Gilgamesh, where do you roam?
You will not find the eternal life that you seek.
When the gods created mankind,
they appointed death for mankind,
kept eternal life in their own hands.
So, Gilgamesh, let your stomach be full,
day and night enjoy yourself in every way,
every day arrange for pleasures.
Day and night, dance and play,
wear fresh clothes.
Keep your head washed, bathe in water,
appreciate the child who holds your hand,
let your wife enjoy herself in your lap."

Having finally accepting his mortality, he is able to return home to Uruk and fulfil his destiny as a man and king. These stories profoundly influenced other cultures, including Greek literature and mythology and the Old Testament; all thanks to the humble Mesopotamian clay tablet. As Neil MacGregor says, writing extends human capacities. It enables us to do more complicated mathematical calculations and philosophical reasoning. But even more, literature "*allows us not just to explore our own thoughts, but to inhabit the thought worlds of others*." This had profound implications for humanity. It means we can share the hopes and fears, friendships and trials, of a character from the earliest civilisation. Writing also strengthened the control of emperors over their people. Their armies might be the basis of their power, but bureaucracies consolidated their rule and imperial propaganda created the imperial traditions which made it legitimate.

EGYPT [OLD KINGDOM] 2686 – 2181 BCE

To some historians Egypt was history's first great and enduring empire. But others ask: was it truly an empire at all?

Egyptian civilisation has achieved huge popularity both academically and in popular culture. Archaeology often gives us frankly disappointing ruins which rely on our imaginations to revive. But not Egypt. The dry climate helped its archaeological treasures to survive in abundance: impressive monuments, pyramids, cities, statues and inscriptions; dramatic hidden tombs stuffed with treasures and mummies. All was designed to convey a sense of "*order, hierarchy, majesty and splendour*", both in the cosmic and worldly realms, and to present and future generations. This would continue as a theme throughout the entire history of empire.

And illuminating Egyptian archaeology is the wealth of hieroglyphics, mostly in temples, tombs and on monuments, vividly recording details of many aspects of ancient Egyptian life and history, from the gods to the pharaohs to the humble labourers shifting and shaping stones for the pyramids. They are hard to read; some signify sounds, others are ideographic signs representing concepts*.

*Only priests read hieroglyphics. Other ancient Egyptians wrote in easier, everyday languages, called *hieratic* and *demotic*. The *Rosetta stone* (discovered 1799) had three versions of the same text, a message from priests to the pharaoh in hieroglyphics, demotic and Greek and enabled a French linguist, Jean Champollion, to begin to decipher them. Pronunciation remains speculative.

However other historians spoil the party by doubting whether Egypt should be classified as an *empire*. Rather, they argue, it was a large, cohesive kingdom, given a strong natural geopolitical focus by its reliance on the annual flooding of the valley of the River Nile to enrich their agricultural production. As we've seen, they called their rulers *pharaohs*, meaning "great house" or palace; part of their sacred role was to control the Nile's annual rise and fall. Intermarriage was a problem; some married their sisters or daughters. Periodically Egypt broke up into northern and southern states ("Lower" and "Upper"); at other times it expanded as their rulers conquered new territory northwards and eastwards into the Middle East. But these expansions were neither vast nor long-lasting. The pull of the Nile valley was too great. Conversely, it was considered a great prize for conquerors. Thus Egypt was always one among several, never the dominant, state.

What Egypt did have was an imperial tradition. Its rulers claimed to be providers of *Maat*, the divine force of harmony, regulating the stars, the floods and the seasons, and also obedience, order, justice and morality amongst the people. Without the pharaoh there would be *Isfet*, chaos. Hierarchy was the key; the pharaoh is portrayed in stone reliefs high above his people and other kings, of Babylonians, Hittites, Assyrians and others. Lieven concludes that if we do decide to classify Egypt as an empire, then it's a highly unusual one, having a very big and cohesive core and a small, fluctuating periphery.

In 1817 Shelley wrote a famous poem, the last five lines of which are quoted as the ultimate verdict on the vanity of emperors and the transience of empire:

Ozymandias
I met a traveller from an antique land,

Who said—"Two vast and trunkless legs of stone
Stand in the desert. . . . Near them, on the sand,
Half sunk a shattered visage lies, whose frown,
And wrinkled lip, and sneer of cold command,
Tell that its sculptor well those passions read
Which yet survive, stamped on these lifeless things,
The hand that mocked them, and the heart that fed;
And on the pedestal, these words appear:
"My name is Ozymandias, King of Kings;
Look on my Works, ye Mighty, and despair!"
Nothing beside remains. Round the decay
Of that colossal Wreck, boundless and bare*.*

Ozymandias is in fact a Greek translation of the name of an Egyptian king, *Rameses II*, king of Egypt. Known as *Ramses the Great* (1279-1213 BCE) his reign was the second longest in Egyptian history. He fought many wars and built extensively including many colossal statues of him found all over Egypt. *"Look on my Works, ye Mighty, and despair!" Nothing beside remains.* Whether we call Egypt an empire or not, it inspired what is surely the last word on the might of empires.

ASSYRIAN 2025 – 609 BCE

The Assyrian empire was the first sizable and enduring empire.

The Assyrian, another empire of the Mesopotamian imperial culture, has a reputation for ruthless savagery, ranging from killing and mutilating captives to deporting whole peoples from their homelands. However historians consider that it was as much their openness about this rather than being necessarily more ferocious than other empires; most empires indulged in this when they thought it necessary.

However in their propaganda, the Assyrians boasted about torturing and executing those who opposed their rule. They terrorised their enemies by offering a clear choice: pay tribute, or face death, mutilation and burning. Tribute fed further conquest, further tribute. Even rulers who paid had to send their children as hostages. Holslag describes it as "*predatory imperialism*". Based on a population of only a few million, their army reached 300,000.

How do we explain their emphasis on savagery? Lieven says that underlying it was a hellish vision of creation: "*A dark blend of religious and militaristic*

ideology placed the king in the centre of the universe and presented Assyria as a land enclosed by a ring of evil."

Holslag develops this vision: "*From the annals of the Assyrian kings – punched into tablets of clay and carved into stone – a clear imperial order emerges. At the centre resided Ashur. He was the chief god who instructed the king. The king lived in a palace surrounded by paradisiacal gardens, which it turn was surrounded by a city with immense walls and gates and inhabited by craftsmen, around which lay farmland, idealised in sculpture as a lush habitat of bountiful date trees, fecund grain fields, and rivers full of fish. This was the "middle kingdom", the land chosen by the gods. The lands beyond – the periphery – were thought to have been abandoned by the gods and left as a 'failed cosmos'. This failed cosmos proved a restless place*." It demanded ferocity to subdue it.

The rise and expansion of Assyria was driven by a succession of able, energetic emperors like *Sennacherib* (705 – 681 BCE), conqueror of Egypt and founder of a new capital, Nineveh. They innovated in military technology, using camels and cavalry as an alternative to chariots, improved steel-making and perfected siege warfare with battering rams and mobile towers.

His grandson, *Ashurbanipal* (669 – 631 BCE), personified the contradictions of Assyria, and perhaps of all empires. While he enjoyed lion-hunting, he chose to be portrayed with a writing stylus tucked into his belt:

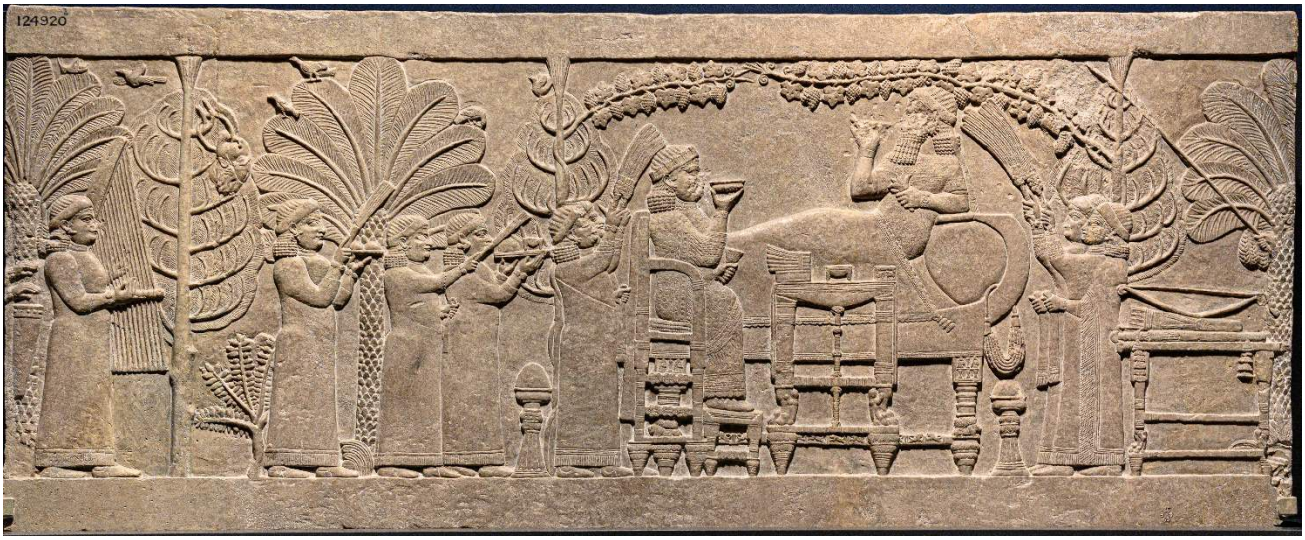
He was famed as a patron of the arts and culture. His new library contained over 100,000 texts covering ancient Mesopotamian language, religion, literature and science; 30,000 survived as clay tablets. He boasted of his prowess in astrology, mathematics and literature. Astrology was considered particularly useful for an ancient ruler; knowing the future was a big help when counsellors offered you conflicting advice. Yet Ashurbanipal too was steeped in the Assyrian darkness.

The Assyrians were famed for the artistry of their realistic carved stone reliefs. One of these, now in the British Museum, portrays Ashurbanipal and his queen in the garden of his palace at Nineveh, "*reposing in a garden of vines, palm trees and birds,"* says Holslag. Called "*Garden Scene*", this civilized scene shows them being waited on with "*birds, a locust in the trees, two women fanning the queen with fly-whisks, two more each bring a dish to the enthroned queen and reclining king, who feast in the arbour amid vines, conifers, and palms. The hands of a woman drummer and a harpist can be seen amid the palms and conifers. There is a table holding his sword, bow and quiver. The furniture is very elaborate."**

**https://www.britishmuseum.org/collection/object/W_1856-0909-53*

But if you look carefully at the trees which frame this panel on the left and right, you can see that hanging from them are two "*grisly trophies of victory",*

believed to be the head of Teumman, king of Elam, and his hand, still clutching his wand of royal power. As Holslag puts it, Ashurbanipal and his queen are "*reposing*" in their garden with "*one of his rivals dangling from a branch*."



*tree 1^*
*tree 2^*

After the death of Ashurbanipal the power of Assyria faltered and it succumbed to our next empire, the Persian. They had a very different vision of empire.

PERSIAN [ACHAEMENID] 550 – 330 BCE

The Persian empire was the first truly great and enduring empire.

The Persians were originally nomads from the Caucasus/Anatolia. They combined the nomadic skills of their ancestral warriors with the sedentary civilization of those they conquered. The Achaemenid empire was huge and diverse, spanning parts of Africa, Asia and Europe. It was known for innovation and tolerance in the way it was governed. It was founded by Cyrus II "the Great", c.560 – 530 BCE. He was a bold, inspirational leader, a skilled military strategist and shrewd politician. His successor Darius I, 522 – 486 BCE (his long reign helped) was a consolidator, creating "*the political, ideological, military and administrative framework which sustained the empire for the rest of its existence*."

An important pillar of the empire was the Zoroastrian religion and its supreme god *Ahura Mazda*. It defined the beginning and the end of the world in terms of a cosmic struggle between good and evil and the fate of good and wicked people after death. The emperor was its high priest and mediator between god and people. Founded by the enigmatic Zoroaster (also known as Zarathustra)

who may have lived on the Asian steppes around 1,000 BCE, Zoroastrian beliefs were only written down much later. In their emphasis on good and evil and a linear, not cyclical, view of time leading to an end of days, they anticipated and influenced all the major monotheistic religions. Tom Holland says Zoroaster was the first of the great prophets in the mould of Moses or Muhammad, and his teachings "*will sound very familiar to anyone brought up as a Jew, a Christian or a Muslim*."

Yet alongside it, the gods of other religions were tolerated, both Mithras, the god of the Medes (the original kingdom alongside the Persian) and of the peoples they conquered. Similarly, those who resisted Persian rule were repressed, but the tribute they demanded were kept to moderate levels. Official propaganda stressed the peace and harmony empire provided. Local elites were conciliated and the emperor ruled through them. This carried risk; it meant the emperor was a distant figure and the people's allegiance was probably not deeply rooted; and any local rebellion would have resources behind it.

But in practice it achieved stability, reinforced by sharing the spoils of empire and the top jobs with the Persian aristocracy, including the *satraps* or provincial governors. The theatre of empire was a sumptuous and highly-choreographed costume drama. The Emperor sat on a raised dais and walked on special carpets. His palace doubled up as a temple. Queens and princesses participated in the formalities. The royal concubines were kept half-confined. In these ways, the Persians created a template for empire which would be imitated throughout history.

What was the Persians' secret? Holslag says that "*the key to maintaining so vast a realm was efficiency: maximising the gains and limiting the sacrifices*." Cyrus said, *"If I make my friends rich, I shall have treasure in them, and at the same time more trusty watchers*." They were innovative. Cyrus diverted the course of the River Euphrates so his soldiers could march into a city along the river bed. He deployed camels against cavalry because the smell would frighten the horses. They built roads and created messenger networks reaching to Pakistan. People said there was "*nothing in the world that travels faster than these Persian couriers*." They boosted trade: they paid rulers of mountainous and desert regions to keep trade routes open; Darius built a canal from the Nile to the Red sea.

There were weaknesses. The succession was not regulated and could be bloody; court conspiracies were common. The empire nearly collapsed after

Cyrus until Darius restored its authority. After Darius a decline set in, culminating in the failure of the invasion of Greece by Xerxes I in 480 BCE.

Then, in the 430's BCE the mighty Persian empire was destroyed by the Greek military machine built up by Philip II of Macedon led by the precocious military genius Alexander the Great. The emperor Darius III complacently allowed the Greeks to cross the Hellespont and gain a bridgehead in Asia. By the time he rallied Persia's considerable reserves it was too late. He was captured and killed. Alexander destroyed the city of Persepolis; also dealing a severe blow to the future of Zoroastrianism; the imperial palace was also a temple.

The Greeks didn't just destroy the Persian empire. Greek propaganda also trashed its reputation. Greek writers portrayed the last Achaemenid Darius III as a coward – in fact he was perfectly competent, just unlucky to be the one who had to face the genius of Alexander the Great. More fundamentally, the Greeks built up their image as brave, freedom-loving, manly, athletic and virtuous by portraying the Persians as the opposite: despotic, cruel, enfeebled by their love of luxury and effete. This became the template for a superior "west" deservedly dominating the inferior "east". This narrative has no basis in history; it was a confection invented to justify West European oceanic empires after 1600, a theme we'll explore in future sessions.

The Zoroastrian religion had risen with the Persian emperors; it fell with them too. It flourished under the Achaemenids, revived under the Sasanians (see below) but when that fell to the Islamic Caliphate, Zoroastrianism lost their state protection. Today it exists across the Middle East only in small minority communities. But Neil MacGregor says "*the politics of the Middle East remain haunted and in some measure shaped by the belief in an eventual apocalypse and the triumph of justice. And when politicians in Tehran talk of the Great Satan, and politicians in Washington denounce the Empire of Evil, one is tempted to point out that "Thus Spake Zarathustra"*.*

**A History of the World in 100 Objects*, 2010. In 1893 the influential modern philosopher Friedrich Nietzsche used this title for his book to frame his critique of Christianity. In 1896 Richard Strauss composed a musical tone poem based on it. In 1968 director Stanley Kubrick used it for his sci fi movie *2001: A Space Odyssey*. Zoroaster haunts on.

Persian afterlife

The reality of the Persians is that although their empire crashed and burned in the 430's BCE, that wasn't the end. Persia lived on in two ways. First, through

their through unusually powerful *imperial tradition*; second, through an equally strong *cultural tradition* in art, architecture and literature, particularly poetry. Each of these long outlived the political life of the original Persian empire; together, they gave Persian identity an astonishing afterlife. Over many centuries new incarnations of the Persian empire kept re-emerging, centred on modern Iran, while new non-Persian empires emerged heavily infused by Persian cultural influence. These empires, either Persian or "*Persianate*", played a significant role throughout the history of empire. To summarise:

Persian empires:

- ✓ *Achaemenid* empire; the first and biggest
- ✓ *Parthian* empire (274 BCE – 224 CE) mixed Persian/central Asian; fought Rome
- ✓ *Sasanian* Empire (224 BCE-651 CE) revived Achaemenid practices; fought the Byzantines
- ✓ *Safavid*, *Qajar* and *Pahlavi* Empires (1536 – 1979) transitioned to modern Iran

Non-Persian but "*Persianate*" empires:

- ✗ *Seljuk empire* (1037-1194); Turkic empire, but adopted Persian bureaucracy, patronised Persian literature and helped spread Persian culture across the Islamic world.
- ✗ *Timurid empire* (1370–1467); Turco-Mongol empire founded by powerful warlord Timur ("Tamerlane"); under his rule, Persian culture flourished.
- ✗ *Mughal empire* (1526 – 1857) Indian empire founded by a descendant of Timur, Babur; his dynasty adopted Persian as the language of the imperial court and it was deeply influenced by Persian culture.
- ✗ *Ottoman empire* (1299 – 1922); founded by a Turkish Anatolian, Osman; the empire was heavily influenced by Persian methods of administration, literature and art, especially early on.

Alexander the Great shows the process of "*Persianisation*". Even as he conquered and destroyed the Persian empire, he was captivated by its culture. Much to the disgust of his Greek army, he adopted Persian manners, enlisted Persian soldiers into his army and surrounded himself with Persian nobles. He was its first captive. *The Arab Caliphates* were next. Having very rapidly conquered Asia, the Middle East and North Africa in the name of Islam, they urgently needed to consolidate their rule. They turned naturally to Persia for their models of bureaucracy and empire. This caused tension with devout Muslim clerics. The *Mongols* and the *Indian Mauryan emperors* followed a

similar path. Both were conquerors in need of an infrastructure of empire; both adopted Persian imperial and cultural traditions.

As well as an imperial tradition, Persia also provided new empires with a ready-made artistic and literary culture. Literary critics rate Persian literature as world class and it gained a strong hold over non-Persian peoples in the wider Middle East, up to the present day. Persian classics were avidly read in royal courts across Asia: the *Rubaiyat of Omar Khayyam,* the poetry of Rumi, the *Conference of the Birds,* the *One Thousand and One Nights*" folk stories, and Ferdowsi's semi-mythical historical verse epic *Shanameh* (Book of Kings).

The greatest Persian poet was *Rumi* – his name means "Roman" because he lived in a formerly Byzantine/Eastern Roman province conquered by the Turks – was a Sufi mystic and scholar and is still much quoted today:

"Sit, be still, and listen."
"Do not feel lonely, the entire universe is inside you."
"You are not a drop in the ocean, you are the entire ocean in a drop."
"Lovers don't finally meet somewhere. They're in each other all along."
"Raise your words, not voice. It is rain that grows flowers, not thunder."

Persia's imperial and cultural traditions combined to assert Persian identity from the demise of Cyrus the Great's empire to the present day. The current Iranian political regime derives from the 1979 Islamic Revolution which overthrew the last Shah and created an Islamic Republic.

Yet, always remarked on by visitors but seldom noticed by the world press, there is a quieter but persistent cultural undercurrent, which remains defiantly Persian. One recent historian (Michael Axworthy *Iran,* 2008) calls it "*an empire of the mind*".* The Persian language still endures. Today the number of Arabic-speakers in the Middle East and north Africa is 400 million. The current population of Iraq is 46.7 million. The number of Persian speakers in the Middle East and central Asia, as a first or second language, is 110 million. Whatever secret Persian culture has, its longevity is phenomenal.

ALEXANDER THE GREAT OF MACEDON (GREEK) 336 – 323 BCE
Was there ever a Greek empire?

Not by name, perhaps because the Greeks spent too much time fighting one another. The restlessness of the Greek city states had a geopolitical cause: a shortage of farmland. This drove them across the seas to trade, migrate, seek

colonies and fight each other. Pericles, the Athenian leader, said, "*Our adventurous spirit has forced an entry into every sea and into every land*." On occasions the city states united into loose confederations, notably the Delian League, dominated by Athens and which ended in the Peloponnesian War (431-404 BCE) with Sparta.

The Greeks best-known venture into empire were the conquests of the Macedon Alexander the Great at the expense of the Persians. created his Greek empire by destroying the Persian one, in the 330's and 320's BCE. Before his untimely death in 323 BCE aged 32, Alexander conquered two million square miles of territory, extending beyond Greece from Egypt to India. It is the greatest single-handed military achievement in history, making him arguably its greatest military commander, only rivalled by Genghis Khan.

However Alexander's "empire" was so short lived (at most 15 years) that it never acquired a name. It dissolved with his early death. He refused to name a successor (when asked which of his generals should take command, he casually replied "*the strongest*". He also neglected to consolidate his control over the territories he conquered. He made no attempt to win over the people. No surprise that his empire died with him.
Yet what followed was a second, unexpected flowering of Greek learning following Alexander's death; historians call it Greece's "Hellenic period" to distinguish it from classical or ancient Greece. In the territories they had conquered, Alexander's generals founded a string of Greek city states which they ruled as kings in their own right (one of these generals, Ptolemy, founded an Egyptian dynasty which lasted right up to Egypt's last pharaoh: she was called Cleopatra). These kingdoms flourished for three centuries as islands of Greek culture and learning in an Asian ocean.

Greek cultural influence in Asia proved long-lasting. Statues and buildings built by later Indian emperors show Greek artistic motifs; intriguingly, this includes some of the gigantic statues of Buddha. This cultural influence included the Greek language which became a *lingua franca**, a common language of culture and learning, used across the region by speakers of many native languages.

This had one momentous consequence. The first written accounts of the life and teachings of Jesus, the original Christian gospels, were written in Greek. Had they not been, historians say that Christianity may not have spread beyond the borders of Judea. But written in Greek, copies spread rapidly across the wider Eurasian world. Christianity took off. So no Alexander the

Great, no Christianity as a world religion, and no European Christendom. Alexander's empire may have been short-lived, but the Greeks' "*empire of the mind*" had lasting importance.

*The term *lingua franca* meaning a widely shared language originated in the later Middle Ages with traders and diplomats in the Mediterranean. They used a language based on Italian but mixed in words from Spanish, Greek, Arabic, Turkish and the Slavic languages. Some said it was just bad Italian.

Biblical geopolitics

Jonathan Holslag makes the point that the "*perpetual struggle"* between the earliest kingdoms and empires "*forms the historical background of the Old Testament".* Obviously the Bible *"venerates the Israelites as a nation chosen by God."* Nonetheless, Holslag considers that*, "no work offers a better picture of the power politics of the region. As an historical account it is an astounding story of wars, shifting alliances, and the permanent threat of great powers like Assyria."*

In the *Book of Judges* we find Israel in chaos, divided by civil wars. But in the *Book of Kings* we see how, after 1043 BCE, the powerful kings Saul, David and Solomon, unify the country and defend it ruthlessly: "*strike all the men with the edge of the sword and take the women and children and animals as booty. The Lord God will deliver them over to you, throwing them into great confusion until they are destroyed."* As Holslag says, historical sources "*confirm the image from the Old Testament of warfare that the divinely ordained use of force – meaning holy war – was crucial for warding off threats and preserving a state's prosperity*."

On a more positive note, in the later *Books of Ezra* and *Isaiah* we encounter the Persian emperor Cyrus. After his conquest of Babylon in 539 BCE, in a good example of Persia's tolerant religious policy, he ordered the release of Jewish captives held by the Babylonians, the return of their holy golden vessels and the rebuilding of their temple in Jerusalem. Earlier the Assyrians had also taken Israelites captive. But curiously there is no conclusive independent evidence to verify the famous Old Testament story of their captivity in Egypt.

Conclusion

Alexander the Great's body was placed in a gold, body-shaped coffin filled with honey. In 322 BCE it was taken by Ptolemy to Alexandria, a city in Egypt founded by Alexander, and later a leading centre of Hellenic (Greek) learning.

His body was entombed there but eventually knowledge of its whereabouts was lost.
Many historians rightly see Alexander as a charismatic leader.

The original meaning of charisma was “touched by the gods.” But emperors didn’t need charisma. They were born and lived “in the shadow of the gods”. They were already sacred beings. Charisma was for mere mortals. Does our craving today for charismatic political leaders hark back to the divinity of emperors?

Next session we’ll discuss how empire developed, in India, China and the west.

SESSION FIVE

Recap: the story so far

Empire arose in the three earliest centres of civilization, Mesopotamia, the North Chine Plain and the North India Plain (some would mention a fourth, Egypt).

Mesopotamia created the template, culminating in the first great empire, **Persia** and its powerful imperial tradition.

China too created a strong imperial ideology, based on the Mandate of Heaven, Confucianism and the Confucian bureaucracy.

In ***India*** the first two empires did not establish a powerful imperial legacy, but rather one of spiritual discipline by promoting Hinduism and Buddhism.

In the west, two empires arose, ***Greece*** with Alexander the Great, and ***Rome***, on the river Tiber in Italy, which grew to a city state, kingdom, republic then empire.

At the ***beginning of the first millennium CE***, the Roman empire in the west and the Han dynasty of China in the east presented an interesting contrast; they followed very different trajectories. In this session we'll consider how this shaped the future history of empire and the world.

HAN CHINA AND THE LATER ROMAN EMPIRE

- Roman empire: western 27 BCE – 476 CE; eastern/Byzantine) 330 BCE – 1453 CE
- Chinese Han dynasty: 206 BCE – 220 CE

THE LATER ROMAN EMPIRE: DECLINE AND FALL

Tensions

We left the Romans last session asking whether they had the capacity to deal effectively with their external threats. The answer is no. The reason is that they failed to overcome the fundamental contradictions experienced by all empires.

Holslag explains what these were. "*At its heart, empire was about advancing the privileges of a small capital area over those of a large surrounding hinterland, and about promoting the interests of a small rich elite over those of the large numbers of poor and needy*." Thus the million or so inhabitants of the city of Rome, enjoyed security, while those living on the frontiers faced constant threat. There was no *Pax Romanus* for them. The landowning elite enjoyed immense wealth and privilege. The gulf between rich and poor grew ever wider. These contradictions, geographical and social, generated tensions which the imperial authorities struggled to manage. Their failure can be blamed on a deterioration in the quality of political decision-making.

This had several causes. Long reigns are good for empires: they promote stability. But in Rome it was the opposite. This was because the army was drawn ever deeper into politics and frequently decided the succession. As the average reign of an emperor grew shorter (averaging six years by 249 CE) their quality declined. Struggling to govern a vast empire, emperors resorted to various strategies. They tried to make themselves more autocratic, making people lie prostrate before them like Persian emperors, but this also isolated them. They embarked on further conquests to increase their reputation and popularity but this resulted in military overstretch. They tried dividing the empire into two, even three smaller units, each with a new capital city. But this discouraged coordinated policies and encouraged succession disputes coups.

At a lower level, the rich governing elite grew increasingly isolated and failed to provide good civic leadership. To ward off discontent and popular rebellion among the poor, the authorities doled out grain and funded popular entertainment
The emperor Constantine (r.306 – 337 CE) tried bolder remedies. Having himself come to power after a civil war, he felt that Rome's multitude of pagan gods did little to help strengthen the empire. He therefore turned to Christianity, which he thought had more potential to unite the people behind the emperor. He also divided the empire, this time permanently, the west ruled from Rome and the east from a new city he founded on the site of an old town named *Byzantium*. This was *Constantinople*. It was a fateful decision. The western empire would fall, but the east would survive. By founding Constantinople, Constantine gave the empire a further thousand years of life.

Fall in the west
Although the east faced the greater military threat, notably from the Parthian ("*Persianate*") empire, it was the west that faced the more intractable problem (discussed last session) of Gibbon's "barbarian invasions", Eurasia's migration crisis or **"***Volkerwanderung***".**

Rome's response to the migrant peoples was to try tried to co-opt them, making them mercenaries in the pay and service of Rome. But this failed spectacularly. The migrants took the money, took the lands they were supposed to be defending, and set up their own "barbarian" kingdoms. They even had the temerity (or good sense) to imitate Roman titles and political forms.

Some historians interpret this to mean that the Roman empire in the west didn't actually fall, but turned into something else, namely a patchwork of post-

Roman “barbarian” kingdoms which adopted Roman forms. However this is not how many people saw it at the time. In 409 – 410 CE, when the northern frontier of the empire broke, and the Visigoths besieged and captured the city of Rome, Jerome, a Roman historian and theologian, expressed everyone’s profound shock: “*The brightest light of the whole world is extinguished; indeed the head had been cut from the Roman empire*.” The Visigoths left the city, loaded with booty. The city’s population halved to 500,000 from famine and disease.

What Holslag calls “*the death struggle”* of the western Roman empire began. Italy became a battleground. The Romans withdrew their troops from Britain and rushed them to the continent as reinforcements, telling the British to fend for themselves. Soon Angles and Saxons from German and Denmark crossed the North sea and created new barbarian kingdoms, and ultimately *England*.

In 476 CE the last emperor Romulus Augustulus was deposed by a Roman general of barbarian descent called Flavian Odoacer He claimed to be acting on the authority of the Eastern Roman Emperor in Constantinople, but urged on by his troops declared himself King of Italy. This was the moment when the western Roman empire officially ceased to exist.

Why Rome fell

Edward Gibbon in his famous book about the end of Rome entitled *Decline and Fall* (1776) blamed Christianity for corrupting the Romans, making them too “unworldly” and undermining their pride. However as we saw above, the emperor Constantine (306 – 337 CE) turned to Christianity because he believed it could make the empire *stronger*, by uniting the people and the emperor in a single shared religion. He was probably right; it certainly worked in the east where the Byzantine empire survived and flourished for another thousand years as a “theocratic” Christian monarchy.

Historians today see it differently: Rome lost the political capacity to face down the escalating external threat of the migrant peoples. Increasingly paralysed, it’s frontiers were breached, its authority collapsed, and the last emperor was deposed.

The myth of Rome

Whether we think the Roman empire fell or morphed into medieval European kingdoms, it is certainly true that after its fall its previously underwhelming imperial tradition suddenly became very appealing. Lieven says that *“Rome was the least ideological empire in the ancient world*.” But after its demise its

allure grew; the myth shone brighter than the reality. In the midst of so much fragmentation and confusion, it represented universal empire and stability.

The new barbarian kings adopted Roman titles to boost their legitimacy. Many kings called themselves *imperator*. The future Alfred the Great aged five, was taken to Rome and given the title *consul* by the Pope, who presented him with a red cloak, sword and jewelled belt. Then in 800 CE Charles king of the Franks (the French) – *Charlemagne* – was crowned *Emperor* by the Pope while visiting Rome. This later evolved into the medieval *Holy Roman Empire* (mocked by Voltaire as neither Holy, nor Roman, nor an Empire). Much later in 1776 we find the American Founding Fathers creating a Roman-style *Senate* and a *Capitol* building. When Napoleon rose to power in France in 1799 he called his regime *The Consulate*; he was its *First Consul*. Most recently the west European nations formed a union in 1957 by signing the *Treaty of Rome*. The appeal of the myth of Rome had little to do with the geopolitical reality of the actual Roman Empire.

The church

There was more to the legacy of Rome than the myth. The former empire's laws and cities were the foundation of those of medieval Europe. And it bequeathed Christianity, thanks to the emperor Constantine and Theodosius I (r. 379–395) who made it the official religion of the Roman Empire. This had monumental consequences. The Christian church continued to provide a vestige of unity, under the bishops of Rome or "popes". Some churchmen believed that therefore the popes should assume the secular powers of the emperors too. How could this work? It was surely too bizarre for a bishop to take over an empire.

Yet not completely so. Amidst the chaos when Rome collapsed it was often the bishops who held things together, providing at least a semblance of authority and order. And the popes did go on to become formidable princes. However in the aftermath of Rome they weren't even officially head of the church. The bishops of Carthage and Constantinople challenged their claim to supremacy. "Pope" was an affectionate not official title which any bishop could use before the 11th century.

On the other hand, Christianity's holiest saints were buried in Rome – Peter and Paul. And in Matthew's gospel, Jesus says, "*You are Peter, and on this rock I will build my church, and the gates of hell shall not prevail against it. I will give you the keys of the kingdom of heaven, and whatever you bind on earth will be bound in heaven, and whatever you loose on earth will be loosed*

in heaven." If the popes were supreme over the church, why not over the empire too?

This exactly what Pope Gelasius said to the Byzantine emperor Zeno in a letter in 476. Gelasius claimed he was superior to Zeno because bishops were superior to princes. On Judgement Day bishops carried an additional burden: they had to account to God for princes as well as for everybody else. Therefore bishops were senior to princes. Therefore the Pope must be superior to the Emperor. Zeno didn't reply. He simply ignored it. Although the idea didn't so away, it never took off. The popes were accepted as head of the church in the west, but nothing more.

Inescapably, the political legacy of Rome was *fragmentation*. Western Europe became a patchwork of smaller, jostling and contending states. As Lieven says, Western Europe had a "*deep-rooted non-imperial tradition*". Perhaps it was this very fragmentation that made the idea of Rome so alluring. Which brings us to the question: what happened to the *eastern* Roman empire?

The Byzantine empire

In the east the Roman empire didn't fragment; it became the Byzantine empire, named after "*Byzantium*", the old town on which the emperor Constantine founded *Constantinople*.

People at the time didn't; call it the Byzantine empire. This was name invented by historians after it had ended. People called it *the Roman Empire*, in Latin *Imperium Romanum,* and in Greek *Basileia Rhomaion*. Western Europeans called it *Imperium Graecorum*, "Empire of the Greeks". The Islamic world called it *Rum*. In the 7th century CE the emperor Heraclius reorganised its government and made Greek its official language instead of Latin. Although they venerated their Roman heritage and culture, their orientation became more Greek and they developed their own distinctive culture.

The word "Byzantine" has also come to mean systems that are overly complex or obscure, while "Byzantine diplomacy" implies trickery and secretive manipulation. These are based on western stereotypes – there is no equivalent use in the Islamic or Slavic worlds. Clearly, the west Europeans found it hard to cope with Byzantium's sophistication.

The Byzantine emperors were determined to keep up appearances. They received diplomatic embassies on a raised throne dressed in purple. Their realm was formidable. In 476 it extended from the Danube to the Red Sea.

Constantinople had 500,000 people, increased by refugees from Italy. It included land in the west, such as Ravenna and Brindisi in eastern Italy, Greece, Bulgaria and part of Serbia in the Balkans, and southern Italy including Sicily. It rivalled Rome is its architecture, with palaces, churches, a hippodrome, cisterns, aqueducts, bath houses and a central square called the *Augustaion* like the Forum. It had mighty city walls and Zeno's successor Anastasius built an additional defensive wall from the Sea of Marmora to the Black Sea against landward attacks.

Yet, like the Popes, the precise status of the Byzantine emperors was fuzzy. The Byzantines maintained that they were obviously the rightful heirs to the Roman emperors. Further, they said they would outshine them, since Rome had been pagan for most of its life while they had always been Christian. They looked down on the new barbarian kings of western Europe who were so easily bought with Roman titles.

Byzantium developed into a Christian *theocracy,* an empire heavily influenced by the church. However centuries of separation and mutual jealousy between the eastern and western churches inevitably caused them to drift apart and develop different practices. In 1054 came the "Great Schism", the moment of formal separation. This created the two largest denominations in Christianity – the Roman Catholic Church headed by the pope and the Eastern (or Greek) Orthodox Church headed by the Patriarch of Constantinople. Christendom was divided long before the Reformation, adding to Europe's fragmentation.

External powers took advantage of the power vacuum, including the Islamic conquests (7th century), the Mongol invasions (13th century); and the Ottoman invasions (15th to 17th century). The popes struggled to unite the medieval kings to go to the middle east to fight Islam in the crusades.

One notorious incident in 1203 during the Third Crusade reveals the appalling disunity of "the west". A fleet of Crusader knights anchored in Venice, having ran out of money, diverted to attack Constantinople. They besieged and captured the Byzantine capital, robbed, killed, raped and expelled its inhabitants, plundered and destroyed its churches, monasteries and palaces, then left to invade Byzantine territories in the Balkans.

Constantinople fell again, in 1453 when the Byzantine empire was conquered by the Islamic Ottoman empire: the final end of Rome. Its conqueror the Sultan Mehmed II claimed to be the rightful successor to the title of Roman emperor. So did the Russian Czars, as the only surviving protectors of the

Eastern Orthodox church. Neither made their claim to be “the new Rome” stick.

Religious disunity continued to plague Europe. In the religious wars of the 16th century Reformation, both the Catholic and Protestant powers considered approaching the Islamic Ottomans for an alliance. Some Protestants justified themselves by pointing out that both Islam and Protestantism disapproved of religious imagery. In 1683 the Islamic Ottomans besieged the Habsburg capital Vienna; the disunited west survived again only by the skin of its teeth.

What are we to make of Byzantium? Was it actually an empire? Or was it more accurately an early proto-nation, an ethno-linguistically Greek, middle ranking power, whose rulers (like the Egyptian pharaohs) happened to be called emperors? On the other hand, the capture of Constantinople in 1453 created shockwaves as great as those to the capture of Rome in 410. Western historians find Byzantium hard to pigeonhole. In Asia and the Islamic world it is different. There is it just *Rum*, Rome.

Perhaps this is the point. If we take a long view, Byzantium was the empire that Rome should have become. Perhaps it nearly did. In 212 CE, the Roman emperor Caracalla extended Roman citizenship, previously restricted to the elite, to every Roman, barring slaves. The change also admitted non-Roman members of the elite to the aristocracy. Historians usually dismiss this as meaningless, devaluing citizenship without actually benefiting anybody, or as a cynical ploy to increase tax revenue and raise more conscripts for the army.

This is plausible. Caracalla was not exactly one of the more brilliant emperors. But his adviser, Ulpian, a Syrian lawyer, was. Some historians think they were genuinely trying to integrate the diverse Roman population more fully. Even slaves gained some new legal protections. With sufficient time and political will, could Rome have evolved into an integrated empire-nation as Byzantium did? And, as we’ll see in a moment, Han China did too? In this form, could the Roman empire have survived?

The “rise the West”

Writers since Montesquieu in the 18th century have said that western Europe’s fragmentation is due to geography. Western Europe has no equivalent to the vast north Chinese or north India plains. It has a long, indented coastline with many inlets, several seas and mountain ranges, and major rivers that don’t link together. Although the climate is conducive to agriculture, it is not

geopolitically conducive to unification or empire. It became a patchwork of states who jostled and contended with one another.

Some historians see this as fragmentation as a positive. They say it spurred innovation, encouraged competition and created a cultural ethos of exploration and enterprise. Without this, there may have been no Columbus, no Newton, no scientific or industrial revolution, no Renaissance or internet. China, by contrast, developed scientific and technological knowledge but lacked the drive or competitive drive to apply and exploit it. This is the traditional triumphalist narrative of "the rise of the west", found for example in the historian Niall Ferguson, a keen advocate of western free-market capitalism, in *Civilization: the Six Killer Apps of Western Power*, 2012.

This is now increasingly challenged. British historian Naoise Mac Sweeney, a professor at the University of Vienna, recently published *The West: A New History of an Old Idea* (2023), points out "the West" barely existed. Medieval and early modern Europe was a fragmented, fractious, weak and divided backwater of negligible importance. It was distracted by bitter and tangled conflicts between Orthodox patriarchs, Catholic popes, Protestant reformers, Holy Roman Emperors, western kings and Byzantine emperors. The Mongol invaders didn't think it was worth invading; having reached Hungary in 1242 they turned back (partly because Genghis Khan had died) and spared Europe the death and destruction they had inflicted on Asia. This was the legacy of the fall of Rome.

By the 19th century, says Mac Sweeney, "*the global supremacy of the West was unchallenged and absolute. Western states controlled the global economy, Western ruled territories across five continents, and Western ideas – about science, morality and history – were exported around the world, often replacing local systems of knowledge. The dominance of the west in this moment was so far-reaching and so absolute that it became hard to imagine that it had not always existed. Just as the realities of the 19th century present meant one path for the West (domination) and another for everyone else (subordination) so it became hard to think of the shape of history other than in terms of Western Civilization*".

This inevitably generated a sense of superiority, triumphalism and arrogance; the west became an amorphous entity; so did "the rest", the inferior others. This is what gave rise to the "rise of the west" narrative. This rise wasn't an inevitable, gradual, centuries-long process dating back to ancient Greece and Rome. It was sudden and unexpected. It exploded on the world.

Next session we need to ask what caused it.

HAN CHINA

China did not fragment. Or did it? The trajectory of Chinese history was brilliantly captured in a novel set in Han China in the 2nd century CE. It is called *The Romance of the Three Kingdoms* and is attributed to Luo Guanzhong (c.1330–1400 CE). Its opening line is, *"The empire, long divided, must unite; long united, must divide"*.

This perfectly describes the pattern of Chinese history. Despite intervals of division and anarchy, the empire always survived and revived. This continued for 3,000 years. As we saw last session, *the Mandate of Heaven* goes a long way to explaining how this could be possible. Han China was one of the periods of revival and progress. They built on the foundations they inherited.

One of their key decisions was to commit China to Confucianism. The fifth Han Emperor, Wen (180 – 157 BCE) asked his chief minister Chen Ping, what was the true role of an emperor? He replied, to carry out the correct rituals and to appoint an able chief minister who would then conduct the government in accordance with cosmic and ethical harmony. This was the Confucian vision of the Chinese empire which as Lieven says lasted throughout its history.

It had its flaws. The emperor in theory had absolute power and had to be able enough to choose and to appoint the right man as chief minister. But then he had to be willing to step aside and let him govern. Further, he would also have to judge when it was time to remove him. Another problem was the bureaucracy. This would be staffed – of course! – by Confucian officials. In theory this should have effective good government. In practice officials could block policies they disliked resulting in paralysis.

It was under the Han emperors, particularly Wu, grandson of Wen, that Confucianism became embedded in the empire. Wu was educated by Confucians and during his long 54-year reign Confucianism became virtually a state religion. Yet ironically he ruled as an autocrat which cannot have pleased his officials. As Lieven comments, "*The alliance between imperial monarchy and Confucian officialdom was the bedrock of the Chinese empire. From the start it contained deep tensions. We simply lack the sources to understand in any detail how these tensions worked out in Wu's reign*."

The Han having given the empire four centuries of unity, it obviously had to divide. After this, the Tang, then the Song dynasties ruled. This is often regarded as the empire's golden age. Culture and invention flourished: gunpowder, printing, compass navigation, clockmaking, hydraulics, astronomical maps and calendars, porcelain manufacture. The economy boomed, reaching levels of development reached " *a level seen nowhere on earth until late 18th century Britain*." Under the Song the empire and the Confucian bureaucracy reached maturity.

This was just as well. To give some perspective, Song China was smaller than Tang China and only about a quarter the size of modern China, but still contained a third of the world's population* (*The figure arrived at in a census of 2 CE was 57,671,400). Only a sophisticated state bureaucracy made it possible. It enabled the Chinese emperors "*to do things beyond the imagination, let alone the capacity, of any European government*." This included a standing army of a million and gigantic hydraulic projects to manage China's turbulent rivers and the waterways essential to communication and trade.

The number of bureaucrats grew from 13,000 under the Tang to 43,000. The downside was it drowned in paper (a Chinese invention). Decision making became convoluted and slow. Officials saw themselves as a virtual priesthood. Reforms were difficult to pass. The examination system to selected officials became a monster. Thousands studied the Confucian classics, law and government and sat the three-yearly exams for a state degree leading to a senior official position. It caried enormous respect and prestige amongst elite families and helped bind them to the empire.

The legacy of Han China

Predictably China split after the Han, until the Tang dynasty (618 CE). The process of continuous strengthening resumed. Confucianism became the basis of government. A period of prosperity, expansion, and innovation began which was continued under the next dynasty, the Song (960).

This was considered the golden age of the Chinese empire. Significant inventions included the moveable type in printing, the application of gunpowder for military uses, the invention of a mechanical clock, improvements in agriculture and shipbuilding, the use of paper money, navigation by compass, and porcelain (China clay) production.

By the end of the Song dynasty the modern face of China was defined and established. It ended with defeats on the northern borderlands which culminated in the Mongol invasions (1211 CE). These set back China's development and helped change the direction of its history, but as we'll see, ultimately it was the Chinese who assimilated the Mongols rather than vice versa.

The chief legacy of the Han dynasty is that Chinese people today call themselves *Han*. Their reforms combined with their long period of unified rule succeeded in developing a sense amongst the Chinese that they truly shared a common ethnic identity. Between the Han and the Song China evolved into a "proto-nation", a state with a strong and enduring imperial-ethno-national identity.

So successful were they that *Han* gradually replaced earlier tribal and regional identities such as the *Huaxia* culture, and differentiated the majority *Han* Chinese from the *Xiongnu* of the west and the *Mongols* and *Manchu* peoples of the north. These peoples on the periphery were considered to be "barbarians" in contrast with the civilized *Han*. This consciousness greatly strengthened the Chinese empire and the modern Chinese nation.

Conclusion: a new era

After the Han and Roman eras, east and west followed very different trajectories. And the reason for this was indeed geographical. But not, as Ferguson says, geographical *fragmentation*: rather geographical *location*. Western Europe is adjacent to the Atlantic. China is adjacent to the steppes. While the Europeans found a new *oceanic* destiny to the west, the Chinese emperors were obliged to focus on the threat of nomadic attacks from the north. Only in the 18th century did the Qin finally destroy their power. Land, not sea, determined China's policy and its destiny. This is the crucial geopolitical difference between east and west.

How are we to interpret these changes?

I suggest that we interpret it as follows. The great empires we have looked at so far were all similar. They were sedentary empires which arose on or near the three core regions of early civilization, the great fertile plains of Mesopotamia, China and India. The fall of Han China and Rome seems to mark the end of this first era of empire.

The great empires of the new era were very different. In particular the Islamic conquests (from the 7th century), the Mongol invasions (13th century) and the European oceanic empires (16th century) all brought changes to how empires were created and defined.

Next session we'll explore this new era and discuss its big new idea: *mobility*.

SESSION SIX

MOBILITY: FROM CAVALRY TO CARAVELS

"*At the sound of horsemen and archers every town takes to flight. Their quivers are like an open grave. Look, an army is coming from the land of the north. They are armed with bow and spear; they are cruel and show no mercy. They sound like the roaring sea as they ride on their horses."*
(Jeremiah, 4-6, Old Testament)

"Britannia waives the rules"
(Punning verse, British Register, 1842)

A new era of empire

At the end of the last session I suggested that the fall of Han China (220 CE) and Rome (476) should be interpreted as the end of the first era of empire, marked by great sedentary empires created in the core regions of Mesopotamia, India and China. They were similar in their origins, evolution, challenge and aspirations.

What was new about the empires of the new era after 600 CE?

If we focus on the three biggest, namely the ***Islamic caliphates*** (from the 630's CE), the ***Mongol invasions*** (from 1207) and the ***European colonisation of the Americas*** (from the 1490's) we see that they originated outside the traditional Mesopotamia/India/China fertile cores. (So did Rome, but it overlapped heavily with the Near East and Egypt). They had very different drives and imperial ideologies. The traditional empires tended to prioritise security and order, cosmic as well as earthly. However the new empires had other motivations:

- The *Islamic conquests* were driven by the zeal of a new religion and eternal salvation. Inspired by the prophet Muhammad (died 632 CE), its rulers regarded themselves as his successors, or "*Caliphs*".
- The *Mongol invasions* were fundamentally motivated by the age-old enmity between the nomadic and the sedentary peoples of Eurasia (see below). They were triggered by the unique success of Genghis (or Chinggis) Khan (1162 – 1227 CE) in uniting and mobilising the fractious nomadic tribes of Mongolia.
- The *European colonial conquests* from the 1490's were motivated by a sense that western Europe was "hemmed in", so they sought power and profit via the oceans; later other ideological elements were added: a

civilizing and Christianising mission, and a triumphalist narrative about "the rise of the west".

However the biggest new feature of these empires is the *speed* and the *scale* of their conquests. These were empires of ***mobility*.**

- *The Islamic conquests* were achieved by Arabic tribesmen who were fired by a new religion. They travelled rapidly on horseback and fought both as cavalry and foot-soldiers. The suddenness with which they defeated and overran existing empires and invaded vast swathes of Eurasian territory, shocked the civilized world.
- *The Mongol invasions* exploited their nomadic skills of speed and mobility on horseback over deserts and steppes to fight as fast-moving but disciplined masses of unstoppable cavalry, spreading awe and terror in equal degrees.
- *The European empires* exploited sea-power, a new mastery of the oceans, gained through the invention of the caravel, the first fast and robust ocean-going ship, and new knowledge of ocean currents. This enabled them to project their naval power over the oceans of the world, and conquer vast colonial territories in the Americas and beyond.

Historians now draw a parallel between the "frictionless mobility" offered by both the flat grasslands of the steppes and the oceans.

- *Nomadic Mongol horsemen* moving over the steppes in huge and fast-moving formations disciplined by Chinggis Khan, proved unstoppable.
- *Caravels*, then larger galleons, could transport European soldiers, armaments and supplies to strike at any coast anywhere in the world.

Mobility revolutionised warfare, Never before in the history of empire did changes in military methods and technology have such a rapid and devastating geopolitical impact.

- No one suspected in the 630's that semi-nomadic tribesmen in the deserts of Arabia could defeat and overrun the Sasanid and Byzantine empires. By 661 they had created the ***Umayyad caliphate*** (661 – 750). a vast Islamic empire spanning three continents, from Spain to India.

- Equally unexpected was the creation of the ***Mongol empire*** (1206 – 1294) which extended for 3,000 miles from Hungary to the Pacific. Had Chinggis Khan not died, and had they not considered Europe a backwater, they might have conquered the west too.

Instead, from the 1490's the ***oceanic empires*** of the Portuguese, Spanish, Dutch, French and British competed for colonial, commercial and naval dominance across the world, and in the 18th century rose to dominance, well before the invention of railways, steam ships or the telegraph.

Mobility revolutionised empire. By land and sea, it made it continental and global.

These new entities were truly empires. They had vast scale and tremendous diversity. Their rulers regarded themselves as the centre of their worlds. The core gained most, the periphery least, in terms of security, wealth, power and privilege.

THE CALIPHATE

Muhammad did not name a successor; nor did his teachings give any guidance as to how his Muslim successors should rule a vast new Islamic imperial state. Yet the Arabs, semi-nomadic peoples from a semi-desert region, had no tradition of empire, rather one of blood-feuds between tribes. Thus the leaders of the Caliphate (Caliph means "successor", i.e. to Muhammad) needed an imperial template. They therefore turned to the strongest one available, namely the Persian: they adopted its bureaucracy, scribes, systems of finance and taxation, military organisation, even styles of art and architecture.

And it's language: the court of the Caliph spoke Persian and read Persian literature. Arabic was the language of Islam, but the Umayyads adapted Arabic script so that it could be used to write in Persian. The Umayyad caliphate was world-conquering; but to a degree Persia conquered the Caliphate. Many traditional-minded Muslim clerics were offended by all this. The sumptuous luxury of the life of the Caliphs seemed to contradict the essence of Islam, on which the Caliphate was supposed to be based.

Islam is more like Judaism than Christianity. It is basically a simple religion: humility and awe in the face of God, righteousness and compassion in the face of humankind. The basic policy of the caliphates was also, to modern eyes, surprisingly tolerant. Holslag says it was "*founded the principles of compassion for believers, protection for subservient non-believers, and retribution for those who resisted.*" The Caliph Umar advised his subjects to live soberly, respect the law, and support the poor. He set up courts to investigate complaints of official corruption. He guaranteed non-believers of

their security if they submitted. "*Their buildings must be low so that exiting their houses would make them bend and remind them of their low status."* Tolerance led to complaints from Muslims.
Muhammad's teachings were collected into the *Quran*. "*Everything in the heavens and earth belongs to God.*" Within the *umma*, the community of believers, justice must prevail: if anyone stole or killed "*out of hostility and injustice, we shall make him suffer fire*." Outside, hostile unbelievers must be subjugated: "*If they neither withdraw, nor offer you peace, nor restrain themselves from fighting you, seize and kill them whenever you encounter them*."

Muhammad never dreamed that in three generations Islam would rule much of the world. Its rapid expansion all but tore the *umma* apart. One bitter division continues to have big political consequences today, particularly in Middle Eastern politics. The first Caliph was Muhammad's father-in-law, Abu Bakr. This raised the question, who was the legitimate heir to Muhammad? A blood-relative? Or someone who was not related but was devoutly committed to his teaching? Islamic thinking was split, and has remained so.

At the time, civil war broke out. The Umayyad clan won and in 661 formed a new Caliphate. At its height, their caliphate ruled a third of the world's population. They built the Great Mosque in Damascus and the Dome of the Rock in Jerusalem which became two of Islam's holiest sites.

The Umayyads called themselves *Sunnis*, followers of the way, i.e. of Muhammad's teachings. *Caliph* meant successor to Muhammad; any pious individual could hold this position. They were opposed by *Shias*, "followers of Ali". Ali was Muhammad's son-in-law; his descendants were Muhammad's bloodline. The Shias believed that they were the only legitimate successors, not the Caliphs. In 680 the son of Ali, grandson of Muhammad, and many of his followers had been killed in a battle against the Umayyad army. The religious and political divide now took on the intensity of a blood-feud.

The Umayyads were overthrown in 750 by the Abbasid Caliphate. They promoted the study and translation of the ancient Greek thinkers and built a new capital, Baghdad which became a leading world centre of learning. They too declined and fragmented until they too were overthrown by the Mongol invasions in 1258 (see below). There was no overall Caliphate until the Ottomans (next session). The huge extent and phenomenally rapid growth of the caliphate had put severe strains on its ability to maintain unity. Thus, like all great empires it was marked by periods of expansion and triumph, but also

competing claims, political upheavals, civil wars, assassinations, rebellions, anarchy and disintegration.

There were many regional caliphs during these periods. The Ottoman empire (next session) informally "inherited" the Caliphate from one of these, the Caliph of Cairo, who handed to Sultan Selim I Muhammad's sword in 1517. But for the Ottomans it was a religious title only; they only tried to revive its political meaning in 1774 during their struggles with Russia. In 1924, following Turkey's defeat in the First World War and a national uprising led by Mustafa Kemal Ataturk, the National Assembly abolished the Ottoman monarchy (sultanate) in 1922 and caliphate in 1924.

Lieven says the caliphate's legacy is two-fold: "*the vast Islamic religious and cultural zone*" which remains of crucial significance in today's world. And historically he calls it "*the ultimate universal empire*".

THE MONGOLS

Relations between nomadic peoples and neighbouring sedentary societies have always been complicated. The Chinese empire illustrates this very well. The emperors invested heavily in strategies designed to manage the threat from the northern peoples they called "the barbarians". These included sending armies to conduct pre-emptive strikes, monitoring nomadic tribal politics for advance warning of combined attacks, appeasement, bribery (rolls of silk), and divide and rule tactics. In the long run there was no permanent solution; none of the policies tried were particularly effective.

The Chinese invested much in wall-building. No single emperor built the Great Wall of China. Numerous emperors built stretches of wall using rammed earth, stones and wood; bricks only came later. Bursts of Intensive building took place under the Zhou, Qin, Han and Ming dynasties. The long-term aspiration was to connect existing stretches to form a continuous line of defence. Ultimately it proved no more effective than the other polices; nor is it visible from space. It wasn't all a waste; at least it reassured people something was being done

Despite the mutual hostility, there was also a basis for trade. The nomadic peoples wanted grain and luxury goods like silk which they needed as booty for their followers in the war-band. Mongol society had elite aristocratic families (including that of Chinggis Khan) but to be successful the leader of a war-band needed both camaraderie and charisma. Chinggis had 10,000 in his.

On their side, the sedentary empires desired the excellent horses bred on the steppes; in the time of Chinggis the steppes had half the world's horses. Nomadic warriors also helped the growth of long-distance trade by "protecting" trade routes (in return for payment) including the silk roads which crossed Eurasia.

Sometimes the nomadic bands and tribes united in loose and usually temporary tribal confederations. But usually the threat they posed was of sudden, small-scale raids, whose speed and mobility was difficult to defend against. Genggis Khan brought a unique unity and discipline to the Mongols. He created highly mobile, fast-moving, massed armies of cavalry, armed with archers and supplied by vast caravans, almost mobile cities. They were unpredictable, unstoppable and terrifying. No empire or city within range of the steppes was safe. Warfare was revolutionalised.

Just as the Caliphate adopted Persian culture, there was a similar pattern with the Mongols. Their first and greatest single conquest was China. The Mongols attacked China in 1207, taking advantage of its troubles. In the 12th century the northern Jurchen kingdom took over northern China and overthrew the Song dynasty. The remnants of the Song dynasty joined with the Mongols to defeat them in 1234. But then the Mongols turned on the Song. Adopting the Song's siege engines and gunpowder weapons, after decades of bloody warfare, the Mongols triumphed and took over the whole of China in 1276

However the Mongols were acutely aware of the superiority of Chinese civilization over their own culture. In 1279, the Mongol conqueror of China, Kublai Khan, declared himself the founder of a new dynasty, the *Yuan.* This act formally ended the Song dynasty. It also completely identified the Mongols with the Chinese empire. Again, as with the Caliphate, the conquerors were themselves conquered.

However this inevitably altered China too. The Song had been China's most dynamic and creative dynasty. Their rule was a cultural and economic golden age. Its inventions and enlightened policies made it the world's largest economy. It brought in pensions and benefits and controlled food prices. Iron and silk making expanded. A navy was established. Song China was widely admired, "*exercising a huge power of attraction over even hostile states*" who fell over themselves to "*emulate the opulence and refinement of the Song*." The Mongol invasion of put an end to this golden age. Millions died. As Holslag stresses the long-term geopolitical significance in the long term of the fact *"the great upsurge of Chinese cosmopolitanism under the Song – one of*

the most outward-looking of Chinese dynasties – had been cut off at the roots." It took three centuries for China's population and agricultural production to recover from the Mongol conquest But in a sense, China never did.

The Mongols brought a similar fate to much of the rest of Asia. In 1258 they reached Baghdad, capital of the Abbasid caliphate and the greatest centre of learning of the Islamic world, and probably of the world itself at that time. It was the largest army ever fielded by the Mongols, led by the grandson of Chinggis Khan, Hulagu Khan. He sent the Caliph a letter demanding the city's surrender.

The Caliph hesitated; there was internal strife; their response was unclear. The Mongols stormed the city. Hundreds of thousands were killed, including the Caliph. Wrapped in a rug, he was trampled to death by horses. The city was looted. Its finest art treasures and architecture were burned. Books from *The House of Wisdom*, a world-famous library, were thrown into the river Tigris. Baghdad was wiped out. The attack destroyed the Abbasid Caliphate. This was terror on a vast scale, used as a warning to all other cities.

After the death of Chinggis in 1227, the Mongol realm broke up. It was divided into four, Yuan China which lasted until 1386; the Golden Horde, Siberia and the northern steppes, including Rus (early Russia), which lasted until the mid-15th century; and the Chagatai Khan of central Asia and Il-khanate in Persia (both conquered by Timur (1370 – 1405), whose vast but short-lived empire briefly united much of the former Mongol realm. Timur (sometimes called Tamerlane) was a Turco-Mongol, a possible descendant of Chinggis and ancestor of Babur who founded the Mughal empire, the Raj of the British empire.

Timur was the last of the great nomadic conquerors. The reason was simple: gunpowder. The so-called "gunpowder empires" such as the Ottomans and the Mughals (next session) were able to use firearms and artillery to mow down the nomadic cavalry (as the Ottomans did to the Turkomans in 1473). Mobility succumbed to firepower. Military technology moved on again.

The European oceanic empires

If the secret of the western Europe's colonial empires was also mobility, what was its motivation? Geopolitics provides an answer. West Europeans were hemmed in to the east and the south by the Islamic Ottoman empire. It dominated the Near East and North Africa and obstructed western trade with the east. The Portuguese explorer Vasco da Gama was thus motivated to look

for an alternative route, by-passing the Near East, by sailing south the length of the Atlantic coast of Africa (no one knew where, or even if, it ended) in the hope that it would eventually strike east and allow navigation to the Indian Ocean, Mughal India and Ming China. In similar fashion, the Italian navigator Columbus sought backing for a scheme to bypass the Near East by going directly west, across the Atlantic, with the intention of striking the east coast of Asia (hence “West Indies”: Columbus never deviated from the belief that had discovered Asia, not a new “new” American continent).

All this voyaging had an important unforeseen consequence: not just the discovery of new routes and new lands, but of indispensable new knowledge about the oceans, specifically ocean currents. Here was the unforeseen key to solving Europe’s “hemmed in” problem: not just new routes to the old world, but knowledge which turned them into frictionless oceanic highways to a new world.

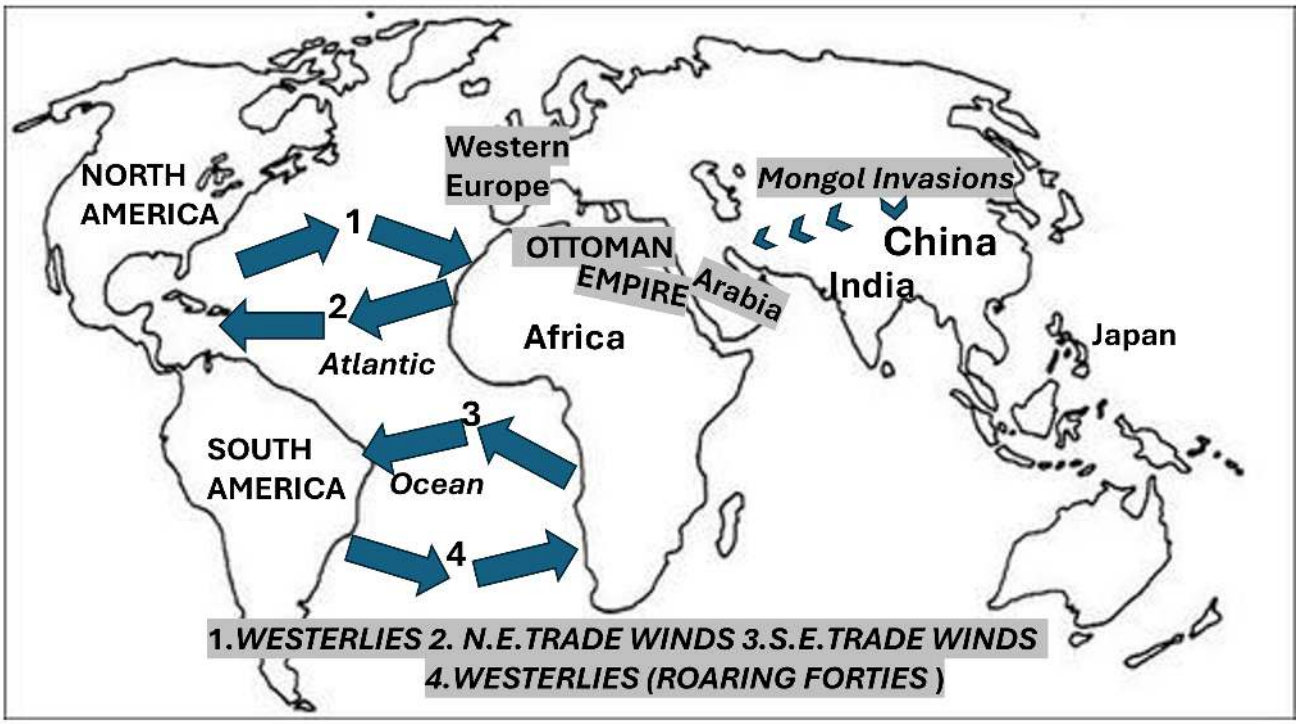
The key was Vasco da Gama. He finally found his route, just after Columbus discovered America. He sailed south down the African coast around the Cape of Good Hope, then eastward to India (1497-9). He had tremedous difficulties with this; his north-south coastal voyaging proved more troubleome than expected. It was this that revealed to the Portuguese the existence of a distinctive pattern of east-west Atlantic currents.

In effect, and to greatly simplify, the Atlantic has four bands of oceanic surface currents going east west. The cause of these is complex; they are part of a pattern over all the world’s oceans, Their cause is fundamentally that the equator is warmer than the poles; warm air rises; and the earth rotates. The end result in the Atlantic is four parallel bands of ocean current: a northern band going west to east; a second parallel band going east-west; a third, south Atlantic, band going east-west; and a fourth going west-east. Navigators in sailing vessels have to use these currents to make progress.

The map below shows these.

Columbus was lucky. He orignally asked the king of Porutgal to back his voyage, but he declined. Had he done so, Columbus would have sailed via the Azores (which lies in band 1 on the map) and he would never have made it across the Atlantic. Instead he appealed to the queen of Spain, who agreed to back him; as a result, he sailed from the Canaries, and discovered America. Thus, using the map, on his outward voyage, Columbus picked up the ***North East Trade Winds (2)***. When he tried to return home by the same route, he

made no progress; fearing they'd run out of supplies, he pushed northwards and managed to pick up the ***westerlies (1)*** which brought him safely home.



From the map we can also see why Vasco da Gama had such trouble; sailing south from Portugal down the coast of Africa meant that he ***crossed all four*** of the Atlantic bands. Portuguese navigators realised what this meant. Oceans had a patern of parallel currents.

This discovery, dissminated among navigators within a generation, allowed them to truly treat the oceans as a highway. Together with the invention of the caravel, it enabled west Europeans to enrich themselves with the produce and treasures of the new world of North, Central and South America, whose peoples, empires and states proved no match for western diseases and superior military technology.

They did so with a ruthlessness which according to Dominic Lieven, one of the foremost historians of empire, was without precedent. Why was this? As discussed above, both the Islamic and Mongol invaders felt culturally inferior to those they conquered. With the Europeans it was quite the opposite; they felt very superior indeed to the peoples they conquered and colonised. In imperial terms, the oceanic empires had a vast gulf between a European core and a colonial periphery. This had devastating consequences.

Dominic Lieven develops this analysis in a hard-hitting passage:

*"In the European trans-oceanic empires, the distinction between metropolis and colonial periphery was stark. It was marked by geography, race and increasingly enormous differences in wealth. The white settler colonies represented by far the greatest example in the history of ethnic cleansing, expropriation and sometimes annihilation of indigenous peoples by conquerors."**

*Dominic Lieven *In the Shadow of the Gods: the Emperor in World History* (2022) pp 23-4.

This helps to explain the unprecedented European exploitation and brutality towards the indigenous peoples in their settler colonies. Forcible removal from ancestral lands resulting in enslavement or death; the spreading of European diseases which wiped out entire indigenous populations; colonial resources ruthlessly exploited for the benefit of the home country.

The rise of the west

But this wasn't yet "the rise of the west" which even as late as1700 was not much in evidence. As Holslag says, the Europeans were perceived by the Ottomans and Mughals as "*squabbling pygmies*", not a threat. In the Americas their armies of *conquistadors* were tiny. "*Even as late as 1700, there were still no more than 200 voyages a year across the Atlantic*." In the Indian Ocean, attempted European incursions were strongly resisted, restricting them to the coasts and islands. At a time when Qing China and Mughal India had more than 150 million people each and the Ottomans more than 30 million, the entire Spanish empire of the Americas had fewer than 20 million .

But after 1700 the European's advantage began to tell. The sedentary empires of Eurasia who hemmed in the west Europeans felt themselves impregnable. But after 1700 the frictionless mobility of western sea power was increasingly turned against their lightly defended coastlines. As the above map suggests, the Ottomans, Mughals, Ming and Japanese were suddenly vulnerable.

The Portuguese were the first to realise that they could use their navy to estabished new coastal trading stations on the coasts of Eurasia. And although they might be remote from traditional land trade routes, the traders started coming to them. For example, in West Africa the flourisihing cross-Saharan trade route was by-passed by new Portuguese trading stations on the West African coast. Soon they were shipping out goods and slaves.

Then the westerners realised that their coastal trading stations could also function as military bases, naval ports through which they could ship in troops. The Indian and Chinese empires might have beeen impregnable to land attack, but their long coastlines were vulnerable to combined sea-and-land attacks. The lighter coastal Asian fleets were no match for the European's faster, more heavily armed ships. Their trade, ports and cities came under increasing threat.
Simultaneously, fuelled by the wealth of their oceanic empires, West Europe's financial, commercial and industrial growth took off in the 18th century: (the so-called *industrial revolution*). By the end of the 19th they dominated the globe. In 1900 world population stood at 1.6 billion. The 280 million people of western and central Europe ruled over oceanic empires of 425 million colonial subjects. Their economic dominance was even more startling. Compared to the period 1500 to 1800, the increase in production per head between 1800 and 2000 was five hundred times greater.

So in terms of the history of empire, what we call "the rise of the west" was actually a two-part process. By 1500 frictionless mobility over the oceans was a reality, enabling the West Europeans to begin their expropriation of the wealth of the Americas. Then from 1700, they used this wealth to finance an assault on the old sedentary empires of Eurasia. It was one of the most astonishing geopolitical revolutions in history: stealing the wealth of the New World to finance their (our) domination of the Old. The speed of this transformation was unprecedented. No longer "hemmed in", but empowered and enriched by frictionless mobility across the world's oceans, the European empires ruled the world.

Conclusion: the closing of the steppes

In an age of geopolitical revolutions, another one occurred which was less noticed at the time: the closing of the steppes. Lieven says that throughout Eurasian history a key geopolitical question for any sedentary empire was or was not it was within range of nomadic warriors. Most of Eurasia, including China, was. Western Europe, South-East Asia and Japan weren't. Throughout history, the balance of power between the sedentary and nomadic worlds fluctuated: "*Looking at the whole span of 2,500 years of nomad-sedentary relations it is a fair generalisation that, whereas nomad empires usually had the edge in terms of military power, in political terms the sedentary empires were mostly more resilient*."

Resilience won in the end. In the 17th and 18th centuries the Russians and Chinese extended their power over the steppes. As the Russian expanded

eastwards into Asia, to Siberia and the Amur river, the Qing Chinese empire advanced northwards into Mongolia and Manchuria. Tensions between the two empires rose. To avoid conflict, Chinese and Russian diplomats met in August 1689 on the Amur river. Here they negotiated the Treaty of Nerchinsk. They carved up the steppes between themselves. Russia withdrew from some regions; China gained control of the Amur river basin.

It was an epoch-making moment: the end of the nomadic world. For millennia the steppes had been a region of free nomadic movement. Their age-old geopolitical struggle ended. The sedentary empires had finally extinguished the nomadic threat. The nomadic legacy lived on in the *Ottoman* (Turkish) and *Mughal* (Indian) emperors, and the *Qing* (or *Manchu*) dynasty in China. These empires combined the nomadic ancestral values of the mounted warrior with the sedentary culture and political heritage of the peoples they ruled.

But the supreme irony is that having disposed of the nomadic threat, from 1700 the sedentary empires of China, India and the Ottomans faced the new, much deadlier “barbarians”: the Europeans. These new barbarians would humiliate them, extort trade concessons, drain them of their independence and resources, and erode their territory. Having plundered the Americas, the west Europeans used the spoils to assault on the ancient empires of the Old. It was the geopolitical equation that made them lords of the earth.

Epilogue: the African Empires and the Trans-Sahara trade route

Empires often depended on gaining control of trade routes. This was certainly the case of the West African empires. Geologically the African continent is a vast extended plateau edged with coastal lowlands. There are no equivalents to the Eurasian Alps or Himalayas. Much of Africa is desert and tropical rainforest. The rivers are broken up by unnavigable waterfalls.

The main geopolitical influence on the growth of African empires was *trade*, specifically control of key trade routes. Thus western and central Africa trading centres like Timbuktu, Gao, Agadez and Djenne were linked by trade routes north across the Sahara Desert to the Mediterranean ports such as Marrakesh, Fez, Tunis and Cairo. Gold, ivory and slaves went north; in exchange, precious salt went south.

West African empires such as Mali, Ghana and Songhai competed to control the sources of these goods and the routes over which they travelled, transported by camel caravans across the Sahara. As always, the routes themselves, which were managed by Arab Berber merchants, carried ideas as

well as goods: they carried Islamic influence and learning from the Caliphate southwards into Africa.

The key driver of this route was west African gold, first recorded in the 5th century BCE by the Carthaginian explorer Hanno who journeyed to the Senegal river and beyond. The later Greek historian Herodotus describe the working of "silent barter": "*the Carthaginians unload their wares and arrange them on the beach; then they reboard their boats and light a smoky fire. When the native inhabitants see the smoke, they come to the shore and, after setting out gold in exchange for the goods, they withdraw. The Carthaginians disembark and examine what the natives have left there, and if the gold appears to them a worthy price for their wares, they take it and depart; if not, they get back on their boats and sit down to wait while the natives approach again and set out more gold, until they satisfy the Carthaginians that the amount is sufficient."*

The Romans also took advantage of the trans-Saharan trade route, exporting their olive oil, fine pottery and luxury goods in exchange for gold, ivory, ebony and exotic animals for their amphitheatres and circuses. But it really took off as a trade route after the spread of Islam across North Africa. The demand for gold rocketed in medieval Eurasia, for use in the making of jewellery, vessels, embroidered clothing and illuminated manuscripts, to mint coins to pay their armies, and for merchants to use trading across the southern Mediterranean.

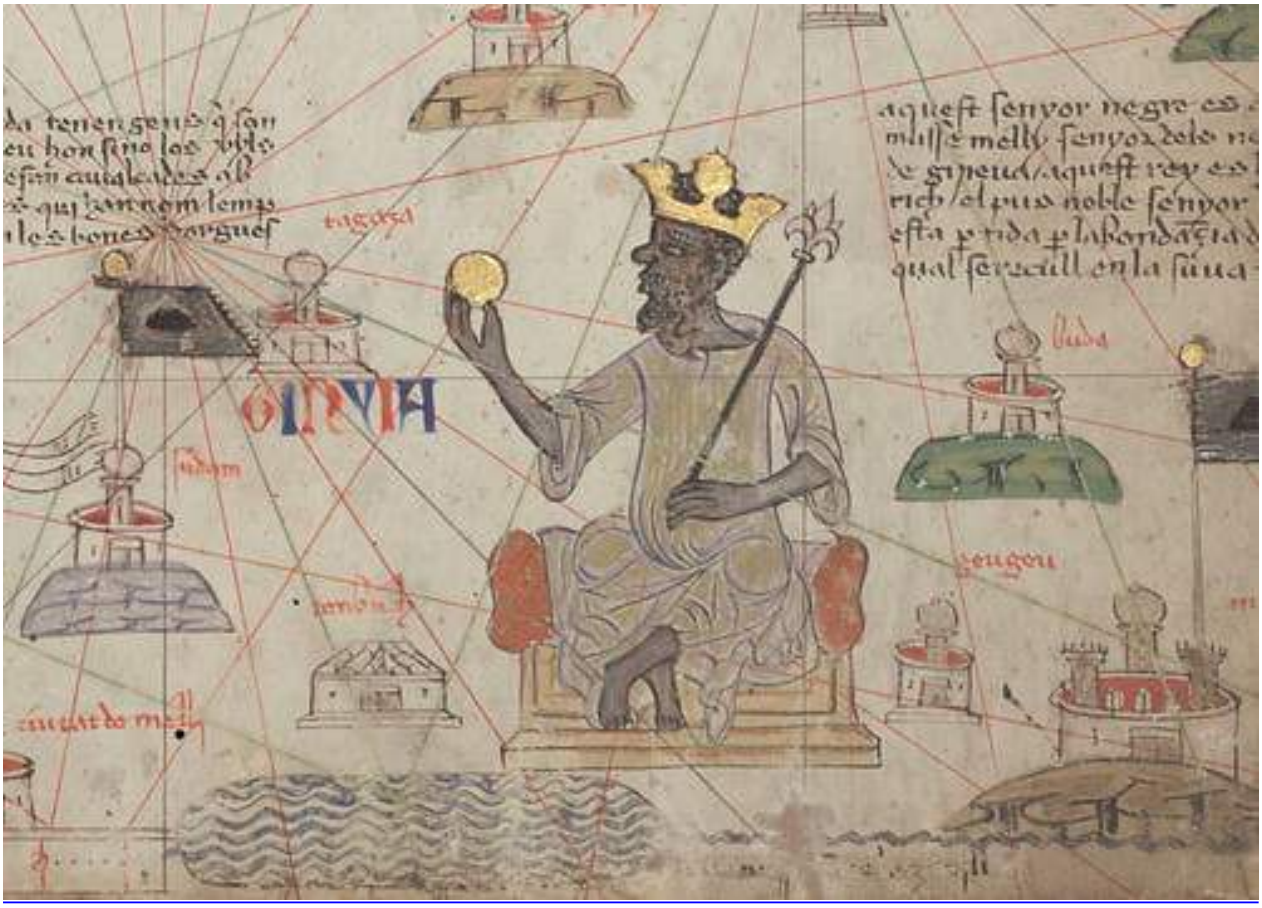
Two thirds of Mediterranean gold came from the gold fields of West Africa of the Upper Niger and Senegal rivers: it was panned as gold dust from alluvial rivers or extracted from shallow mines. Cast into bars for transporting, it was traded in return for salt. It was used to preserve meat and flavour food but was scarce in west Africa. It was extracted from natural deposits and sent south in great slabs; in the 11th century CE a 90-kilo block was worth more 450 grams of gold.

The emperors of Ghana claimed ownership of any large gold nugget that was found in their empire, and stockpiled them in their palace. This helped to keep the price up, while its magical properties reinforced his supernatural powers. Gold dust was carefully weighed and used for decoration or as currency (they didn't mint coins).

In 1324 the emperor of Mali, Mansa Musa, went on a famous pilgrimage (*haj*) to Mecca. He took tons of gold, which he either spent or gave as gifts, including a massive one to the Sultan of Egypt. He injected so much gold into

the economy that he actually caused the Cairo gold market in Cairo to crash; it took twelve years to recover. He also brought back Muslim architects and scholars to Timbuctu, where he built a new mosque and a university. He is probably the source of many ancient legends of cities paved with gold which tempted later generations of adventurers.

It all ended from 1471 when a Portuguese fleet from Lisbon arrived, and established a naval presence on the west African coast, by-passing the Sahara trade route. The African's trade monopoly was over. Other European colonial powers soon joined in the chase for wealth. When other global goldfields opened in South America and elsewhere, the Europeans developed an equally lucrative trade: shipping African slaves across the Atlantic for profit and to provide labour for their plantations in the colonies.



Manu Masa, emperor of Mali

The history of the oceanic empires was always told from a Eurocentric perspective which ignored or decried African culture. This attitude produced some very silly responses in the late 19th and early 20th century when ancient African works of art came to light in modern-day Nigeria. The 15th century *Ife* empire royal heads and the 16th century Benin bronze plaques caused a

sensation when exhibited in the west. Some refused to believe they could be African. It was suggested that they must have been influenced by European Renaissance artists, or that the mythical island of Atlantis was here and when it sank Greek survivors made them, or that Benin was one of the lost tribes of Israel.

When their African provenance was established, attitudes were transformed. African civilizations had existed. Nigerian-born novelist Ben Okri admires the tranquillity he senses in the *Ifa* head in the British Museum: "*Tranquillity in a work of art speaks of a great internal civilization, because you can't have tranquillity without reflection, without having asked the great questions about your place in the universe and having answered those questions to some degree of satisfaction. That for me is what civilization is*."

Speaking of heads, the Caliphs were unlucky. Abd al-Malik, the 9th caliph, saw the value of an emperor issuing currency with the image of their head on them, an idea pioneered by the Greek Alexander the Great and the first Roman emperor Augustus. In 696 Abd al-Malik issued his own coins, based on Byzantine designs. It has his own full-length figure on them, wearing Arab robes and a Bedouin head-dress, with a whip on his belt, and his hand resting menacingly on his sword. Fear and respect are the message. It is possibly the earliest representation of a Muslim, and unique in showing what caliphs wore.

But in 697 it was suddenly withdrawn. The new coins had only Arabic text, quoted from the Quran. "*God is One, God is the Eternal. He begets not, neither is He begotten*." The Muslim clerics had clearly had their say. For the next thirteen hundred years portraits and any figurative art were very strongly discouraged in the official Islamic world. As Neil MacGregor says, "*If coins declare the dominant power in a society, it is clear that in this society it is now not the emperor, but the world of God*."

History books and films frequently use images on coins to help bring past rulers back to life for their readers and viewers. But not the caliphs. And in the modern age of image-based PR, that renders them virtually anonymous.

SESSION SEVEN

EARLY MODERN EMPIRE: OTTOMAN, MUGHAL, EUROPEAN

Introduction and outline

The foundation of the Ottoman empire by Osman in 1299 centred on Anatolia (modern-day-Turkey) began the last great period of classic, sedentary empire-building. The following empires all rose to power during the ***early modern era***, from the ***16th to the 18th century***:

- The ***Mughal*** (Indian) 1526 – 1857 CE
- The ***Ottoman*** (Turkish) 1299 – 1922 CE
- The ***Habsburg*** (Austrian) 1282 – 1918
- The ***Romanov*** (Russian) 1721 – 1917.

- The ***Mughal empire*** was an Islamic Persianate empire with nomadic origins.
- The ***Ottoman empire*** was an Islamic sultanate with nomadic origins.
- The ***Habsburg empire*** was a European dynastic and oceanic empire.
- The ***Romanov empire*** was a European dynastic empire, with Orthodox Christian, Asian and Mongol influences.

The **geopolitics of the early modern era** were complex. As we saw last session, the ***Ottoman*** and ***Mughal*** empires hemmed in the west Europeans, directing their ambitions westward over the oceans after 1500. The ***Ottoman*** empire challenged the ***Habsburg*** empire in eastern Europe but twice failed to capture Vienna. The ***Habsburg*** empire originated in the Duchy of Austria and for a time also included Spain, whose overseas colonies made it the first truly global empire. The ***Mughal*** empire seemed secure behind the Himalayas, but in the 18th century succumbed to western European oceanic power, particularly from the British, whose East India Company took over the country. After the 1857 Indian rebellion, the British dissolved both the East India Company and the ***Mughal*** empire and imposed direct rule over "*the Raj*". Victoria and her successors held the title *Indiae Imperator* until 1948.

THE MUGHAL EMPIRE (1526 – 1857)

The Mughals were India's greatest imperial dynasty. As in western Europe, Empire did not take root in India. A thousand years separate the era of the Mauryan and Gupta empires (ended 550) and the birth of the Mughal empire (1526). Yet in its origins the Mughal empire incorporated a vast diversity of influences. A nomadic, Islamic and Persianate dynasty ruled over a majority

Hindu people, which also included Muslims, Sikhs, Jains, Christians, Zoroastrians and Buddhists. And its founder, Babur, was a Turkic-Mongol descendant of Tamerlane (Timur) on his father's side and Chinggis Khan on his mother's. Here were the makings of a culturally and intellectually rich imperial tradition.

Babur

Babur, (Persian for "tiger") was the leader of a Mongolian warband of archers. The Mughal empire he founded blended Persianate, Islamic and steppe traditions with Indian Sanskrit culture. Babur was descended from Timur and Chinggis Khan inherited Uzbekistan in 1494. Their line took pride in their ancestry but lacked dynastic solidarity; each brother believed they had an equal right to succeed and fought one another incessantly.

Timur's empire failed politically but was culturally brilliant, combining ancient Persian/Achaemenid and Zoroastrian traditions with Hellenic/Greek influences from Alexander the Great's time, plus Islam. In the 10th and 11th centuries this rich blend of traditions had made the region home to the world's finest philosophers, scientists, historians and mathematicians. The region was devastated by the Mongol invasions and the Black Death, but the Timurids revived them in the 15th century. Particularly celebrated was the observatory they built in Samarkand.

India was difficult to invade. Its northern land border was accessible only via the high passes of the Hindu Kush, Afghanistan and the Khyber pass. It was easy for opposing forces to defend. The Sultan of Delhi has the distinction of being able to stop even the Mongols. Babur succeeded by exploiting political divisions between the northern rulers, making exploratory raids, smashing his enemies in two swift battles, and gaining a tenuous hold on the North Indian Plain.

Why did Babur want to conquer India? Part of the answer was that he had found his native Uzbecks too difficult and obstructive to his ambitions. The other part was that he was tempted by the wealth of India, such as the rich farmland of the Punjab and the North India Plain. Conquering it could give him the means to restore the honour of his ancient Timur line. He didn't actually like India, not its people, culture, food or climate: "*Hindustan is a place of little charm. There is no beauty in its people, no graceful social intercourse, no poetic talent, no etiquette, nobility or manliness. The arts and crafts have no harmony or symmetry. There are no good horses, meat, grapes, melons or*

other fruit." But significantly he added, *"The one nice aspect of Hindustan is that it is a large country with lots of gold and money*."

Akbar

His grandson, Akbar, was the Mughal's most remarkable emperor, despite being illiterate, possibly due to dyslexia. He favoured the Shia Sufi branch of Islam, noted for its mysticism, which was also attractive to many Hindus. But he was also interested in Sunni beliefs. Uniquely, he held debates between Muslims, Hindu brahmans, Jesuits, Zoroastrians and Jains. He offended both Jesuits and Moslems by rejecting monotheism in favour of an eclectic spirituality which combined the insights of all creeds.

Akbar's achievement was, through compromise and tolerance, to root his conquering dynasty in a country where Hindus were the majority. Lieven said he "*turned a central Asia conquest machine into a political system rooted in the Indian subcontinent*." He did so by promoting a unique imperial ideology. He presented himself as the arbiter of disputes over Islamic doctrine, the saint of an imperial Sufi sect, and the inheritor of Persian and Hindu traditions of sacred monarchy. He even threw in astrology, calling himself "*Lord of the Conjunction*" (between Saturn and Jupiter).

More practically, Akbar greatly expanded Mughal territory. The Mughals were military innovators. In 1514 Babur chained wagons together on the battlefield to serve as temporary fortresses defended by muskets and cannon and from behind which cavalry charges were launched. And in 1568 Akbar, faced with a huge enemy fortress perched in inaccessible hilly terrain in the city of Chittor, ordered a huge gash to be carved in a mountainside to allow his great siege guns to move into position and blast at its immensely thick walls at point blank range. Akbar's cavalry mastered the core of the North India Plain and conquered the rich provinces of Bengal and Gujarati and the strategically important Rajasthan which linked the ports to the North Indian Plain. He built an amphibious fleet to project his power into the jungles, swamps and rivers of Bengal. He preferred compromise and co-opting defeated local rulers, but used terror when opposed. He built good relations with leading Hindus.

Decline and fall

Geopolitically the Mughal empire seemed secure. Its territory was vast and increasing yet united. Succession disputes were eliminated. Emperors went on great tours with their splendid courts and thousands of soldiers. But it had weaknesses. its roots were shallow, outside the core in the forests, mountains and jungles. A Dutch observer said they were "*king of the plains and open*

roads only." There was no real bureaucracy (until the British later created the Indian Civil Service).
The Mughals failed for several reasons. The emperors were fixated on reconquering their ancestral lands north of India but met defeat in the 1640's. In 1739 the semi-nomadic Khurasan people north of the frontier broke through, sacked Delhi and stole the Peacock throne. Then in 1757 Sir Robert Clive, on behalf of Britain's East India Company, defeated the Mughal army at the battle of Plessey. The Company seized Bengal and used it as a regional base to gradually extend their control of the whole subcontinent. The British, by gaining India, the jewel in the crown of their rapidly expanding oceanic empire, put themselves at the forefront of European power and progress. But in fact the Mughal empire was already imploding. The Ottoman and Chinese empires would follow a similar route, cracking under prolonged western pressure before the final extinction.

British rule was based on an ideology of cultural, racial and class supremacy, cloaked in a "civilizing mission". But as the 1857 rebellion showed, they ignored Indian sensibilities at their peril. Anglo-Indian relations were much more complex and nuanced than they appeared. They involved many layers of subtlety, ambiguity and irony. The Mughals, like the Ottomans and Chinese, discovered that cultural depth, traditions and splendour were no match for western naval mobility and firepower. As humourist Hilaire Belloc put it in *The Modern Traveller*, 1898:
"*Whatever happens, we have got*
The Maxim gun, and they have not."

<u>THE OTTOMAN EMPIRE (1299 – 1922)</u>
The longevity of the Ottoman empire – born in the Middle Ages, surviving well into the modern era – is only one of its surprising features. In 1453 it captured Constantinople, Eurasia's greatest city which had defied the armies of Islam for 800 years This ended the Byzantine empire, the last vestige of Rome; the Ottomans promptly claimed to be the rightful heirs of both Alexander the Great and Rome: the universal empire. Three centuries later they went further, claiming to be the heirs of the Islamic caliphate world. This is an astonishing record for any empire.

The Ottomans became one of three great Muslim empires in 16th century Eurasia, together with the Mughals and the Safavids (Iran/Persia). The Ottomans, regarded as nobodies when they began, outlived the other two, lasting 650 years. They began in the 13th century as a very successful warband on the fringes of Islam and Christianity. Their founder, Osman I,

based their legitimacy on the claim that the last of the Turkish-Persian Seljuk dynasty had granted them their core lands in the 11th century. From the Seljuks they also inherited an aspiration to universal world empire based on justice and equity, confirmed to Osman in a dream. Islam, the Seljuks and folklore combined to give the Ottomans their legitimacy.

Two conquests however transformed them into a great world empire: they captured *Constantinople*, the capital of Byzantium, in 1453; and took over the *Holy Places of Islam* in Arabia in 1517, from the control of the Egyptian *mamelukes.* Capturing Medina and Mecca made the Ottomans the custodians of Sunni Islam.

The golden age of the Ottoman empire was between 1453 and 1600. The Sultans Mehmed II (from 1444), Selim I (1512) and Suleyman I (1520) were formidable, majestic and remote emperors. Suleyman refused to call Charles V Holy Roman Emperor: that title belonged to him. However after Suleyman the power of the Sultans was eclipsed by the nobles, scholars and army leaders (Janissaries). Incursions from the Russian empire rallied them around the sultans in a bid to reverse the decline; this included declaring the sultan the Caliph of all Islam. Trying to reverse decline became the recurring pattern. By 1908 the so-called Young Turks, modernising army officers and westernised professionals, took over the running of the empire. But defeat in the First World War finally discredited the Ottoman dynasty and the military dictator Mustapha Kemal (Ataturk) ended it in 1924, together with the Caliphate. This was the birth of the modern republic of Turkey.

As we saw in a previous session, the Ottomans cared little for dynastic loyalty. Successors to the sultanate were expected to battle their way through and kill all their brothers and nephews (later they were locked in cells in the harem instead, not necessarily however a good education for future emperors). Dismissed viziers were also often killed. The people didn't mind this; an autocratic, formidable sultan would keep the elite landowners off their backs and keep taxes down.

Suleyman the Magnificent

Suleyman was the most famous Ottoman emperor. He was called "lawgiver", and set up schools called *madrasas* to produce teachers and judges. He fought twelve wars to conquer Serbia, Hungary and Mesopotamia. He defeated the Safavids to the east and the Habsburgs to the west. He challenged Portugal's bid to dominate the Indian Ocean. But he dreamed of

more, a universal Muslim empire that would surpass even the past grandeur of the Arabian Caliphate.

But long wars exhausted the Ottomans, gaining neither territory nor booty. Warfare was changing, towards firepower, shock-tactics and tight, disciplined formations. Coordination and logistics came to the fore. Defeats by the Russians came as a warning that the Ottomans were losing the initiative. The Russians pushed them back from the Black Sea, Crimea, the Caucasus and the Balkans.

Geopolitics was against them. Suleyman failed to get beyond Belgrade in the west or Baghdad in the east; these were 344 miles and 828 miles respectively from Constantinople. Distance, logistics and communications defeated them. Their failure to capture Vienna after two sieges saved the Habsburgs in Austria. Nor could they defeat the Safavids in Iran. Forced to co-exist with their greatest rivals, the Ottomans had reached their natural geopolitical limits.

As with the Mughals, culturally they glittered, particularly in law, their Persian-inspired literature and poetry, their exquisitely fine and austere mosques, their carpets and Iznik tiles. But politically and militarily they struggled against the odds to ward off decline in a race against the west they could not win.

THE HABSBURG EMPIRE (1282 – 1918)

The Habsburg story is above all a story of *dynasty*. At its height, the Habsburg empire inherited by Charles V in 1519 was the first true empire to emerge in Europe since the age of Rome, certainly the first since Charlemagne in 800. It was also the first truly global empire. However, it also contained deep contradictions which proved to be the seeds of its destruction. These contradictions can be traced back to the manner of its creation.

The famous boast of the Habsburg dynasty, who controlled the duchy of Austria since the late 13th century, was, let others wage wars, but you, happy Austria, shall marry ("*Bella gerant alii, tu felix Austria nube*".) They were famous for accumulating their vast territorial empire by strategic marriages. This is somewhat misleading however; military conquest and luck also played a part.

Either way, the upshot was that the Habsburg dominions inherited by Charles V in 1519 included Austria, Hungary, the Holy Roman Empire, Spain, Portugal, the Netherlands (formerly the Duchy of Burgundy), plus immense overseas

colonies spanning both hemispheres and the Atlantic, Pacific and Indian oceans. This was the first empire "*upon which the sun never sets*".

But the very success of the Habsburgs came with costs, First, dynastic marriages within Europe's royal dynasties inevitably brought much evidence of inbreeding, in the form of mental weakness, physical deformity and infertility. Charles V had the infamous "Habsburg jaw" and drooping mouth. And as we'll see, infertility impeded their dynastic interest at significant moments.

Second, the increasing size and power of their empire alarmed the other European states who came together to form alliances against them to restore the balance of power. Charles V was suspected of aspiring to universal empire. His son Philip II, king of Spain from 1556 to 1598 adopted the motto "*Non sufficit orbis*" – the world is not enough – with a symbol of a horse jumping over a globe, used on Spanish coins and medals.

Third, the vast and diverse Habsburg territories proved virtually impossible to rule. The emperor Charles V and his son Philip II king of Spain were contrasting figures. Neither was particularly intelligent. But they faced a superhuman challenge. Charles was outgoing, exuberant and chivalrous. He loved military campaigning, the company of women, iced beer and oysters. But the burdens of incessant travel through his vast domains wore him out and brought on spells of depression.

Philip by contrast is described by Lieven as austere and self-disciplined, "*the quintessential royal chief bureaucrat, weighed down by the burdens of administration and operating most happily through written reports rather than face-to-face meetings*." This turned him into "a *sinister, black-clothed recluse, weaving plots behind the blank stone walls of his palace-monastery, the Escorial near Madrid."* Obsessional and inflexible, he was hard-working yet often inefficient. He was devoted to his wife*, sisters and daughters, collected books, art and exotic plants and exemplified "*the loneliness of power*". Failures such as the defeat of the Spanish Armada in 1588 caused him to despair and to doubt that God was with the Habsburg cause. There was no Habsburg tradition of the theatre of empire: no coronations, no grand thrones, no personality cults. Lieven finds the way they submerged their own personalities and lives in the interests of the dynasty "*admirable, moving and terrifying*."

*Before becoming king of Spain, Philip had a brief arranged marriage to Queen Mary I of England. They married in Winchester. On her death, he proposed to Elizabeth I but she declined.

The last Habsburg to rule Spain was Charles II. On his death in 1700 he had no heir, a possible consequence of in-breeding. He willed Spain to his great nephew, Philip of Anjou. Europe was alarmed. Philip was a member of the Bourbon family – the royal family of France. Any chance of a union between the French and Spanish thrones raised the spectre of a new superpower. Even though Spain was in decline, it still ruled the Netherlands plus much of Italy and the Americas. To allay these fears, under the terms of the will Philip had to renounce all future claim to the French throne. But it wasn't enough. Europe was spooked. War resulted.

The *War of the Spanish Succession* lasted from 1701 to 1714. It was waged in Europe and the Americas. It ended in mutual exhaustion and with the agreement that Philip should become king of Spain on exactly the same terms he'd originally accepted in 1700. The Bourbons are still kings of Spain today. Futile dynastic wars were the price of dynastic empires.

The Austrian Habsburgs were survivors, skilled at regrouping in the face of adversity. In 1529 and 1683 they just managed to hold off Ottoman sieges of Vienna, halting the advance of Isam. They survived the French Revolution of 1789, the 1848 revolutions and the rise of a united Italy and Germany which reduced their influence in those regions. But nationalism defeated them in the end.

In the summer of 1914, as the great powers of Europe once again teetered on the brink of war, the Habsburgs were the only power who believed their very existence was at stake if they didn't go to war. Throughout the 19th century they had been fighting a rear-guard action against the rising tide of nationalism which they knew would destroy their multi-national empire.

In 1914 it all came down to Bosnia. In June a terrorist plot hatched in Serbia and carried out by a Bosnian nationalist succeeded in assassinating the archduke Franz Ferdinand, the heir to the Habsburg empire, in Sarajevo, the Bosnian capital. The Habsburg emperor resolved to attack and destroy Serbia. But Russia could not let an ally and fellow Slav nation be so treated. The First World War broke out in August. In 1918 the Habsburgs faced defeat and the break-up of their empire into a patchwork of small new nations. Today Austrians still have their huge former imperial capital, Vienna, to remind them.

In 1914 the Habsburgs did what they had always done: they put the interests of the dynasty before everything else, including the peace and future of

Europe. In the midst of the horrors of the First World War, Count Czernin, a former Habsburg foreign minister, realised the horror of what they'd done: "*We were bound to die. We were at liberty to choose the manner of our death, and we chose the most terrible*."

THE RUSSIAN EMPIRE (1721 – 1917)

The history of the Russian empire can be told as a tale of two cities: Moscow, the ancient capital of Muscovy (though Kiev can claim to be an even more ancient capital of "Rus"); and St Petersburg, founded on the Baltic in1703 by Peter the Great. He made it Russia's new capital in 1714. On the outbreak of the First World War in 1914 it was given the less Germanic name of Petrograd. After the 1917 Revolution the communist government renamed it Leningrad (1924) in honour of their just-deceased leader Lenin. After the fall of communism in 1991, a referendum narrowly voted to change it back to St Petersburg again. Meanwhile, Moscow had been made the capital again in 1918 and has remained so ever since. Thus Moscow represents the old Russia of the east, St Petersburg the new Russia of the west.

This history reflects the identity crisis that lies at the heart of Russian history: basically, are they part of Europe or not? Geopolitically, Russia is on the edge of Europe. It also lacks natural barriers to the west, leaving it exposed to European attack. Its early history is ambivalent. Its origins lay in a viking dynasty called the *Rurikid*, who moved their capital from Novgorod to Kiev in Ukraine. Then came the Mongol invasion, after which Moscow emerged at the new capital.

Here accounts differ. The Russians claim that the Ukrainians have no national history; they are simply Russians. Ukrainian nationalists argue that their national history incorporates that of Russia. When the early Russian Tsars drove the invading Poles out of Ukraine they called themselves "*Tsars of all the Russias*". They suppressed Ukrainian identity and imposed the Russian language.

After the 1917 Russian revolution, things briefly relaxed: Russia, Ukraine and other historical states joined together to create the so-called "*Union of Soviet Socialist Republics*" (USSR), united by their communist ideology. But Stalin in the 1930's sought once again to crush Ukrainian cultural identity. This was in turn relaxed yet again in the 1960's under Soviet leader Nikita Khrushchev, a Ukrainian by birth, who granted Ukraine some autonomy. Then came the collapse of the USSR in 1991. Ukrainian nationalism enjoyed a resurgence.

But for Russians the end of communism meant the loss of great power status through the break-up of their former “empires”, both Tsarist and communist. All was confusion. The Russians were forced back upon their history to forge a new national identity. But which history?

There are contradictory influences. The decision in 988 of Vladimir the Great, ruler of Kievan Rus, to convert to Orthodox Christianity tied Russia firmly to Europe and the west – or at least to Byzantium. Yet it also tended to isolate it as an Orthodox country from the Catholic or Protestant churches of the west. Similarly although most of the Russian population live in the western territories, the vast expansion eastward to Siberia begun by Ivan the Terrible gained made the Russian Tsars rulers of one-sixth of the world’s landmass, albeit that the east is an inhospitable and sparsely populated region.

Another fundamental influence came from Russia’s two centuries of subjection under the Mongols. The humiliations and brutality they experienced left a deep mark. So did the difficult process of becoming Tsarist Russia under the *Romanov* dynasty, during which they experienced the traumatic “*time of the troubles*”, a period of weakness, collapse, Polish invasion and civil war until the Romanov triumphed and united Russia. All this added to Russia’s already complex worldview, where only strong leadership and territorial expansion could ward off a descent into weakness, collapse and humiliation; yet even they may not be sufficient to prevent it. Defeat and dissolution were constant fears.

Underlying these fraught historical issues was the fundamental geographical one. In the time of the troubles, the Poles had invaded Russia from the west. There were no natural barriers to prevent this. The mighty Ural mountains lay far to the east. Europeans could attack at will. After the Poles came Napoleon (1812), the Kaiser (1914), then Hitler (1941). All attacked from the west. The bitter paradox of Russian history was that immense scale brought no security.

This was intensified by their acute awareness of how Europeans looked down on them as only half-civilized. Worse, they themselves half-believed it was true; not even Tchaikovsky or Tolstoy could quite dissuade them. In the 19th century some Russian thinkers and artists felt they should reject European values altogether and embrace an Asian identity. Others believed they could bring something unique to European culture: a more sincere Orthodox Christian piety; a more authentic peasant simplicity; a corrective to the materialism, falsity and affectation of European so-called sophistication.

But others, like Peter the Great (see below), wanted the opposite: to wholeheartedly embrace the west, reject Asia and suppress all non-European aspects of its culture as backward and outdated. All the elements of what Freud would later call the inferiority complex were here.

Moscow the Third Rome

Russian history provided a final twist, in some ways the strangest one of all. This story goes back to 1453. In that fateful year, after resisting the advance of Islam for over 600 years, the mighty city of Constantinople was captured by the Ottomans. This shocking event ended the Byzantine empire. Rome was finally extinguished. The rulers of Russia, soon to be Tsars, now saw a unique opportunity which they seized. They claimed that, as the only remaining Orthodox Christian power, they had thus become its protector. Further, this made them the true heirs to Rome. They were, in effect, the Third Rome. By the ancient principle of imperial translation, universal empires like Rome could never end: their mantle would be passed to the rightful heir. To put it simply, *Moscow was the New Rome*. At the time few took this seriously, apart from a few devout Russian Orthodox churchmen and optimistic advisers to the Tsars. As the Russian monk Philotheus of Pskov wrote in a letter to Vasili III, "*Two Romes have fallen. The third stands. And there will be no fourth. No one shall replace your Christian Tsardom*!"

In fact Russia soon took a different direction. In 1721 the Russian senate formally offered the title of emperor to Peter the Great (1672 – 1725) who had just defeated Russia's latest great rival in the north, Sweden. Peter had always made clear his belief that the Russians could not hope to compete as a European power unless they westernised their country. He embarked on a programme of reforms to do this, facing down opposition from the traditionally minded aristocracy and peasants.

Ironically, although Peter was the great westerniser, he was hardly a model of typical European monarchy. He was seven feet tall, waved his arms about wildly when talking, couldn't sit still, loved learning manual crafts and how to operate machines, personally shaved off nobleman's Asian-looking beards, and designed, then tried out, dental equipment. When visiting Deptford dockyard he abandoned his English hosts and Russian minders to join the labour force on the shop floor. His high-jinks with his entourage inside the English stately home he was lent included indoor pistol target-practice, to the dismay of his host.

There was something slightly forced about St Petersburg, his new capital and "window on the west", the symbol of westernisation. The nobles had to be forced to build new houses there. It's public architecture was a little too grandiose for European tastes. Peter's approach to westernising Russia could only ever be superficial.

Thus the story of the Russian empire in the 18th and 19th centuries was one of attempts to push through modernising reforms along western lines but with only partial success. Serfdom was abolished in 1861 but rural poverty continued. Industry grew in the cities but produced worker discontent rather than prosperity. A parliament was granted, but given no powers, angering liberals. In the First World War Russia fought on the winning side but dropped out in 1917 before victory was achieved due to the long-predicted revolution. This brought communist rule under Lenin, forced industrialisation under Stalin, victory against Hitler, even the space race: but ultimately defeat in the Cold War.

Out of the wreckage of the fall of the USSR in 1991, Vladimir Putin constructed a new Russian identity. Its inspirations were contradictory. It aimed to resurrect the superpower status of the lost USSR, and to support this by reviving the old ideology of Moscow as the New Rome. This essentially spiritual idea, that Russia had a unique, God-given mission to save humanity, had revived in the late 19th century among Russian Pan Slav thinkers. But now Putin gave it the place of honour in his worldview. Russia is neither European nor Asian, neither eastern nor western, neither communist nor capitalist. Russia is the heir to Rome and to Byzantium. It is a unique civilization with a unique destiny. Russia must expand to gain secure frontiers. Russians must be unified by bringing Ukraine into line. European and American opposition to this programme must be resisted.

According to journalist Kristaps Andrejsons, "*These imperial myths are what define Russia, what it even means to be a Russian. Without them, Russia just stops being Russia in the eyes of many. Putin is convinced that if this social glue is disrupted, then Russia will just split up in pieces again—and if he allows that to happen, then his legacy is ruined. For him, there can be no separate Ukrainian language, culture, or history.*"*

*"Russia and Ukraine Are Trapped in Medieval Myths", Feb 2002, https://foreignpolicy.com/2022/02/06/russia-and-ukraine-are-trapped-in-medieval-myths/ He quotes an article by Russian President Putin (July 2021) on the Kremlin's official website called "*On the Historical Unity of Russians and Ukrainians*" which he calls "*a key guide to the historical stories that shape Putin's and many Russians' attitudes*." See also:

Jiaqi Cao. “Religious Origin and Political Extension of the idea of ‘Moscow – Third Rome’”. *Advance,* October 2023, **10.31124/advance.24306514.v1**

Are these ideas inspired or demented? Can being the heirs of Byzantium and custodians of a revived Orthodox Christianity seriously provide a launch-pad for a genuine national resurgence in the 21st century? Ot are they the irrational but predictable response of a nation which has experienced humiliation and sudden decline? Many Russians are said to support Putin. This is hardly due to his personal charm or charisma. He presides over a grim, authoritarian sham-democracy, ruthless and even murderous towards political opponents. Censorship and propaganda are absolute.

Karl Marx said that history repeats itself, the first time as tragedy, the second as farce. Putin’s cranky medievalism could be called farcical were it not that a million people have died so far in his bungled attempt to crush Ukraine.

Historians of empire Dominic Lieven concludes: “*Any state whose roots lay in the vast Muscovite heartland and which evolved through surmounting these geopolitical challenges, was unlikely to be a model of liberty and benevolence*.”

Next

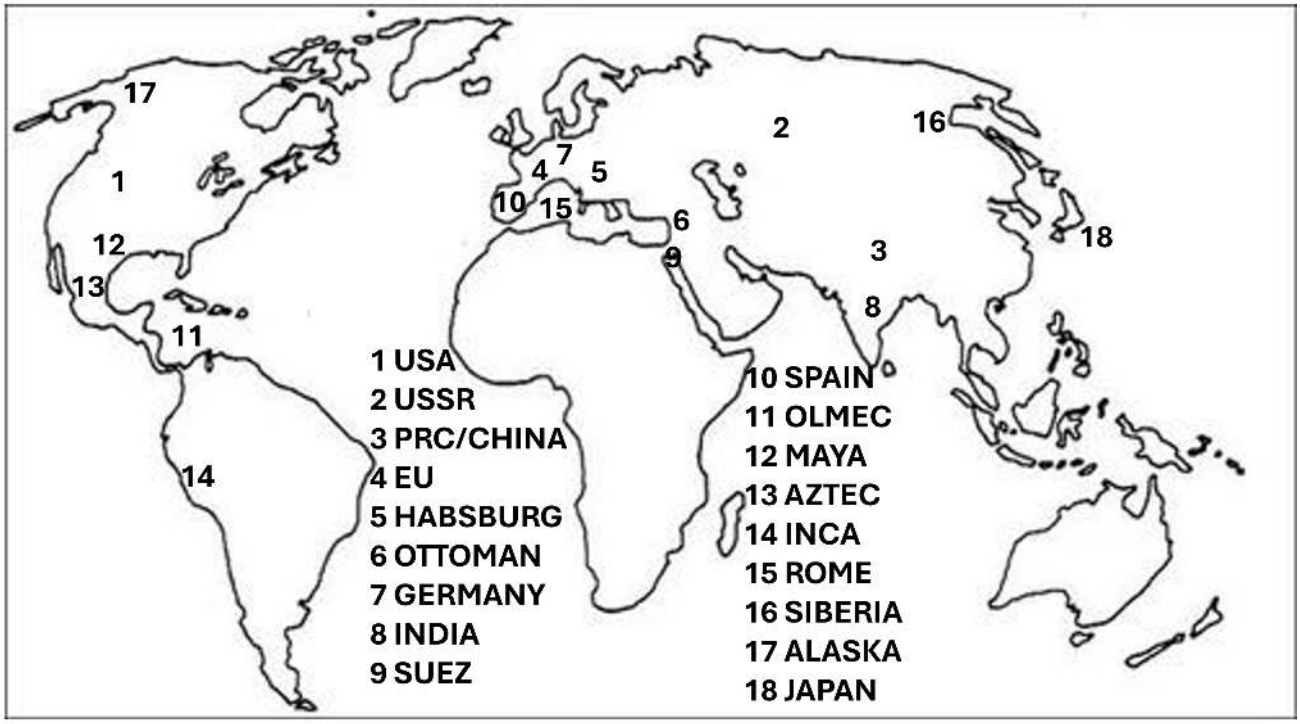
These four empires existed on the eve of modern times. The Mughal ended in 1857, the Romanov in 1917, the Habsburg in 1918 and the Ottoman 1924. Next session we’ll discuss how and more fundamentally why the age of empire, almost as long as history itself, finally ended.

SESSION EIGHT

THE FATE OF EMPIRE

In this session we'll consider the ***disappearance, afterlife, survival*** and ***legacy*** of empire.

Locations mentioned:



Empire lasted for around 5,000 years, in essentials unchanged. But in the 20th century it all but disappeared. Remarkably, every substantial land empire to survive into the twentieth century – that is the Chinese, Romanov/Russian, German, Habsburg/Austrian and Ottoman/Turkish – all disappeared in the decade between 1912 and 1922. The greatest ever empire of India, the Mughal, had ended in 1857. The Holy Roman Empire, founded by Charlemagne in 800, long centred on Germany and the Habsburgs, ended in 1806. Napoleon I had a French empire from 1804 to 1815; his nephew Napoleon III from 1851 to 1870.

Today, only Japan has an emperor. We live in a world politically made up of nation-states. There are other large-scale supra- or non-national entities, ranging from the UN, the EU and NATO to Google, MacDonalds and Facebook. And of course X. Few would call them empires. However, what about the superpowers, present and future, such as the USA, the People's Republic of China, the Russian Federation and the Republic India. Are these

not empires in all but name? Some non-western states resent the way in which the west claim that its values, of "western civilization", are now universal. States such as China, Egypt Iran and Turkey suggest they are "civilization states" – because they can claim to embody not merely a nation but a whole ancient cultural tradition or civilization.

PART ONE - DISAPPEARANCE

Why did empire disappear?

Empire disappeared for three basic reasons. All three are linked to the French Revolution of 1789.

First, the decline of religion and the rise of *secularism*. Emperors were sacred beings who promised to uphold the cosmic as well as the earthly order. But the 18th century Enlightenment promised a new age of reason and secularism. Religion no longer provided the same degree of legitimacy. This helped to inspire the French Revolution.

Second, and allied to this, was the rise of *democracy*. The French Revolution proclaimed a new age of democratically elected leaders. This directly challenged the legitimacy of hereditary, autocratic emperors.

Third, the rise of *nationalism*. The French Revolution, by proclaiming the sovereignty of the people, also encouraged the idea of a national community, people who share common traditions, language and history. This undermined the legitimacy of nationally diverse (or "multinational") empires.

In 1815 the monarchs of Europe united at the Congress of Vienna determined to bury all trace of the French Revolution. The Treaty of Vienna looked forward hopefully: "*The time will come when treaties will no longer be mere truces, when they will once more be observed with that religious faith, that sacred inviolability which underlies the esteem, the power and the preservation of empires*."

Some hope. The French Revolution could not be silenced; secularism, democracy and nationalism were on the march. The nineteenth century saw further waves of revolutions, demanding more democratic governments and national self-rule. 1848 has gone down in history as the "the year of revolutions". Meanwhile, nationalism was redrawing the map of Europe: Italy and Germany became unified. Empires promised security to a vast diversity peoples. But 19th century nationalists believed that such security would best

be provided by living alongside their fellow nationals, that is people who shared a common national identity, defined by a shared history, traditions and customs. This was the death-knell for empire.

Empire prided itself on its diversity, but this was now considered an anachronism. The multinational Habsburg empire included Austrians, Germans, Czechs, Slovaks, Hungarians, Slovenes, Croats, Bosnians, Poles, Rumanians, Italians, Ukrainians, Belgians, Dutch, Italians. Similarly, the multinational Ottoman empire included Turks, Greeks. Bulgarians, Serbs, Montenegrins, Macedonians, Albanians, Bosnians, Herzegovinians, Iraqis, Syrians, Lebanese, Palestinians, Jordanians, Egyptians, Libyans, Tunisians, Algerians, Sudanese, Arabians and Yemenis.

It would be wrong to assume that all these diverse peoples automatically objected to living under Habsburg or Ottoman rule. Empire did provide security in diversity. Far worse to be a national minority within a nation-state. The Habsburg and Ottoman empires broke up and fragmented into their various national groups, the cores becoming the nation-states *Austria* and *Turkey*. But national borders can never be drawn with exactitude. Not every former subject cheered when the empires fell. This helped seed future instability and war. Yet the rise of nationalism was inexorable.

As we saw last session, there was a struggle between two different concepts of empire, traditional sedentary land empires and “empires of mobility” such as the west European oceanic empires. Thus when the British lost their American colonies in 1783, they adapted quickly and diverted their energies across the world to completing their subjugation of India. Yet this global struggle between the sedentary and oceanic empires proved a long one, continuing unabated from1500 to 1900. The oceanic empires only finally triumphed in the 1920’s, by which time the great land empires of Eurasia were no more.

Fall of the land empires

The first to go was the Chinese empire in 1912. It disintegrated into the chaotic rule of war lords. After civil wars and war with Japan, the communist leader Mao emerged triumphant as leader of the Peoples’ Republic of China in 1949. The First World War (1914 – 1918) destroyed the other great sedentary empires. The Russian empire fell with the Russian Revolution of 1917. The communist leader Lenin seized power and proclaimed the USSR in 1924. He and his successor Stalin were often referred to as “Red Czars”.

The German empire fell with defeat in 1918. This was a recent creation, effectively a wider German nation-state, when the disparate states of Germany came together in 1871 after their leading state Prussia defeated France in a short war. The Prussian kings, the *Hohenzollerns,* became German emperors. But having been made by victory in 1871, it was unmade by defeat in 1918. Germany then went from a republic in 1918 to Hitler's *Third Reich* in 1933. *Reich* means state or empire; *Third* because it came after the *Holy Roman Empire* and the *Hohenzollern* empire. Another defeat, in 1945, destroyed Hitler's "empire". Defeat in the First World War also destroyed the Habsburg empire (1918) and the Ottoman empire (1924).

The west European oceanic empires seem to have triumphed. But their victory was short-lived. The biggest of them, the British Empire, actually reached its maximum size in 1923 when it gained new colonies from the defunct Ottoman empire in the Middle East. But it was already suffering from overstretch, struggling to defend its far-flung colonies. The war had also taken its toll on Britain's finances and economy.

Then came the Second World War (1939 – 1945). The Germans and Japanese, disappointed by the outcome of the First World War, in the 1930's embarked on ruthless military conquests in Europe and Asia; in effect, an attempt to revive territorial empire. Their defeat was only assured by the participation of the USA and the USSR, both non-empires and hostile to the concept (see below).

End of the Oceanic empires

After 1945 nationalism spread beyond Europe and swept across the world. The colonial peoples of the west European oceanic empires demanded independence and national self-determination. This became a tidal wave of "*decolonisation*", even though the leaders of newly independent ex-colonies often faced insuperable problems. The outcome was inevitable.

The oceanic colonial empires were all dissolved in the second half of the 20th century. Nationalist leaders like Gandhi in India led independence struggles; Indian independence was gained in 1947, the beginning of the end of the British empire.

These flames were fanned by the new superpowers, Russia, America and China. All were hostile to empire as a concept. The Russians had overthrown the Romanov empire in 1917. The Chinese had deposed the last Qing emperor in 1912. And the USA owed its very existence to winning the first ever

war of national independence: the revolt of the thirteen British colonies against the crown in 1776. Thus, although the Americans were close allies of the British in the Second World War and after, they were unremittingly opposed to the continuance of the British empire into the postwar world. This came to a head in the Suez crisis (1956) when they pulled the plug on an Anglo-French military campaign against Egypt to regain control of the Suez canal. Some historians suggest this represents the "real" end of the British empire.

America: empire of liberty?

Despite the USA's hostility to empire, many have argued that America is an empire in all but name. The future power of America was predicted early on in its history. In 1776 economist Adam Smith said they were building "*an extensive empire which seems very likely to become one of the greatest and most formidable that ever was in the world*."

Historian Niall Ferguson points out, "*There were no more self-confident imperialists than the Founding Fathers themselves*." Both George Washington and Alexander Hamilton used the word empire and John Jay said one day it could rival the British Empire. In 1811, John Quincy Adams envisioned a nation "*coextensive with the North American continent, destined by God and by nature to be the most populous and most powerful people ever combined under one social compact*." Thomas Jefferson said that it would become "*an empire of liberty*", which would drive the "*freedom of the globe."* This is how many Americans see it today.

America's nineteenth century westward expansion across the continent and the dispossession of the Native Americans certainly resembles an imperial conquest. It is true that some territories were purchased rather than conquered, such Louisiana, Oregon and Alaska. Either way, the outcome was what historian John Lewis Gaddis called "*continental hegemony*." From thirteen British colonies to a tiny English-speaking republic clinging to the Atlantic seaboard and finally to a continental, then hemispheric, then global empire. In 1845, in a New York newspaper editorial, a journalist called John Louis O'Sullivan memorably called it America's "*manifest destiny*"*.

*"*The right of our manifest destiny to overspread and to possess the whole of the continent which Providence has given us for the development of the great experiment of liberty and federated self-government entrusted to us*."

Many Americans believe they have built Jefferson's "empire of liberty", but others are less sure. America's wars in Vietnam, the Middle East and Afghanistan mean that not everyone agrees with John Gaddis that America has gained "*hegemony by consent*." Further, many Americans favour a policy of "*isolationism.*" If America can be said to have an imperial tradition, it is a deeply ambivalent one.

For a very brief time at the turn of the nineteenth/twentieth centuries, America did take the traditional road of empire by seizing a handful of overseas colonies, including Cuba, Puerto Rico, Hawaii and the Philippines. But they soon lost interest. American global power was based not on colonisation but on *indirect rule* and *informal empire*, consisting of network of military bases, trade agreements, financial aid, arms supplies and technical advice, all reinforced by diverse forms of cultural soft power: Hollywood, Nashville, Tamla Motown, Coca Cola, MacDonalds, Google, Amazon, Facebook and X.

Perhaps the verdict is: *empire is dead. Long live empire.*

PART TWO: AFTERLIFE

The disunited states of South America

So much for North America. What about the South? Thomas Jefferson was wrong in predicting that "*It is impossible not to look forward to distant times*" when the American system will "*cover the whole northern, if not the southern continent*". *What a colossus shall we be when the southern continent comes up to our mark!*" But this never happened; Spain's colonies in South American never evolved into a "United States of South America". Why not?

Basically, neither the geography nor the history of South America were conducive to political unification. Spain's colonies were territorially huge, covering most of Central and South America with its vast rainforests and mountains. The Spanish had been reluctant to colonise the interior; most settled on the coasts. Also the Spanish colonies were forbidden from communicating with each other; everything had to go through Madrid. As a result, the South American interior lacked infrastructure, impeding internal communication. Also, the Spanish rulers imposed the feudal rule of aristocratic landowners on their colonies; the result was poverty, inequality and poor literacy. The Spanish priority was to extract as much profit as possible in the form of cash crops and particularly precious metals, notably silver. In 1807 Napoleon invaded Spain and deposed the king. This triggered the Spanish

colonists to revolt and gain independence. Unlike the British colonists of the North, the Spanish colonists had no powerful common enemy to unite them.

All this was in marked contrast to history of North America. Circumstances in the South conspired against unity of political purpose or a shared identity. South America failed to develop a common national identity or political culture. The Venezuelan revolutionary Simon Bolivar tried to get the former Spanish colonies to agree a merger into a single state, but he met constant opposition. They couldn't even agree on whether to be a republic or a monarchy. Bolivar died in 1830. There were to be no Founding Fathers in South America.

The ancient Americas

But what South America *did* have was spectacular ancient empires. In these sessions we have concentrated on Eurasia. But in his book *Civilizations*, 2001, Felipe Fernandez-Armesto says that civilizations* can rise up wherever humans can survive. Thus, says Armesto, we shouldn't be surprised to find civilizations and empires arising everywhere, including the unpromising and inaccessible Andean mountains.

*He defines *civilization* as the attempt by human communities to "*refashion their natural environment*" by transforming it "*for their own ends*". Civilization is "*the struggle to impose their own kind of order on the world around them. The more strenuous in challenging nature, the more civilized the society*."

Thus the rich and complex American civilizations and empires of the ***Olmec, Maya*** and ***Aztec*** (central or Meso-America) and the ***Inca*** (South America) seem to have arisen in complete isolation both from one another and from Eurasia. Armesto says *"two huge cultural areas, in Mesoamerica and the Andes, created networks of exchange over impressive distances, but remained for centuries almost sealed from the rest of the world and - astonishingly – with no knowledge of each other."*

Neil MacGregor (*A History of the World In 100 Objects,* 2010) summarises the story of how humans reached ancient America, as revealed by archaeology and DNA. By 40,000 years ago human migrants from Africa had settled all over Eurasia. By 20,000 years ago they'd crossed the temporary frozen land bridge linking Siberia to Alaska and reached north America. By 12,000 years ago they'd spread the whole length of North and South America. Archaeologists call these first Americans *the Clovis people*, after a site in New Mexico. It wasn't until 1500 CE that Europeans – the Spanish – first established communication across the Atlantic and encountered the ancient

American civilizations. Almost immediately they conquered and destroyed them.

Archaeologists call the ancient American empires the ***Olmec, Maya, Aztec,*** and ***Inca***. Compared to Eurasian empires, far less is known of their individual histories, but their material remains tell an overall story of great richness and complexity.

The ***Olmec*** (1200 – 400 BCE) laid the cultural foundations for those who followed. Like the first Eurasian empires, theirs arose on lowlands with rich alluvial soils and a major river system, namely the river *Coatzacoalcos*, in the lowlands of the Gulf of Mexico. Olmec means "rubber people"; they extracted natural latex from the rubber tree. They traded widely in luxury goods of jade and obsidian, built monumental carved heads, made smaller jade masks and bequeathed to their successor empires a love of ball games and bloodletting.

Next came the ***Maya*** in the Yucatan peninsula and lowland Guatemala, peaking in the 6th century CE. They excelled at pyramid-building, writing, calendars and maths. By 900 CE most of their grand stone cities had been abandoned. Suggested causes for their collapse are chronic warfare, climate change or overpopulation.

Then the **Aztec** rose in central Mexico from the 13th to the 15th centuries. They controlled many of the region's city states from their capital city *Tenochtitlan*. Their culture borrowed from both the Olmec and the Maya. At its height, the Aztec empire incorporated around 500 small states and five to six million people. It was a complex social, political, religious and commercial order. The abrupt end of their empire can be dated precisely to 1521, when the Spanish arrived on the scene. The *conquistador* Hernan Cortes captured *Tenochtitlan*, killed the emperor *Montezuma*, murdered many of the Aztec elite, ruthlessly crushed all resistance, and at a stroke ended the last native civilization of central America. However the *Conquistarors'* deadliest weapon was European diseases like smallpox, mumps and measles which spread with devastating speed among native populations who lacked natural resistance. The population of the city of Tenochtitlan fell by 40%. Cortes ordered its destruction and built Mexico City on its ruins. It became the chief European city of the Americas.

Finally there were the ***Inca,*** the greatest of all the ancient American empires. Older and further south, they emerged in the Peruvian Andes around 1100. At its height, the Inca empire ruled most of western South America from the

Andes to the Pacific. *Machu Picchu*, their royal winter retreat, only discovered in 1911, was built around 1450. It was fifty miles away from their capital, Cusco, in the Andes. They practiced mummification, freezing bodies in the cold, dry mountain air, which were brought out to attend weddings, harvest festivals and important community meetings. Human sacrifice was practiced, but not on the gruesome industrial scale of the Aztecs. The Andes environment wasn't easy. Rainfall was limited; growing crops were a struggle and riverside land was scarce. The Incas had conquered the Cusco valley around 1300. By digging hillside terraces and irrigation canals they succeeded in growing corn, beans, potatoes, quinoa and avocados. They freeze-dried potatoes which could keep for ten years.

An Inca military fort built of stones set like a jigsaw; this helped in earthquakes.

The ninth emperor *Pachacuti Inca Yupanqui* (below) and his son *Topa* expanded the empire to its peak, controlling most of western South America and ruling twelve million people who spoke thirty languages.

They built an impressive system of roads along the coast and through the Andes with tunnels and bridges; relay runners carried messages up to 150 miles a day. Unusually they didn't have written language, using knotted cords, *quipu* (below). Researchers are using computers to try to decipher these long-lost codes.

The Spanish conquistadors arrived in the 1520's. The Inca empire was already experiencing rebellions and smallpox had killed perhaps 65% of the population. The conquistador Francisco Pizarro came looking for gold and silver which the Incas mined in the Andes. In 1533 Pizarro defeated the

emperor *Atahualpa* by allying with his rebel enemies. Atahualpa tried to buy him off with gold. Pizarro took it, melted it down, and killed him anyway.

Inca gold mask of the sun god, Inti.

<u>Afterlife: ruins of empire</u>

Enigmatic and inaccessible ruins such as *Machu Pichu* (below) have captured the imagination of the modern world.

Ruins have long had the power to do this. An Anglo-Saxon poem called *The Ruin* is probably about the Roman city of Bath:

This masonry is wondrous; fates broke it
courtyard pavements were smashed
the work of giants is decaying
Roofs are fallen, ruinous towers,
the frosty gate with frost on cement is ravaged,
chipped roofs are torn, fallen
And so these buildings grow desolate,
and this red-curved roof parts
from its tiles of the ceiling-vault.

Christopher Woodward (*Ruins: A Journey Through History, Art, and Literature*, 2001) argues that the city of Rome is unique because it has some of the finest classical and pagan ruins alongside some of the holiest Christian shrines. During its fall, although it was captured by barbarians more than once, they didn't destroy its great public buildings (turning off the aqueducts was enough to force a surrender). As pagan Rome crumbled, a new Christian city gradually emerged in its midst. Constantine began this process in the 4th century, carefully locating Christian shrines such as the church of St Peter's (site of Peter's martyrdom) away from the ancient pagan sites. For a thousand years the stones of pagan Rome were recycled in this way. Woodward says that the combined power of the *classical* and the *Christian* – "*the two greatest influences on the mind of Europe*" – made Rome the perfect demonstration of the central Christian idea of the transience of all earthly things (*sic transit gloria mundi;* "thus passes the glory of the world"). He also quotes the poet and artist John Dyer, poet and artist who after visiting in 1724 made the crucial discovery that "*Rome's triumphal arches* [were] *more beautiful now than ever they were*."

Ruins have always attracted writers, poets and artists, seeking the sublime and the picturesque. Wealthy and educated aristocrats returned from their Grand Tour and had replica ruins built on their country estates. Ruins, from Rome to Machu Pichu, became an important part of the afterlife of empire.

PART THREE – SURVIVAL

The Japanese empire

Considering that Japan is the world's only surviving empire, its story is unusual. It is the longest continuous hereditary monarchy in the world, with only one ruling family dating back to the 6th century emperor *Kinmei*. Anyone earlier is considered mythological, including the first emperor *Jimmu*,

traditionally dated to 11 February 660 BCE. The ruling family has no name, but is referred to as *Kōshitsu*: “the imperial family”. The Japanese words for emperor (*Tenno*) and Japan (*Nihon*) date from the 7th century.

Although revered, the emperors were heads of state only symbolically; the job of ruling was done either by regents or by officials called *shoguns*. In 1868, under severe pressure to admit western imports and influences, the emperors were ”*restored*”. But this was misleading; under the new constitution, their power still remained largely symbolic; prime ministers, powerful oligarchs and military leaders held the reins of power.

In the late 19th century Japan resisted colonisation by systematically adopting western technology, industry and institutions, yet striving to preserve the “core” of Japanese culture and identity. This was symbolised by their adoption of the western suit, renamed the *sebiro* (“Saville Row”). It was a difficult balancing act. As the power of the military grew, in the 1930’s they entered the “dark valley” of militarism, conquest and war. In 1945 two American atom bombs forced them to surrender. The emperor *Hirohito* told them they must “*endure the unendurable*”.

The Americans occupied Japan yet allowed the emperors to remain; they needed a strong and cohesive Japan as an ally against Russia in the emerging Cold War. In the 1950’s and 60’s Japan enjoyed a renaissance of industrial and hi-tech dominance, until relative economic stagnation set in, resisting all attempts to kick-start growth*.

*An aging population, few natural resources and lack immigration are suggested causes.

Japan and Britain compared

Japan and Britain are over 6,000 miles apart. Yet people have often pointed out the similarities between them. They have had a complex relationship, with much mutual admiration. The British were intrigued by Japanese culture; the Japanese admired Britian as a paragon of the modern. They were diplomatic allies from 1902 to 1922, bitter enemies from 1941 to 1945, and on the same side since the Cold War. Both are offshore islanders, adjacent to large continents, of similar size, population density and latitude. They share strong naval traditions, historic overseas empires and ancient, respected monarchies. Both are heavily industrialised and arguably share cultural values such as self-restraint and propriety.

But there are also significant differences. Japan is to the east of the ocean, Britain to the west, so their climates differ. Japan gets thick snows from cold Siberian air and muggy summers from southerly monsoon winds. Japan's geology is much younger, and its mountain peaks are higher, steeper and sharper. The British settled widely throughout their isles, but the Japanese had to cram into scarcer lowlands. Glaciation made Britain's rolling lowlands and rounded highlands and also reduced its native biodiversity. Japan's mountainsides encouraged the cultivation of rice, Britain's lowlands dry-field crops like wheat and barley. Britain's landscape is more deforested.

Yet the decisive difference, although it doesn't sound much, is crucial: Japan is much further away from the continent than Britian. Britain lies 21 miles away from France; Japan is 125 miles away from Korea; and 528 miles from China. This meant that Japan was generally safe from invasion and it could, if it wished, cut itself off culturally, as it did during some historical periods. Neither applied to Britain, which could never feel secure or isolate itself from Europe. Our history is filled with invading Romans, Angles, Saxons, vikings and Normans. We battled the French for centuries. Spain and Germany threatened invasions. This is more historically significant than any of the other above factors.

It is true that as offshore islanders, both countries evolved a sense of uniqueness. The Japanese speak of *Shimaguni Konjo* ("island mentality"), the British of "exceptionalism" and being a "chosen people". The Japanese were saved by storms which in the 13th century destroyed two attempted invasion fleets sent by the Mongols. They celebrate them as "divine winds" or *kamikaze*. In the same way the British celebrate the destruction of the Spanish Armada and the "miracle of deliverance" at Dunkirk. Yet there's a crucial difference: Japan's "island mentality" celebrates *insularity*; the British, significantly closer to their continent, have always known they could never isolate themselves. We are both island nations, but one is much more so than the other.

Endangered dynasty?

The current emperor of Japan, Naruhito, was educated in Britain, speaks good English, and plays the viola. His wife, the empress, also speaks impeccable English, went to Harvard, and was an aspiring diplomat within the Japanese Foreign Ministry before she married the crown prince in 1993. But the dynasty has a problem, the ancient Achilles heel of empire: the succession. It is running out of heirs.*

*This section is based on Ella Tennant *Japan's looming imperial crisis – why it's time to open the succession to female heirs,* The Conversation, July 4, 2024 https://theconversation.com/japans-looming-imperial-crisis-why-its-time-to-open-the-succession-to-female-heirs-233795#:~:text=As%20things%20stand%2C%20there%20are,Naruhito's%20uncle)%2C%20Prince%20Masahito.

Naruhito's father, Akihito, abdicated in 2019 due to failing health. This reopened the debate about allowing a female successor. It has growing public support, 90% in a recent poll. A group was set up to explore it. Conservatives tried to shut it down, saying that male succession is based on ancient tradition and was "inherently Japanese". Supporters of change point out that Japan frequently had women rulers until the 7th century; it was ended when they decided to follow Chinese practice. But it is clear that Japan's ancient imperial tradition was *matriarchal.* Queen Himiko (180 – 240) first unified then ruled Japan. Critics admit this, but say that nearly all women rulers were succeeded by men. However the Japanese state religion Shinto teaches that all the Japanese rulers are descended from *Amaterasu*, *goddess* of the sun.

If women were admitted to the succession, there would be an ideal heir-in-waiting: Princess Aiko, Naruhito's popular 22-year-old daughter. As it is the three current heirs to Naruhito are his younger brother, Prince Akishino (58), Akishino's son Prince Hisahito (17) and Naruhito's uncle, Prince Masahito (88). The birth of Prince Hisahito in 2006, the emperor's nephew, provided a new male heir. Opponents of change used this to try to close down the debate. But with as royal women cease to be royal when they marry a commoner, while royal male babies are not being born, the inexorably shrinking royal family may yet force the issue.

Naruhito's era as emperor is designated as *Reiwa*, which translates as "beautiful harmony." Japan certainly seems to have sought and found a unique harmony between the ancient world of empire and the modern hi-tech world. The symbol of the Japanese emperors is a sacred mirror, and cities like Tokyo certainly hold up a mirror to today's connected, frenetic and globalised world. But behind the mirror lie unresolved complexities, contradictions and enigmas.

PART FOUR – LEGACIES OF EMPIRE

One view of empire is that it ***self-destructed***. As we saw last session, the long Romanov-Habsburg struggle to control the Balkans as the Ottomans declined helped trigger the First World War. This is the theme of a classic 1965 book by historian Laurence Lafore called *The Long Fuse: An Interpretation of the*

Origins of World War One. This war saw the destruction of all three empires, together with the German empire. Historian Richard Overy has also interpreted the Second World War as an imperial conflict, between the "satisfied" empires like the British and French against the "dissatisfied" Germans, Italians and Japanese who fought to change the status quo. Thus it could be argued that empire went out not in a blaze of glory, but in an inglorious bout of self-destruction.

More positively historians like Niall Ferguson argue that ***empire created the modern globalised world order***. This refers to the western European oceanic empires, particularly the British (*Empire: How Britain Made the Modern World*, 2002). Others, like Ernest Gellner, disagree, saying that wider economic and scientific changes such as the Industrial and scientific Revolutions created the modern world order. We'll consider this in our forthcoming topic, the history of science.

As empire disappeared, many predicted a ***new era of world peace***. It was believed that the coming of democracy, national self-government and general prosperity would make war unthinkable. This ***proved an illusion***. Despite the United Nations (1945) and the Universal Declaration of Human Rights (1948). Wars in Korea, Vietnam, the Middle East, and near-wars over Berlin and Cuba. soon brought disillusion.

The ideas of two philosophers are relevant here. Rousseau said in the 18th century that people were innately rational and good. Whether they turn out that way depended on the experiences provided by their environment. Good societies will promote good people and social harmony. Hobbes, back in the 17th century, held the alternative view that people were innately selfish and bad. Their bad impulses must be curbed by a strong government. This was essentially what emperors did. Strong, autocratic, sacred emperors saved everyone from the sort of horrible anarchy that Hobbes warned against ("nasty, brutish and short"). Thus the age of empire followed Hobbes; the modern age of liberal democracy Rousseau.

There is another interpretation: the so-called "***security dilemma***". This holds that wars are caused because states, feeling insecure, create big armies. This in turn frightened neighbouring states who responded by also building armies. Each side claimed to be acting defensively. Paradoxically, wars were caused by the very actions taken to prevent them. This was bad enough in the age of empire, but with the coming of modern weapons of mass destruction, it leaves human survival permanently hanging by a thread. Our inability to get past this

could be humanity's greatest failure. Hobbes stalks this interpretation of history more that Rousseau does. Diplomacy appeared early on in the history of empires and can mitigate but not solve the security dilemma. In the end a tipping point is reached where diplomacy fails and war can no longer be averted.

The truth is that even though war has been exhaustively studied, fundamentally it remains a mystery. Does it originate within human nature or human civilization? Or is it a denial of both? Is war so ingrained within us that we can't study it in a detached way? Or have we just become acclimatised to it? This may seem a depressing conclusion. But Holslag argues that diplomats need to acquire a knowledge of history if only to clarify the nature and the scale of the problem.

PART FIVE – CONCLUSION

Empire endured and changed relatively little for a very long time. To some it represents violence and inequality, while others see its majesty and magnificence. R.G. Collingwood once said that to understand anything in the past, historians need to ask, "*To what question was this the answer*?" "Empire" was the answer to the question: "*how can we enable large numbers of diverse peoples to live together in security*?" Empires – vast, diverse states ruled by powerful autocrats who were sacred beings and had large armies – could, it was believed, maintain order, harmony and security, both earthly and spiritual.

Empire ended because we found new answers to the question. We turned against diverse multi-national states ruled by autocrats and sustained by religion, in favour of homogeneous nation-states ruled by elected leaders sustained by democratic and secular values. From today's modern perspective, these choices may seem self-evidently good. But this substitution alone has not guaranteed good governance. Nation-states often struggle to cope with diversity. Democracy hasn't guaranteed a peaceful world and the election cycle is sometimes felt to impair long-term policymaking. But for the moment these are the best answers we have. Or maybe the question itself is unanswerable and we just have to muddle through regardless.

But what seems more likely is that the passing of empire represents much more than just a change in political arrangements. Empire existed for four thousand years, yet ended in the blink of an eye and few mourned its passing. Clearly it was part of the profound changes – cultural, political economic, scientific and technological – which in the last couple of hundred years have

produced a new worldview and a new world order, almost a new way of being human.

Only historians bother much about empires now. And to quote Churchill, himself a writer of history, democracy is the worst form of government, apart from all the alternatives. But no doubt in the dim and distant past some wit said the same about empire.

Verwood u3a History Group: Topic for 2024 –2025

ANCESTRAL POWERS: PART TWO

A GLOBAL HISTORY OF SCIENCE

The Light Invisible
O Greater Light, we praise Thee for the less;
The eastern light our spires touch at morning,
The light that slants upon our western doors at evening,
The twilight over stagnant pools at batflight,
Moon light and star light, owl and moth light,
Glow-worm glowlight on a grassblade,

The light of altar and of sanctuary;
Small lights of those who meditate at midnight
And lights directed through the coloured panes of windows
And light reflected from the polished stone,
We see the light but see not whence it comes.
O Light Invisible, we glorify Thee!

(From T.S. Eliot *The Rock* (1934)

OUTLINE

1. **NARRATIVES**
   How interpretations of the history of science are radically changing
2. **ORIGINS**
   How the earliest civilizations contributed to science
3. **LIGHT AGES**
   How cultural interactions meant that medieval science wasn't a "dark age"
4. **EXPLORATIONS**
   How early modern science was shaped by 16th century global exploration
5. **INSTITUTIONS**

How 18th century science moved on from being a pursuit for gentleman

6. **THE MARCH OF PROGRESS**

How the 19th century search for laws led science into fields of power

7. **INVISIBLE REALMS**

How 20th century science revealed previously hidden worlds

8. **WAVES**

How modern state and industrial investment created today's "big science"

SESSION ONE

NARRATIVES

How traditional interpretations of the history of science are changing

"In a sense, the history of science is the history of everything."
(from Patricia Fara *Science: A Four Thousand Year History,* 2009)

What is science?
Where to begin? Science, in the sense of the careful study of natural phenomena, goes back to the dawn of civilization. The problem is it wasn't called science.

The word "science" comes from the Latin *scientia,* meaning "knowledge" or "study". The equivalent ancient Greek word was "*episteme"*, used by Aristotle, often recognised as a pioneer of ancient science. In the middle ages what we call science they called "*natural philosophy*". This changed in the early 19th century to "*natural science*", which gradually became "*science*". This happened alongside the emergence of separate specialist *disciplines*, of physics, chemistry and biology. The word "*scientist*" was invented in 1834 by William Whewell, an English philosopher, who used it in a book review, modelling it on the word "*artist*". This came to replace *natural philosopher*. Thus in a purely literal sense, neither "*science*" nor "*scientists*" existed prior to the 19th century.

But this is also true in a more meaningful sense, as illustrated by the ancient Greek Aristotle. He studied and wrote about the natural world and the animal kingdom in a way that today we'd want to call "scientific". But as he tells us, much of his "research" involved consulting beekeepers, farmers, horse-trainers and fishermen, people who had gained their knowledge in a practical way through their work. They weren't scholars in search of truth. But the knowledge they accumulated forms the original bedrock of modern science.

This fact is fundamental to understanding the history of science. As Patricial Fara says in her introduction to *Science: A Four Thousand Year History* (2009), "*writing about science's long-term history involves tracing the origins of something that didn't exist until relatively recently, and so it means considering people who weren't doing whatever it is that scientists do now.*" Instead "*they developed a variety of skills – navigating by the stars, smelting ores, preparing herbal medicines, building ships, designing canon – that contributed to the*

global scientific enterprise of today." The priority for these people and activities was anything but the quest for abstract truth. Scientific knowledge was accumulated throughout history largely incidentally – and without scientists.

For this and other reasons the history of science raises many fascinating questions. If it wasn't driven by the heroes of tradition, what did drive it? If it wasn't purely European, what were the contributions of other cultures? How did it relate to religion? How has current scientific thinking evolved? Should we be excited or worried to be living through discoveries like modern genetics and artificial intelligence? Gaining an updated historical perspective on science may not give us all the answers to these questions, but it will give us a more secure foundation for thinking about them. This is a history with more than usual importance.

Histories of science

We all have some idea of how the history of science goes. We grew up with stories of Newton and the apple tree and Galileo with his telescope, maybe even Copernicus proving that the earth orbited the sun. Later, Pasteur and Marie Curie. These were the heroes of science, indeed its very creators.

And science itself has become heroic. In the widest sense, including its practical application in technology, it increasingly defines our civilization. Not everyone agrees that this is a positive thing. The unforeseen consequences of nuclear, genetic and computer science are dominant concerns. A current book warning of the potential perils of Artificial Intelligence (AI) is by one of its leading pioneers and developers, Mustafa Suleyman: *The Coming Wave: Technology, Power and the 21st century's Greatest Dilemma* (2023, with Mikal Bhaskar). Suleyman founded *Deepmind* and *Inflection AI.* There is also a belief that some people make inflated claims for scientific knowledge. Nuclear physicist Ernest Rutherford is reported as saying that physics is the only true science; everything else is stamp-collecting. This view, which rejects all other types of knowledge as inferior or invalid, is called *scientIsm*.

Yet a revolution is occurring among historians of science who are increasingly calling for change. They are not saying that the traditional story needs to be modified, or that some of its details need updating, but rather that it needs to be scrapped altogether. Most of the fundamental assumptions underlying the history of science, which used to be taken for granted, have been challenged. It didn't begin in the 15th century or in Europe. It wasn't made by a few heroic individuals like Copernicus, Galileo or Newton. It wasn't inherited from ancient

Greece. It wasn't driven by reason and experiment. It wasn't held back by religion; on the contrary, religious people like medieval monks and Islamic scholars played a key role in advancing it.

In these sessions we need to ask why the traditional interpretation is increasingly rejected in favour of a radically new narrative. It turns out that that the history of science is less neat and tidy than we thought, but in the process it has become richer and more interesting.

Why do interpretations of history change?

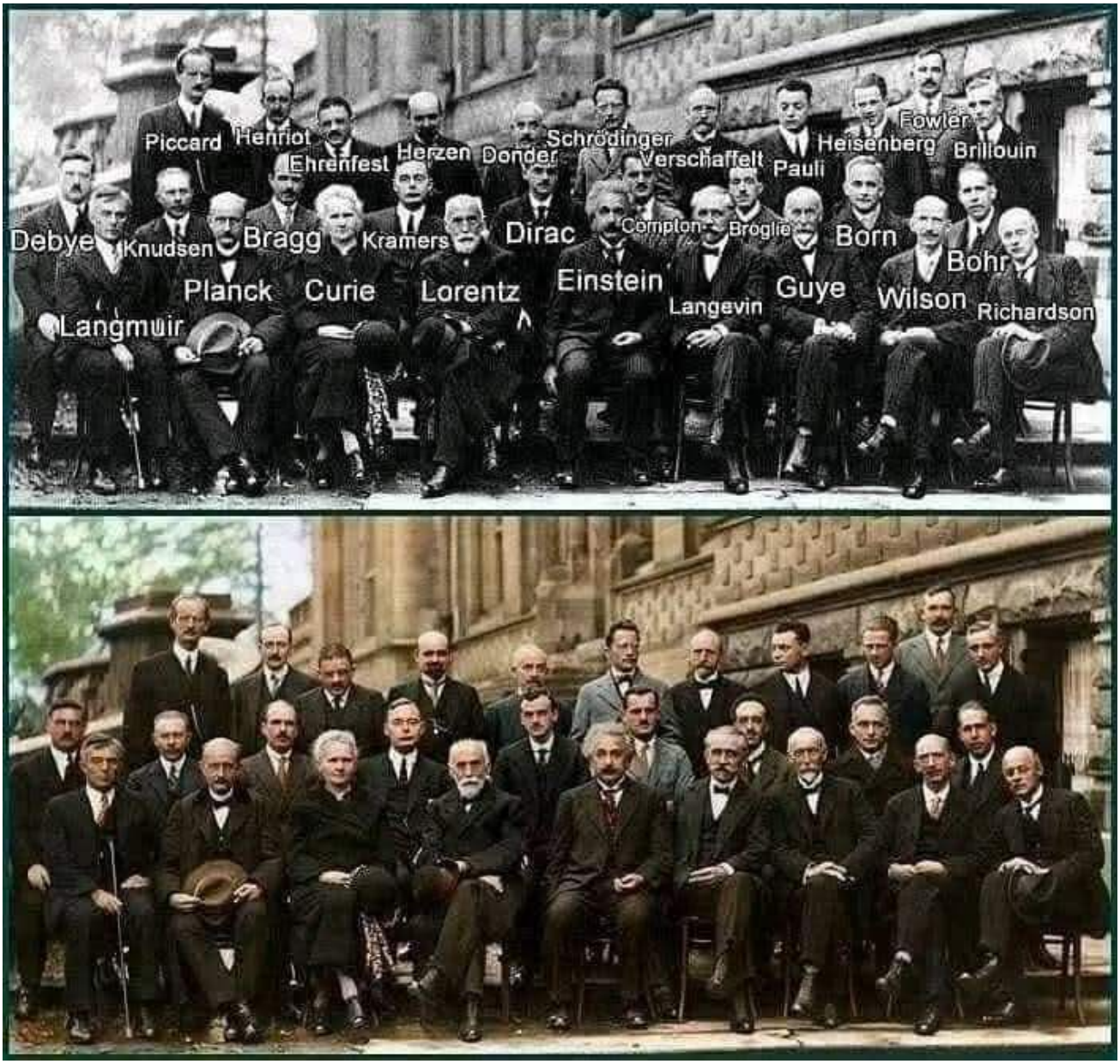
"History" has two meanings: *everything that happened in the past* and also *the body of historical knowledge*, built up by historians from the available evidence using their skills of historical research and usually published in books and articles.

How do we know that history is true? The main safeguard against blatant fraud is
peer review. Whenever historians publish their work, other historians scrutinise it. An extreme and notorious case was David Irving, a British writer who claimed that the Holocaust of the1940's never happened. American historian Deborah Lipstadt published a book called *Denying the Holocaust* (1993) accusing Irving of distorting the evidence to suit his extreme political views. Irving sued her and her publisher, *Penguin Books*, for libel. In court Lipstadt's legal team proved that Irving had both distorted and falsified evidence. He was left discredited and bankrupted. This is a unique instance, but it illustrates the principle of peer review.

One of the key skills of historians is to select the most significant facts and events, and present them in a meaningful and interesting way; essentially as a *story*. Historians don't merely recount the evidence, they *interpret* it. This relies on making judgements, so it's not surprising that disagreements arise. A further factor is that historical interpretations tend to reflect the times when the history is being written. Changing times mean changing interpretations. Today we view the world very differently to earlier generations.

This has had a big impact on interpretations of the history of science. The importance of science in modern society has grown exponentially. This has been accompanied by a growing concern over its potential for harm. Belief in progress, widely shared in the 18th and 19th centuries, is now less certain. Other changes in attitudes and values have had an impact too. Earlier histories of science have been criticised for making assumptions which are

Eurocentric (“Europe is superior”) and *patriarchal* (“men are superior”). They presented the view that modern science was created by a few heroic individuals, generally western European males. Today’s historians are more likely to be interested in the contribution of wider historic forces, more diverse cultures, and more groups of people than 15th century upper-class European males. Here are some of them.



This was taken at a physics conference held in Brussels in 1927 about electrons, photons and the clams of the new quantum theory. The leading figures were Albert Einstein (front-centre) and Niels Bohr (front-right). At this conference there was a big dispute. Einstein, the “father of relativity” didn’t feel able to accept that everything was relative. He clung to the belief that here

was one key constant in the universe: the speed of light. As we'll see in a later session, the quantum theorists disagreed. Quantum theory continues to divide physicists.

Two narratives of the history of science

HISTORY OF SCIENCE TRADITIONAL NARRATIVE (“teleological”)	***HISTORY OF SCIENCE REVISED NARRATIVE (“non-teleological”)***

1 The history of science is the story of the *inevitable rise of western European science* from the16th century. Its earlier history was basically a prelude. **2 The supremacy of western European science was inevitable because it was based on *reason and experiment*, making it the *absolute* and *universal truth*.** **3 The history of science was driven by *a few heroic west Europeans,* nearly all *men.*** **4 The heroes of science passed on their *key discoveries* like a baton, from hero to hero.** **5 The *theoretical knowledge* of scientists was *superior* to the practical, technological knowledge created by artisans and engineers.** **6 Modern science (like western civilization) was derived from the *ancient Greeks.* Their writings were "*rediscovered*" by the west Europeans from the 14th century during the Renaissance.**	**1 *All past societies* contributed to the history of science, including the earliest civilizations such as China, India, the Islamic empire, western Europe.** **2 Throughout history people developed systems of knowledge and beliefs according to *what mattered to them.* "*Truth" varies* in different times and places.** **3 The traditional narrative is both *Eurocentric* and *patriarchal* and *distorts* history.** **4 Science was not driven by a few geniuses, but by the *totality of history*, including *women*.** **5 Scientific knowledge was created *not just by scholars* seeking truth, but *by diverse groups for many reasons,* such as artisans, astrologers, monks, etc.** **6 Neither science nor "western civilization" came from ancient Greece. The real question is, what *overall historical circumstances* led to western European science dominating the world?**
1.What are your <u>personal responses</u> to the above? ***2. Do you find yourself <u>leaning more</u> towards either side?*** ***3. What <u>questions</u> do you have?***	

The page above gives an outline summary of the *traditional* and the *revised* narratives which I hope will provide an interpretive framework for our sessions.

The traditional narrative is described as *teleological*. This means it assumes that the history of science marches forward to a definite goal or destination. The narrative is shaped to give the impression that the triumph of western science was inevitable and predestined. *Teleology* comes from *telos*, Greek for "end" or "purpose", and *ology*, Greek for "study of". The revised narrative by contrast is *non-teleological*. It assumes that the march of history unfolds without any particular predestined goal or destination. Therefore the rise of modern science wasn't inevitable. Few historians today accept the view that history has any kind of destination. The traditional narrative also inclines towards the view that history in general is driven by "great men". The contrary view is history that wider historical movements are more significant. Most historians consider that the "great man" theory is outdated and probably see some truth in both points of view. History books are popular, but biographies even more so.

Two metaphors

Another way of looking at this is to say that the traditional narrative sees science as like *climbing a mountain*. Several peoples in past periods made limited progress upwards, but only the west Europeans seemed to have had the "intellectual stamina" to actually conquer the mountain and reach the "*Summit of Truth*". The revised narrative sees science as more like an *ocean* into which many streams and rivers flowed. The activities and ideas of myriad peoples in all periods flowed down into the "*Ocean of Knowledge*"; all contributed to its richness and depth. The metaphors we use matter; they embody different basic assumptions about the nature of history.

Science before scientists

If "scientists" only existed after 1833, then we can't define science as simply "whatever scientists do". So how and when do we begin? The starting point must be to stop seeing the history of science as a succession of heroic geniuses motivated by the thirst for abstract knowledge passing on the baton of theory like Olympic athletes. Nor was this history driven by meticulous experimentation, with occasional leaps of inspired imagination which unlocked the secrets of nature to reveal the absolute truth of things. This is the traditional narrative. Instead we will find stories of real people, women even, who made mistakes, needed to make money and trampled on their rivals. It was never enough to be right: what mattered was whether people said you were right. These stories took place beyond Europe. The history of science

lives not in esoteric experiments and abstract theories but in the real world of politics, war and business.

Science is hard to pin down. What do ancient Greek natural philosophy, ancient Chinese astronomy, Renaissance astrology and modern science and technology have in common? Something, clearly. But what? The starting point for them lies not with scientists but an array of people who were preoccupied with developing other skills; navigating by the stars; smelting metals; making herbal remedies; building ships; designing cannons. Rather than obsessing about what science is or what scientists do, better questions are:

- *Did religion inhibit science – or encourage it?*
- *Were magic and alchemy completely different to science?*
- *Is the appearance of so few women in the history of science due to history or historians?*
- *Are there different sorts of science, each valid historically?*

And the killer question: ***how and why did science become such a powerful force in history*****?**

This was not due to the heroes of science like Copernicus, Kepler. Galileo or Newton. They were not considered heroes in their own time. They only became heroes later *because science itself became so important and powerful.* When Newton published his book of gravity in 1687 few thought it was worth reading. The heroes then were those learned in the study of the classics and the Bible. But by the twentieth century Newton had become a world-famous figure, revered as a god of science. By then science had become a truly global enterprise, intertwined with the worlds of commerce, finance, industry, empire, warfare and the state. Science and society changed in tandem with one another.

<u>Science in the world</u>

Science didn't develop apart from the world, popping up as a series of unassailable facts. Any scientific fact is not neutral, but is shaped by geography and history – who says it, where and when. Attitudes towards science change. As it became ever more successful and powerful, scepticism about its claims and consequences also increased. Global warming, genetic manipulation, nuclear technology and Artificial Intelligence are now front-line issues. Science is inextricably intertwined with technology and medicine. In many sense, it dominates our lives. This brings us to the ultimate questions

about the history of science*: how did we get here? And how can it help us to improve the future?*

SESSION TWO

ORIGINS

How science emerged in the earliest civilizations

When and where did science begin?

When to the Italian poet *Petrarch* (1304 – 1374) looked back from his own lifetime to the fall of ancient Rome, he could see only *the Dark Ages*. Petrarch was one of the founders of the *Renaissance* (circa 1400 – 1600), an artistic and intellectual movement based on the "rediscovery" of ancient classical art and learning.

Petrarch's idea, that the Middle Ages were one long dark age, has coloured historians' views ever since. Thus, traditional historians of science dismissed both medieval science and, being also Eurocentric, anything outside Europe.

But today's historians are interested in science in both ancient and medieval times, and in India, China and the Islamic empire as well as Europe. Therefore the history of science is now considered to date back to the dawn of civilization itself. This takes us back to ancient *Mesopotamia*.

Ancient Babylonians

The Mesopotamians devised the earliest writing system: *cuneiform* written by using a reed with a wedged point on wax tablets. This explains why today we count time in 60 seconds, 60 minutes and 24 hours, and angles up to 360 degrees. One reason is that these numbers are more divisible than the decimal 10 (10 is divisible by 2 and 5, whereas 12 is divisible by 2,3,4 and 6). But the other reason is to do with their writing system called cuneiform, written with a wedge on a wax tablet.

A vertical wedge-mark was used for *single* numbers. A diagonal was used for *tens*. They grouped the first nine digits in threes, one below the other, easy for the eye to see. Similarly the diagonal for tens were grouped in easy-to-see fives. Five diagonal tens and three rows of three singles gives 59. They then moved everything over one place to the left and started again, like going from 99 to 100. So recording numbers in 60's was logical, following from the writing system.

The developments in mathematics took place in the Mesopotamian city kingdom of *Babylonia*. Surviving wax tablets record catalogues of stars which they used as *portents*, to predict future events. Between the 8th and 1st centuries BCE no fewer than a third of a million observations were recorded. How they were compiled is unknown. Included in them were clouds; in ancient times stars and clouds were assumed to belong in the same heavenly realm; hence the study of weather was called *meteorology*.

The ancient Greeks, through their contacts with Egypt, absorbed the Babylonians' star catalogues, although whereas the Babylonians thought about the universe through *arithmetic* and *algebra*, the Greek thought through *geometry*, with stars moving on imaginary celestial spheres, This was the foundation of all subsequent star catalogues. The Babylonians also bequeathed to us the familiar *signs of the Zodiac*. These are 12 equal zones of the sky for each lunar month named from a prominent constellation. A basic problem in astronomy is matching up the time taken by the earth's rotation (gives us days) and by its movement around the sun (gives us years). They don't quite match and this makes regular adjustments necessary. We get round this by having months of different lengths and a leap year (with an extra day) every 4 years. The Babylonians had equal length months but added a 13th month every 3 years.

Skywatchers were motivated not by the thirst for abstract astronomical knowledge, but for religious and political reasons – to read the text of the heavens and to win the trust of powerful rulers by helping them to make wise decisions.

Ancient Greeks

Thus the history of science begins without any named heroes. These only arrive with the ancient Greeks. Heroes are useful to historians: they help the story to flow. Even so, there is no generally agreed list of great Greek scientists. They didn't form a single ancient Greek scientific community. The better-known ones lived in widely separated times and places. Plato had the idea that the Greeks were passing knowledge on like the baton in a scholarly relay race. This idea traditionally appealed to historians. It made the story easier to follow and more exciting. It provided heroic main characters. It also helped bridge the rather long, boring periods when not much seemed to be happening. The modern narrative sees these "heroes" not as hovering, god-like, *above* the world, but as real people living, working and thinking *in* the world. Worldly things preoccupied them.

This explains why they were so much more admired by later generations than in their own lifetimes. Aristarchus suggested that the earth may orbit the sun, anticipating Copernicus by many centuries. But nobody believed him. His (in hindsight) revolutionary insight had zero impact. This demonstrates an important aspect of the history of science,. Being right isn't always enough. If an idea is to prevail, people must *say* it's right. This applies to Alexander of Hero's prototype model steam engine and Leonardo's sketch of a helicopter. Scientific ideas were not transmitted in an intellectual vacuum. They were constantly modified. They existed in the minds of people who were also living their own lives and pursuing their own careers. Nor did science progress in a straight line. Weird ideas co-existed alongside the one we now perceive as "true".

Ancient Greek science

The Greeks were interested in four main areas of science: the universe; life and medicine; matter; and practical knowledge or technology.

1.The Greek universe

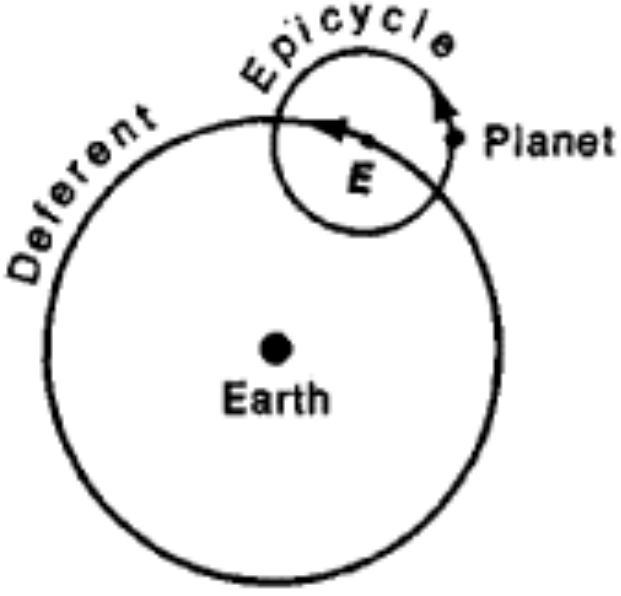
It is a misconception that science has advanced through experimentation. Just as much, people's theories and preconceptions about how the universe *ought* to work often override the evidence of their observations. A good example is that the ancient Greeks, notably Plato, believed that the main thing about the universe is that it has *cosmic order* and *mathematical harmony*. Yet they also saw that the 7 planets visible to the naked eye moved in the sky in an *irregular* way. Indeed the word "planet" means "wandering star". The other stars move across the sky but each remains in a fixed position relative to the others. This puzzled astronomers until Newton.

Plato inherited the idea of mathematical harmony from Pythagoras, a mathematician from Italy. He investigated geometry which means "measuring land"; it originated in practical surveying. Pythagoras and his disciples believed that maths was the key to the universe. They saw numbers everywhere. They searched for their hidden meanings. They saw in them the meaning and the beauty of the cosmos. On hearing the musical notes made by a blacksmith hammering metal, Pythagoras investigated the notes made by the strings on a musical instrument (twice the length gave an octave). He believed that the movement of the planets produced cosmic music, a belief that survived to the 17th century CE.

Aristotle relied more on thinking than making accurate observations. He didn't have access to Babylonia's mass of observations. He believed the universe

consisted of two realms. The celestial or heavenly realm was stable and orderly, with a mysterious aethereal substance through which the planets moved in perfect circle. They were kept in motion by an “Unmoved Mover”. The conquest of Persia by Alexander the Great (Aristotle has his tutor) revealed the Babylonian star catalogues. These were the foundation for Aristotle’s pupil *Ptolemy of Alexandria* (d. 170 CE) who built up a massive catalogue of over 1,000 stars plus tables and diagrams showing the movements of the planets. This survived and was passed on the European astronomers via Islamic scholars (more next session). Ptolemy dominated ancient and medieval astronomy. He synthesised the Babylonian observations with ancient Greek theory. He agreed with Aristotle that the planets moved in circles but at different speeds. He also invented or perhaps popularised an instrument called the armillary sphere to measure starry coordinates.

From the modern perspective, the big problem with Ptolemy was that he inherited the ancient belief that the earth stood still and the sun circulated around it. But even after Copernicus showed the earth circulated around the sun, sailors found that for navigating from the stars, it was more convenient to continue to use Ptolemy’s system and assume the earth *did* move!* One of his system’s big problems was that planets sometimes appeared to move *backwards*. His elaborate solution was to imagine *epicycles,* which circled around the world while a planet circled around the centre of the epicycle.



This is an example of trying to reconcile the observation with dogmatic belief. Once you accept that (a) the earth does move, and (b) planets move in elliptical orbits, not circles, this problem goes away. Ptolemy thus looks

simultaneously backwards and forwards; backwards to the ancient Greeks for his model of the solar system, forwards to modern astronomy in realising you have to reconcile your model to accurate astronomical observations and geometrical calculations. Ptolemy also kept the 12 signs of the Zodiac and the astrological belief that stars influence all aspects of human life. We might laugh at this; but the sun undoubtedly does; why not stars? Ptolemy also related parts of the body to signs of the Zodiac and to the 7 planets: hence the "7 ages of man" . Theirs was a very *holistic* view of the cosmos; everything was linked to everything else.

2.Ancient Greek life and medicine

At the time of Socrates and Plato, *Hippocrates of Cos* founded a medical school. They exaggerated how much of their teaching was new; much was inherited. The key was to create detailed case reports. Through these they built up such a bank of practical knowledge that they could predict the *course* of an illness despite lacking any real understanding of the *cause*. This gave to patients the appearance that the physician was in control. Often the best they could do was help the patient die comfortably. They also impressed on patients the importance of healthy living. Their focus was on the individual patient's constitution rather than on universal diseases. The key theory associated with Hippocrates and his school was the use of customised prescriptions to keep the mind and body on an even keel. It was believed that this hinged on the existence of internal bodily fluids called *humours*. Good health depended on maintaining a proper balance between the humours. This theory dominated European medical thinking until the 18th century CE. This may seem staggering. But it had advantages. Giving the patients responsibility for their own health made them feel less helpless. The patient analysed their daily symptoms and took measures to rebalance their humours. This seemed a natural process of self-healing. Yet at the same time the physician could charge high fees!

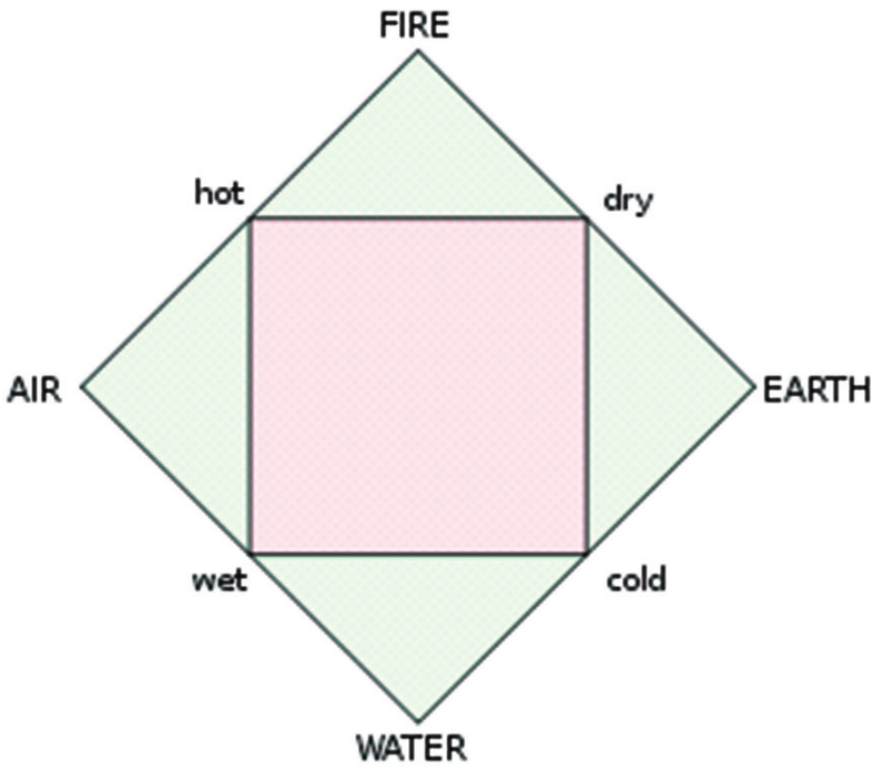
A century after Hippocrates, Aristotle embarked on a study of plants and animals to try to gain understanding of the natural universe. (Before the word "scientist" was adopted after 1833, the name "*natural philosopher*" was in general used. Aristotle was the pioneer). He made important errors, but he understood that theory must be at least informed by observation. His writings catalogued many facts. Natural philosophers weren't allowed to dissect human bodies, but Aristotle learned from the wounds, fractures and amputations of military casualties.

His work was built on by *Galen* in the 2nd century, an expert surgeon who treated injured soldiers and gladiators. His writings dominated anatomical knowledge in Europe until the 16th century. Galen elaborated on the Hippocratic humours. He identified them as *blood, yellow bile, phlegm* and *black bile*. Blood was the source of vitality. Yellow bile was for digestion. Phlegm was a coolant of fevers. Black bile darkened the blood and controlled melancholy and depression. All the humours influenced both the body and the mind, including temperament and behaviour. Too much yellow bile made a person thin and mean; too much phlegm, fat, pale and lazy. Galen derived his anatomical knowledge from actual bodies, including animals such as pigs and apes; this led to errors when applying it to humans. He had no concept of a circulatory system; he said blood was made in the liver, then consumed in the body.

3.Ancient Greek matter

As regards the question of what the universe was made of, the Greeks thought there were two main possibilities, which dominated European thought until the 17th century. Matter, they thought, was either continuous or made of discrete particles. Either no gaps, or gaps. The early Greeks including Aristotle thought matter was continuous, made up of a few basic elements which blended together. Later Greeks were *atomists,* believing that matter was made of minute, indivisible, unchanging particles (atom is Greek for *indivisible* or *uncuttable*).

Aristotle believed there were four terrestrial *elements, earth, water, air* and *fire*. These gave rise to four natural qualities, *hot, dry, cold* and *wet*. This combination makes a neat scheme.



It helps us to think about what happens when we heat water or burn wood. The Greeks didn't ask, where's the evidence? They were philosophers not experimenters. They were asking philosophical questions: why is the universe stable? How could it have emerged from the initial chaos? Why should a coherent universe exist at all? Aristotle's approach was *teleological* (that word again!) Creation, he believed, must have a purpose or goal; an ends-based approach. Thus eyes exist because we need to be able to see. Nature has an intrinsic property of reaching *order*. The universe was steady, systematic and purposeful. Aristotelianism appealed to Christians despite its pagan origins because it fitted in their view of God: He is an intelligent Creator with a grand plan who thus brings order to Creation. This mattered because it made Aristotelianism intellectually respectable in Christian Europe. So great was his influence that Christian scholars referred to him simply as "*The Philosopher*".

This didn't apply to *Epicurus* who came just after, around 300 BCE. To Epicurus the universe was based on *chance*. It had neither design nor stability. Our universe was simply one of many. Matter arose from collisions between indivisible atoms streaming, banging together and combining in the vast void (disagreeing with Aristotle who said matter was *continuous*). Plato and Aristotle said the ultimate goal for humanity was to live a virtuous life. Epicurus rejected this. He concluded that since existence was ultimately a matter of

chance encounters between unthinking atoms, there was no point in getting anxious or striving for perfection. Take life as it comes. But far from being relaxed about this lack of order or moral purpose in creation, many ancient Greeks found it a source of anxiety and refused to accept it. A teleological, purposeful cosmos was morally comforting.

The Greeks couldn't prove any of their theories about matter. Atoms couldn't be seen, let alone isolated and tested to see if they were indivisible. Ancient Greek science rested on more on thought and faith than observation, and certainly not experimentation. Moral and ethical factors were the ultimate test of Truth. This would remain true for many centuries.

4.Greek technology

All this undermines the idea that modern science was somehow derived directly from the ancient Greeks. Archimedes is credited with some suspiciously modern-sounding inventions. Did he really succeed in making a huge mirror capable of setting fire to Roman warships? And a giant screw for lifting water? The word technology dates from the 19th century, from the Greek *techne*. This means knowledge gained through doing practical work, such as a manual skill. Science, from *scientia* was used to mean knowledge gained from books. Scholars talked about the science of language or of ethics. This led to a hierarchy of learning. Scholars and scholarship were respected; practical knowledge was looked down on. Manual labour was despised. Scholars felt superior to those who had to earn a living rather than having wealth, or a wealthy patron. This hierarchy still endures. Scientists are superior to engineers. Academic and vocational qualifications, despite many decades of government propaganda, still lack "parity of esteem".

Before the 19th century therefore nobody could be a scientist or a technologist; the words did not exist. Modern science therefore originated from elitist academic scholars (or armchair philosophers) and from common people who developed their expertise and knowledge in order to earn a living. These people – women as well as men – worked as farmers, textiles-makers, miners, metal workers. They solved problems and made things work. They knew how to make plants grow and animals thrive. They built bridges, irrigation systems, pulley systems and engines of war. They used triangulation to make sure a wall was vertical; scholars used it to map the universe. Philosophers aimed to understand the world; they would tell you how a tree grew. Workers aimed to describe the world; they could tell you how many planks you needed to build your barn. Thus Archimedes the philosopher and mathematician built machines not to press olives or lift weights but to show off

grand mathematical principles. They were intended to evoke wonder, not to get work done. So Hero of Alexander's so-called ancient Greek prototype steam engine was never a working machine, just a model to show how steam could make a hollow ball rotate.

Modern technology is more than this. It requires practical feasibility, political will to get it made, and commercial potential to finance its use. The ancient Greeks were not great iron-makers. They couldn't make large cylinders or steam-tight pistons. They lacked the infrastructure to set up a complex factory system. These were all necessary preconditions for the 18th century industrial revolution.

The ancient Greeks were an exceptional and gifted people. But the traditional narrative conceals what their achievement were founded on. They inherited much from the past. And they learned much from their skilled workers, who greatly outnumbered their philosophers. Ptolemy, famed for his astronomically accurate armillary sphere made no mention of the skilled workers who actually made it. Aristotle, unusually, personally carried out some dissections. But he also relied on beekeepers, farmers, stockbreeders, horse trainers and fishers, who supplied data essential for his learned books about the natural world. He very occasionally mentions these people in a general way, but none are ever named or credited for contributing their specialist knowledge to his works.

Heroes of science

Plenty of the heroes in the traditional narrative of the history of science were ancient Greeks. Heroes make for good stories. Some the Greek ones helped not just by making great discoveries but also by suffering dramatic deaths in the pursuit of their work. Thus Socrates was sentenced to take poison for allegedly corrupting Athenian youth (i.e. teaching them to think). Archimedes was killed by a soldier when he refused to move because he was too absorbed in finishing a piece of geometry. A good story needs dramatic twists. But an accurate story needs to include all the relevant characters, however humble their station in life, not just a few carefully selected and approved "heroes".

SESSION THREE

LIGHT AGES

How Medieval science was shaped by cultural interactions

It used to be thought that the Middle Ages was a *Dark Age* in the history of science. It was said that after the fall of Rome, the power of the Christian church smothered science and innovation under a blanket of religious superstition. This view was challenged in a recent book by historian Seb Falk: *The Light Ages: A Medieval Journey of Discovery* (2020). He shows that religion actually *encouraged* science rather than retarded it. Also medieval scientists like Roger Bacon researched optics and light. Thus, in two senses, the "Dark Ages" were actually light ages.

How ancient learning was passed on

It also used to be said that the Islamic empire preserved and translated the learning of the ancient Greeks, then transmitted it to the western Europeans. This however is a Eurocentric narrative which misses out a crucial stage. Islamic scholars weren't neutral transmitters. They were serious thinkers in their own right. They built world-class libraries and observatories. They didn't merely *translate* ancient Greek learning. They *absorbed* and *transformed* it. What the Europeans received was ancient Greek learning "*Islamised*". The Europeans themselves then transformed it into a "*Christianised*" version. It is a complex story of different cultures interacting with each other.

Medieval science: the Islamic world

From the 8th century CE, the rulers of the Islamic empire poured money into learning and science to boost their prestige. They assimilated ancient Greek thinking but also changed it. Thus science was not seen as conflicting with religion, but rather a way of approaching God through studying his creation. We can see this in one of the greatest Islamic scholars, Avicenna (*Abu Ali ibn Sina*) whose *Book of Healing* (1027) aimed to "heal" the reader of ignorance. It is a poetic and philosophical meditation on all the knowledge needed for spiritual fulfilment. It is also an encyclopaedic summary of learning. He wrote about medicine, mathematics, music, astronomy and optics. He invented the words *alcohol, alkali* and *sugar*. Avicenna was not a reclusive, academic thinker, but an itinerant polymath. He toured then cities of Persia, worked as a court physician, soldier and political administrator. On medicine alone he wrote a million words, his own observations as well as ancient knowledge. He

designed a special pannier so he could write books while travelling on horseback.

But his writings were praised not for originality but for their thoroughness and systematic organisation. Avicenna studied the world to better approach God and he saw no conflict between science and religion. Muslims were urged to gain knowledge as part of their spiritual quest for perfection. The physical and divine worlds were seen as inextricably linked. *Islam* means submitting to and being at one with God. As Patricia Fara says, Avicenna's aim "*was not to pick apart the structure of the universe, but to be led towards the unity of God*."

Islam saw two distinct types of learning: the *revealed* knowledge of religion and *scientific* knowledge, much of it stemming from the ancient Greeks. Thus hospitals and observatories were built as scientific training establishments. Teaching hospitals had their own libraries and bathhouses; health, hygiene and spiritual well-being were seen as one. Physicians were licensed and standards were high. The Caliph of Baghdad had a huge library full of Greek books. Paper replaced papyrus and vellum. Research into astronomy and the natural world blossomed and Islamic rulers prized their reputations as patrons of learning.

This lasted until the 12th century when their priorities changed towards other ways of pursuing of spiritual perfection, especially religious revelation. Muslims dd not see this as rejecting science, rather a change of emphasis.

Islam, Persia and India

The Islamic empire at its height was so vast that the ancient learning they inherited and assimilated wasn't just Greek, but also incorporated ancient Persian and Indian learning. This was then spread throughout the Islamic world by merchants and by pilgrims travelling to Mecca on the *Haj*. It included maths, arithmetic and geometry, astronomy and music (based on Pythagoras); and observations of plants, animals, minerals and optics, all interpreted as part of a purposeful universe (based on Aristotle).

Their art and architecture used geometry and symmetry. Islamic medicine combined Hippocrates (Greek), Galen (Roman) and traditional Indian, Persian and Arabic remedies. The study of optics was encouraged partly because desert sands caused eye diseases (*retina* and *cataract* are Arabic words) and partly because it was believed that light was itself God.

As we can see, many activities we would now consider *scientific* had a religious dimension. Each individual was seen as a microcosm of the cosmos, while the cosmos mirrored the soul. Muslims thought of spiritual progress in terms of numbers; the individual ascends upwards from the confused multiplicity of earthly existence to the perfect Oneness of God. Astronomers explored the perfection and harmony of the heavens. Number revolutionised religious music; in the 12th century they introduced on musical scores measurement of the time interval between notes as well as their value.

Other aspects of science had a religious motive. Accurate calendars were needed to ensure Muslims fasted for equal times. Accurate time keeping was needed for daily prayers. Compass directions were needed to face Mecca.

Medieval science: Christian Europe

The Islamic world inherited the science of the ancient world, assimilated it and adapted it to Islam. Christian Europe in turn gained its knowledge of ancient science from the Islamic world. And just as Muslim scholars *Islamised* ancient science, so European scholars *Christianised* it.

Galileo and other Europeans wrongly dismissed the Middle Ages as a blank page in the history of science. In fact important progress was made. Practical knowledge increased with improved crop rotations, cattle breeding and mills. Herbalists and monastic healers studied pharmacy and botany.

As in the Islamic world, religion didn't conflict with science, and religious scholars preserved scientific knowledge. Christian monks valued and copied ancient secular texts even though they were "pagan". Stargazers accumulated data to navigate ships but also to calculate the date of Easter.

A big aspect of medieval science was the measurement of *time*. This too owed much to religious observance. Christians had regular prayer times which structured their daily lives. In monasteries, bells summoned monks and nuns to prayer seven times a day. This was the birth of the modern age of measured time, a whole new concept which would replace the rhythms of nature. Early sundials and water-clocks measured hours in differing lengths; summer daylight being longer, so were the hours. A church in Milan in 1376, was the first to install a clock which struck the hours equally.

These early mechanical clocks were only accurate to within 15 minutes, yet they marked the beginning of the modern age of precise time measurement and global coordination on which the modern scientific world depends.

Cathedral clock towers reached heavenwards to God but also regulated earthly time below. Gradually control of time passed away from the church. In 1730 the French king ordered all Paris clocks to coordinate with his. And in 1748 Ben Franklin wrote, "*Time is money*". Time now belonged not to God but to the state and Mammon.

Cathedral and monastic schools taught both ancient and Christian learning. A teacher at Chartres cathedral school, Bernard, is the original source for Newton's famous quote. "*If have seen further, it is by standing on the shoulders of giants*"; his "giants" were Plato and the Bible. Then groups of scholars broke free of the church and created the first independent universities, beginning in Bologna, Paris and Oxford. Their scholars were highly regarded and they were relatively free to discuss controversial ideas.

Gradually some Christian scholars moved away from the idea that nothing could happen unless God willed it, towards the idea God had designed His creation like a harmonious machine which ran more or less independently according to scientific laws. God might intervene with the occasional miracles or supernatural event, but basically it was a self-regulating universe. This made room for science; Christians should study God's creation, the natural world and the heavens, as well as the Bible.

When Christian scholars learned that the Islamic world had Arabic translations of ancient Greek texts, demand for these soared. From the end of the 12th century translations of these books from Arabic into Latin took European learning in a new direction. But it was a very gradual change of emphasis rather than a sudden explosion of scientific thinking. As in the Islamic world, science was seen as a way to approach God. Roger Bacon, an eminent 13th century English Franciscan scholar, also did research, especially into optics; light was believed to be both earthly and divine.

Although Roger Bacon is often called England's first scientist, he was not very systematic in his investigations and experimented to confirm what he already believed. He believed that studying the natural world moved our minds upwards, from basic sensory perceptions, through abstract ideas and mathematical understanding, finally arriving at the appreciation of the Divine unity of the cosmos. Galileo mocked his "Dark Age" predecessors for their ignorant superstition. But it is more accurate to say that for Bacon science is a sacred activity; it moves our minds upwards to God.

Aristotle and the Middle Ages

Medieval Europeans particularly admired the ancient Greek, Aristotle. This was partly due to Thomas Aquinas. Aquinas was an Italian aristocrat who rejected his privileged life and became a Dominican Friar. Some calls him the greatest ever Catholic thinker. He was a university teacher, adviser to popes and princes, and he made Aristotle acceptable to Christians. God, said Aquinas, had singled out humanity by giving us the power to reason. Christians should use it, and study both the Bible *and* the natural world as "natural philosophers". Crucially, he argued that God would never allow truths derived from reason to conflict with those derived from faith.

To be fair, to this did require some discreet "modifying" of Aristotle from the ancient Greek version. Thus, Christian astronomers quietly added an extra transparent sphere to Aristotle's cosmos to allow for the Biblical Heaven. Aristotle also believed in astrology which was a problem for Christians who believed in free will. Physicians believed that the stars could influence us through our four humours. Aquinas responded by saying that surely a good Christian would have enough self-control over his passions to resist these astrological influences. The two belief systems seemed to coexist reasonably happily. The Black Death was said to be caused by planetary conjunctions causing corrupt vapours in the atmosphere. However these were said to have been ordered by God to show his displeasure with human sinfulness.

***Star-Net*: the miraculous medieval astrolabe**

One of the greatest inventions of the ancient and medieval worlds was itself a scientific instrument: the ***astrolabe***. It was a unique instrument, portable and versatile**,** which used sets of rotating brass plates to model the celestial sphere. Legend said that Ptolemy had the idea when he was riding a donkey while carrying on astronomical armillary sphere. He dropped it and the donkey trod on it, squashing it flat.

In fact it was probably invented in ancient Greece; the first recorded use was by a Greek mathematician Hipparchus in the 2nd century BCE. It was improved over the centuries and used in the Roman and Islamic empires, medieval and early modern Europe. by scholars, astronomers, astrologers, religious devotees, merchants and sailors. It was later replaced by the sextant and quadrant. Its uses were many, notably calculating latitude and telling the time.

The astrolabe was a miracle of miniaturisation and ingenuity. It represents a unique synthesis of ancient and medieval astronomical learning and the highest standards of craft skills. It enabled people in the Middle Ages to orient

themselves on earth in terms of both time and space. How does the astrolabe perform this apparent miracle? The basic answer, is that it triangulates three key variables: the altitude of an observed star or the sun (its angle above the horizon); its position on the celestial map of the sky; and the passage of time.

The astrolabe was particularly popular in the Islamic world. The 10th century astronomer Abd al-Rahman al-Sufi wrote a book about it with 386 chapters. He claimed it had 1,000 uses, in astrology, astronomy, religious observance (the location of Mecca, the times of daily prayer, the dates of Ramadan), navigational, seasonal and daily timekeeping, even tide tables.

The secret of the astrolabe was that in measuring the altitude of a celestial object, you not only defined *its* location in the celestial sphere; you also defined *your* location in relation to *it*. It positioned *you* in the cosmos. This must rank as one of the great inventions in the history of science and indeed of civilization, proof in itself that the Middle Ages was no Dark Age.

At the end of these notes is a “beginner’s guide” to the astrolabe with pictures.

Ancient Chinese science

China was much more culturally self-contained. European historians knew little of Chinese science until Joseph Needham in the 1940’s. A left-wing scientist, he travelled in China widely, married a Chinese scientist and wrote 20-volume history of Chinese inventions. He identified over 250, including the abacus, gearwheels, toilet paper, the umbrella, and the zoetrope (early moving pictures), gunpowder, the magnetic compass and printing. The Silk Road brought these innovations to the wider world. China, Needham showed, was no superstitious backwater. It was ahead of Europe and its discoveries helped to nurture its modern science.

European historians were outraged. They considered Chinese science as inferior. They said that the Chinese only used gunpowder for fireworks. In fact, the evidence pointed to China having cannons before Europe. What *is* true is that their inventions had much less impact in China than they did in Europe. For example, the Chinese valued their compasses for showing south, the favoured direction for the Emperor to face! Spain and Venice exploited its potential much more fully for oceanic navigation. Ditto printing: the Chinese valued books as storehouses for traditional information, not catalysts for change. There were no large libraries, accessible to scholars, as developed under Islam.

In China, there was a more rigid gulf between learned scholars and humble artisans. The exam system for gaining advancement was also rigid and quashed innovation. Scholars memorised texts and discussed philosophical and ethical debates rather than doing original research. The Chinese empire was highly centralised and hierarchical. In Europe, by contrast, private enterprise and smaller fiefdoms encouraged competition and innovation.

Thus, Chinese and European thought diverged. Christians were moving to the belief in a self-regulating universe, created and governed by God through natural laws which scientists could discover. The Chinese believed that both earthly and heavenly order depended on the rituals performed by the Emperors.

Shen Gua, a powerful state official, ran a great astronomical 5-year project to record the position of the planets by recording nightly observations. A network of observatories used instruments driven by clockwork and waterwheels, timepieces and rotating globes of the heavens. But his motive wasn't knowledge for its own sake, rather to improve the calendar to enable better horoscopes for the emperor. In similar fashion he oversaw map-making projects, with the aim of pleasing the Emperor by showing how extensive were the territories he ruled! And he made a study of salt, not as a chemical, but "*as a means to wealth, profit without end, emerging from the sea*." He also oversaw a huge water drainage system employing 14,000 labourers. Shen was a powerful bureaucrat, not scientist. He sought to improve the state, not gain scientific knowledge for its own sake. His writings include astronomy, medicine and optics, but also court gossip, political memoirs and useful maxims.

Needham's big question was, why did modern science appear in Europe not China? Needham said it was partly geography. Europe had a long, convoluted coastline, an invitation to maritime activity. China didn't; instead, its vast landmass dictated different priorities: improving peasant farming to ensure there was enough food, and holding the empire together.

Needham was a Marxist historian. According to Marxist theory (another example of teleological thinking!) history follows a definite pattern: from feudal agriculture (lords and knights) to commercial capitalism (merchants), then industrial capitalism (rich factory owners), and finally revolution and a workers' state.
Needham said that while Europe developed through these stages (though only Russia had the workers' revolution), China didn't. It remained trapped in a

feudal, agricultural economy. Its centralised state bureaucracy focussed on tax collection, maintaining and coordinating food production, and keeping order. State officials did all this very efficiently. Nation-wide state projects to conserve water, improve transport and promote education were effective and encouraged technology. But the whole system stifled initiative and took away any incentive to accumulate personal wealth. Thus the potential of science and technology was not exploited

Needham's ideas were only partially accepted. But his great contribution was to show that China's medieval science rivalled and even surpassed Europe. The real question in the history of science is not, why was Europe ahead of other parts of the world, but rather, what was it about Europe that meant that *its* version of science came to dominate the world?

Alchemy

Finally, *alchemy*, a medieval pseudo-science emerged in the later Middle Ages. Strange and secretive, it operated outside the church and the universities. Many took it seriously. It derived from the probably mythical *Hermes* Trismegitus ("thrice mighty Hermes"), thought to be a composite of several ancient Egyptian sages. There are scattered references to him in ancient Babylonian, Greek, Chinese and Indian writings. The "Hermetic tradition" reached Europe via Islamic translations of Ptolemy and other ancient writers in the 12th century. "*Alchemy*" is an Arabic word.

In essence, Alchemy aimed to study and control the mysterious processes of change in nature, such as water freezing into ice, seeds growing into trees or iron turning into rust. This was explained in terms of Aristotle's elements and qualities (see session 2) and astrological influences. Alchemy was essentially religious: it sought God through a quest for perfection. Its ultimate goal was to find the *Philosopher's Stone*, a universal means of improvement and purification. Through it the body could be purified and rid of disease, the soul could be purified and attain divine enlightenment, and base metal could be cleansed of its impurities and turned into pure gold.

Alchemists carried out experiments in a special chamber called a *labatorium* (place of labour or work) using instruments such as a furnace for separating pure elixir from gross animal or mineral matter. They also had a place set aside for prayer and musical instruments, a nod to Pythagorean harmony.

Alchemy is often mocked, but if dirty lumps of ore can be transformed into shiny metal, and bread and wine become the body of Christ, why shouldn't

alchemists turn metal into gold? They never did, of course. The church's objection was that alchemists aimed to master the universe, not just understand it. Yet this anticipates modern science which makes the same claim! It also emphasised experimentation rather than books and natural rather than supernatural explanations. Roger Bacon and Issac Newton were devotees. There were useful spin-offs like new medicines (which qualified physicians used on the quiet).

The fact that alchemic experimentation used stills, furnaces, basins and flasks to heat, distil and crystalise substances also obviously anticipate modern chemistry. Patricia Fara says that Alchemy bridges the gap between Aristotle and modern mathematical laboratory science. Those who denigrate Alchemy but revere Newton as the ultimate scientific hero have a hard time explaining why he was an enthusiastic alchemist throughout his life. Their usual strategy is not to mention it.

Conclusion: science in the Middle Ages

The Middle Ages was not a Dark Age in the history of science. It played a crucial part in transformation of the ancient scientific inheritance and its transmission to the modern world.

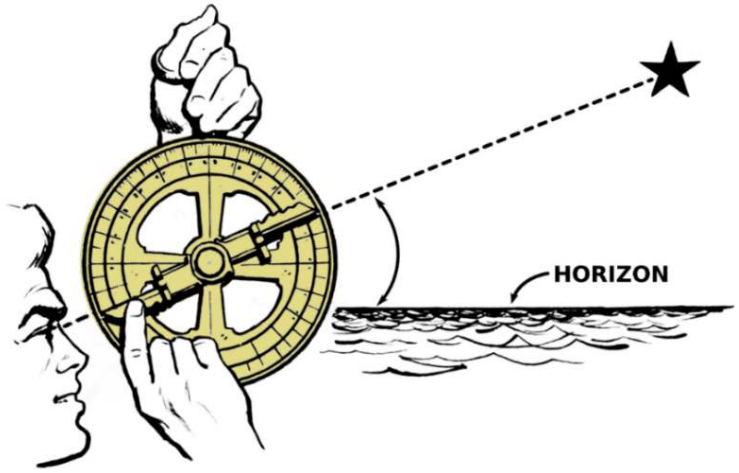
To summarise, science began in the ancient civilizations, from Mesopotamia to Greece. This ancient legacy was inherited by the Islamic world following its extensive conquests in the 7th century. They translated ancient Greek and other texts into Arabic and adapted science to Islam. Arabic became the language of science. In Europe in the Middle Ages, Christian monks also copied ancient Greek texts and translated them into Latin. But many had only survived in Arabic translations, so they also translated these into Latin. Just as Islamic scholars had adapted ancient science to Islam, so European scholars *Christianised it.* Aristotle in particular was adapted to Christian beliefs by Thomas Aquinas and others. This *Islamised* and *Christianised* scientific inheritance was then passed on to the modern world.

China was apart from all this. In the Middle Ages it excelled at invention but with its centralised Empire, rigid culture and peasant economy, failed to exploit them as fully as the west.

Religion helped medieval science as much as hindered it. Muslims needed to find the direction of Mecca to pray. And both Christians and Muslims needed good calendars and timekeeping to observe their religions. Science in the Middle Ages was complex. But one thing is clear: it was no Dark Age.

<u>The Astrolabe: A Beginner's Guide</u>

An Astrolabe is a 2-D portable model of the celestial sphere. It consists of a brass case ("*MATER"*) with scales of degrees and hours of the day round the edge, plus a rotating bar ("*RULE*") to help read them. On the back is the *ALIDADE,* a rotating bar with viewing holes at each end to view stars and measure their *ALTITUDE* (angle above the horizon), like this:



The *Mater* holds a set of discs or plates. The *LATITUDE PLATE* represents the sky marked out in gridlines. The *STAR-NET PLATE* ("*RETE"*) rests on top, representing the prominent stars, so most of it is cut away to leave visible the *Latitude Plate* below. The non-cutaway metal parts of the *rete* have pointers and labels indicating the prominent stars; rotating this plate moves them round the sky. Also cut away is the *ECLIPTIC RING*, an off-set circle showing the zone through which the sun moves. This is marked with the signs of the zodiac which double up as a calendar.

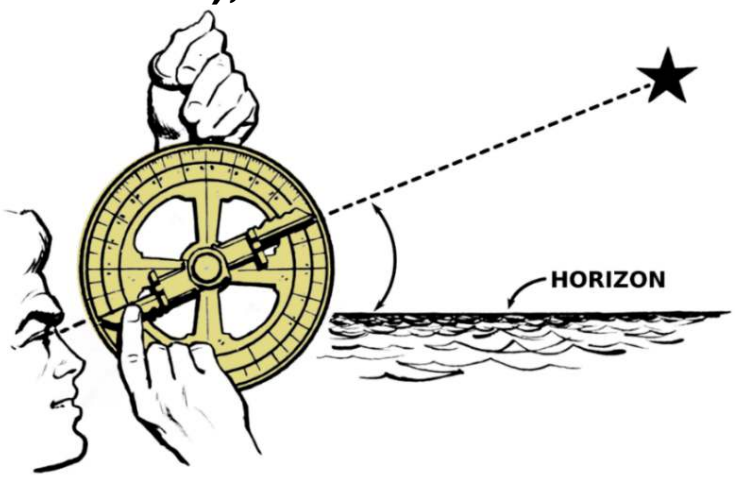
1.<u>TO FIND YOUR LATITUDE</u>: measure the altitude of the sun at noon OR the Northern Star, *Polaris*, as above. This angle gives your latitude (distance above the equator) in degrees.

2.<u>TO TELL THE TIME</u>*:* measure the altitude of the sun or any known star. Set the date from the ecliptic ring, then turn the *reme*/*rule* together to align the date with the altitude. The hours scale on the rim of the *Mater* now shows you the time.

A rete, showing the cutaways, stars and star pointers, and the smaller, off-centre ecliptic ring. The lines of the latitude plate are visible underneath.

A dismantled astrolabe. There were different plates for each latitude

<u>The Astrolabe: *a 2-D portable model of the celestial sphere.*</u> It consists of a brass case ("*MATER"*) with scales of degrees and hours of the day round the edge, plus a rotating bar ("*RULE*") to help read them. On the back is the *ALIDADE,* a rotating bar with viewing holes at each end to view stars and measure their *ALTITUDE* (angle above the horizon), like this:



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SESSION FOUR

EXPLORATIONS

The story so far…

In ***Session One*** we looked at changing interpretations of the history of science, away from the idea of a few 16th and 17th century heroic male western scientists towards a more holistic and inclusive narrative.

In ***Session Two*** we saw how science originated in the ancient civilizations, particularly Mesopotamia, Babylonia and ancient Greece, and was developed not just by learned scholars but also artisans with practical skills and knowledge.

In ***Session Three*** we saw how the legacy of ancient science was passed on, assimilated and transformed by the Islamic world, then Christian Europea, during the Middle Ages, which were not, as used to be said, a "Dark Age" of science.

In ***this Session*** we'll look at how after Columbus, the early modern period (1500 to1700) became the age of exploration, trade and empire, which in turn led to an upsurge of European scientific exploration and achievement, especially in astronomy, anatomy and medicine.

How 16th century exploration shaped early modern science

Was there a scientific revolution?

Historians used to call the history of science between 1500 and 1700 "*the Scientific Revolution*" which they said was the foundation of modern science. Yet Patricia Fara doubts whether there even was such a thing. Who is right?

It is certainly true that some remarkable discoveries were made during this time, particularly in astronomy, but also in the science of the human body.

However today historians think it's an exaggeration to call them *The* Scientific Revolution. Modern science was not fully formed by 1700. There were more revolutions to come.

Further, modern interpretations see scientific progress as driven by the whole of history, not just a few heroic individuals in one time and place. Instead, I would argue that what drove scientific progress between1500 and 1700 was the wider context of the age of global exploration and trade.

How did the age of exploration change science?

The word science comes from the Latin *scientia* which actually meant knowledge acquired by scholars from books. But Columbus' discovery of the Americas revealed a new world beyond the scope of all books, past or present. The only way to learn about this world was by *observation*. This was not a new idea. Aristotle had advocated it. But so great was his reputation that for centuries scholars fell into the habit of relying on *his* observations. To challenge them was unthinkable. Now this seemed less certain.

One result of the growth in oceanic trade after 1500 was the rise of a global network of scientific exchange. This began as collectors began exchanging plant, animal and mineral specimens. New crops, potatoes, beans and tomatoes were brought from the New World to Eurasia; in exchange onions, cabbages, lettuce and watermelons were introduced to the Americas. Slaves took rice from Africa to America.

New knowledge travelled in all directions. European traders and missionaries soon found they could only survive in the New World by learning from local guides, whose information then travelled back to Europe. Native Americans, Africans and Asians gave knowledge of building materials, plants, animals and other essential knowledge to Europeans, their supposed superiors.

A global trade in exotic curiosities also began. Private museums became popular on Europe, "theatres of nature". People were learning from each other and from natural specimens rather than from books. Natural history revived via royal courts and great aristocratic houses and the scholars they patronised more than in the universities. But books themselves also improved. Large, printed woodcuts provided accurate illustrations alongside the text. Previously plants and animals were classified more by what they symbolised (cunning foxes etc). Now a more realistic approach began. Illustrated printed books also boosted astronomy.

Thus, after 1500 scientific knowledge increased on the back of exploration, trade and colonisation. Books and scientific instruments were exchanged and collectors and scholars visited one another. Merchants demanded more accurate maps of oceans and coastlines. Ironically, the explorer who had triggered it all, Columbus, never believed that he had discovered America. He was convinced that he had discovered what he was looking for, an oceanic Atlantic route to east Asia. Despite returning on several more voyages, he remained convinced that he was exploring the spice islands off modern Indonesia. In his retirement he wrote a book about the Bible and died in 1506, a wealthy but disappointed man.

How did magic affect the history of science?

Science was also encouraged by a more ancient and arcane craft: magic. ***John Dee (1527 – 1609)*** was the most famous and respected of a number of Renaissance period scholars who aspired to become "*natural magi*", studying magic as the key to the universe. Dee was a university-educated mathematician who became the adviser and court astrologer to Queen Elizabeth I. People liked his practical, non-bookish approach. He believed that mathematics was the key both to solving technological problems and mediating between the earthly and angelic realms. Although he died poor, he was immortalised by Shakespeare as the magician Prospero in *The Tempest*: he stages a shipwreck on his island, reforms people's characters and calls upon spirits to achieve his ends.

The standard textbook on natural magic was Henry Agrippa's *Occult Philosophy* (1531). He was a German magus and diplomat and his three-volume book synthesised European, ancient Greek and Arabic magic. He in turn derived much knowledge from the scattered writings of the mythical *Hermes Trismegistus*, (the Alchemy man, last session) who blended the teachings Plato, Christianity and traditional magic. Another well-known magi was Theo von Hohenheim, aka *Paracelsus* (1493 – 1541), a Swiss travelling scholar and healer who treated patients using cosmic "*correspondences*". This angered traditional physicians whose treatments were based on rebalancing the bodily humours. But princes and wealthy aristocrats played safe by hiring magicians to supplement their physicians.

This was also true of another branch of magic, Jewish *cabalism*, which travelled from Moorish Spain to Renaissance Italy. In its Christian form it claimed to teach healers how to control the higher spiritual powers in order to access the benign powers of God and the angels. This attracted hostility from the Catholic church, who accused them of trying to usurp God.

This is actually a key point. Traditional university scholars were content to do science as a way of contemplating the omnipotence of God and the wonders of His creation. But those who engaged in the arcane arts of Alchemy and natural magic believed that understanding the universe was only the first step to *controlling* and *changing* it. They used numerical symbolism to draw down celestial powers from the stars and planets, developed medicines, love potions and spells, and offered to divine the future and ward off melancholy. Apothecaries and herbalists were happy to supply magical remedies. Gentleman scholars were intrigued by magic's arcane theoretical element. Even Newton, the hero of modern science, was interested in both magic and Alchemy, as well as being a Biblical scholar.

Thus, the magi anticipated significant aspects of modern science. Patricia Fara says, "*Magicians and artisans taught scientists to use their hands as well as their heads – if they wanted to control the world they would have to leave their sequestered studies and engage with physical reality*." Magi also introduced chemical remedies such as mercury into mainstream medicine rather than relying on herbal and natural measures to balance the humours.

Further, John Dee anticipated "*a new scientific lifestyle for gentlemen*" (Fara). He worked from home with his family, very unlike the cloistered unmarried scholars in monasteries and universities. Dee built up a huge library and combined theoretical work, laboratory investigations and developing practical applications. Over the next two centuries we see many gentlemen scientists converting their homes into centres for scientific research. Husbands and wives collaborated. Only in the 19th century did science move to large laboratories attached to universities or factories.

<u>Exploring the heavens: Copernicus to Galileo</u>

As sailors explored the New World and the oceans beyond, scientists turned their attention to exploring the heavens. Astronomy had always been a key part of pre-modern science, and In 1500 it was on the brink of some crucial breakthroughs.

A key figure was ***Galileo (Galileo Galilei, 1564 – 1642).*** The story of his conflict with the Roman Catholic church is often seen as a heroic struggle for scientific truth against religious bigotry. In fact this version was largely the creation of a , a 20th century left-wing playwright, Berthold Brecht. Galileo, an Italian astronomer and physicist, was deeply religious. So was the other main

character in the story, ***Nicholaus Copernicus (1473 – 1543)***, a Polish cathedral monk and astronomer.

In 1453, the last year of his life, Copernicus published *On the Revolutions of the Heavenly Spheres*. This set out the theory that the earth circled around the sun, not vice versa. It created a "sun-centred (*heliocentric*)" cosmos.
Copernicus studied at the university of Kracow and also spent time in Italy studying and teaching. He was well educated in the classic texts and wasn't a particularly great observer of the heavens, more "*a desk-bound scholar with his heart in the past*" (Fara). At the time, his great book, literally world-moving in retrospect, was little noticed. Even 50 years later it had gained relatively few supporters.
Copernicus' ideal was a harmonious, mathematically structured universe. Ptolemy's earth-centred model of the heavens sometimes conflicted with the observations recorded by astronomers and his solution to this worked in theory but was over-complicated and hardly elegant: *epicycles* (planets orbiting around an orbiting point, see Session 2). "Fara describes them as "*cumbersome geometrical fudges*".

Copernicus' simpler but drastic solution was to put the sun at the centre with the earth and the planets revolving around it. This resolved most (not all) of the observational problems. Not all, because Copernicus, following Plato, wrongly believed that the paths of the planets must be perfect circles. But it matched astronomers' actual observations pretty well. And it was elegant: no more fudges.

The Catholic Church took little notice at this point. Indeed, Copernicus actually dedicated his book to the Pope! But there were objections: not that it contradicted the Bible, but that it contradicted Aristotle! He had taught that the chaotic earthly realm was totally separate from the eternal perfection of the heavens. And of course it ran counter to common sense – how could the earth be whizzing through space? Many accepted the ancient argument that if you fire an arrow straight upwards, it falls on the same spot (as long as you duck) proving the earth stands still. However most astronomers were happy to follow Copernicus. Mathematically it worked fine. But few took it seriously as a model for how things actually were "out there" in the universe. This took time to sink in.

Copernicus' said in his book that he intended to rely on mathematics to explain the universe. This wasn't the way scientists (or natural philosophers) had ever worked; and in his book Copernicus *apologises* for doing so! Yet this can be

seen as the revolutionary moment which opened the door to the modern mathematical approach to science. A century, later in his great book on gravity, Newton completed the revolution. He fused mathematics and natural philosophy together "*making astronomy a mathematical science that aimed to describe and explain the cosmos*." (Fara). But Copernicus had shown the way.

Many astronomers were now able to enjoy the patronage of princes and aristocrats and escape the restrictive atmosphere of the universities. ***Tycho Brahe (1546 – 1601)***, a Danish noble and astronomer, enjoyed the patronage of the king of Denmark. One of Brahe's observational instruments was a huge 2-metre-high quadrant fixed to the wall. He proposed the weird theory that while the other planets circled the sun, the sun circled the earth! Even more bizarrely, this model did resolve many of the remaining observational problems!

However in 1609 his assistant ***Johannes Kepler (1571 – 1630)*** used Brahe's observational data to support a much neater alternative: the planets moved around the sun in *elliptical* (egg-shaped) orbits, not circles. Observations of Mercury confirmed this in 1631. Now model matched the observations. This was a major breakthrough, all the more impressive because it violated the ancient Platonic belief in the circle as a powerful universal form. (Less impressive was Kepler's belief that the planets were held in orbit by magnetism and that music played a part!)

Galileo was another Renaissance scientist who enjoyed noble patronage, at the court of the Medici family in Florence. Here he redesigned a new Dutch instrument, the telescope, and applied it to astronomy. The visible blurry smudges were not very impressive. But Galileo was a determined campaigner for the Copernicus model. He couldn't offer proof, only probabilities. The moon had a rocky face, he said; it looked like Bohemia! He also saw moons around Jupiter; why then shouldn't the earth also be moving together with its moon? And Venus through the telescope definitely looked like a disc, not a speck like the stars. In lectures and books Galileo agitated for Copernicus' model. The pope asked him to keep quiet. Galileo responded by writing a book defending Copernicus in which Ptolemy's model was defended by a character he tactlessly called *Simplicio*, an idiot.

This was provocative, and the pope duly summoned Galileo to Rome, held a trial and sentenced him to the mildest of punishments: lax house arrest in a comfortable villa. Not quite the dramatic confrontation portrayed by Brecht (above). This was hardly cruel church persecution, more a quarrel between

two different factions *within* the church. The new model did contradict certain passages in the Bible, But many in the church hierarchy were relaxed about this. Galileo was obviously not a heretic and many backed him. The "scientists" were equally divided; many backed Ptolemy, some even Brahe.

With so much divided opinion, it probably made political sense for the Pope to stick with the status quo for the time being. Had Galileo been more diplomatic he could easily have avoided official condemnation. Only much later, in the 19th and 20th centuries, was he portrayed as the heroic martyr for truth against religious bigotry. It made a good story. But as we've seen in previous sessions, religion usually helped rather than hindered the growth of science. Galileo became a useful hero for those trying to raise the status of science and for freedom-fighters people like Brecht. "*It was scientific propagandists who launched the notion that science and religion must inevitably be at war*" (Fara).

Exploring the body: Vesalius and Harvey

As well as the heavens, the human body became another arena for scientific exploration and discovery during the 16th and 17th centuries. The big names were ***Andreas Vesalius (1514 – 1564)*** and ***William Harvey (1578 – 1657).***

Vesalius*,* the *"father of anatomy",* came from Brussels and studied in Italy. He regarded the human body as "*a microcosm of the universe, sympathetically linked as complementary parts of God's harmonious whole*" (Fara). His book, *On the Structure of the Human Body* was published in1543, the same year as Copernicus' *Revolutions.* The great authority on anatomy was the ancient Roman, Galen. But instead of following his advice to study the body, not books, physicians relied on Galen's own observations. Vesalius, the son of an apothecary, thought physicians should be more hands-on and learn the skills of the surgeon, traditionally regarded as their social inferiors.

The traditional training for medical students was for a professor to read from a Latin medical textbook while an assisting surgeon dissected a corpse and a demonstrator pointed out features. Vesalius began as a demonstrator; soon he was doing all three jobs himself. He was a naturally theatrical performer. His book too described actual dissections with both text and highly accurate and detailed illustrations of nerves, veins, arteries, muscles, organs and bones. It was "*the true text of the body*" (Fara). He corrected Galen, who had sometimes relied on animal dissections.

Yet at first many physicians still preferred to believe Galen; and even Vesalius himself copied some of his errors, such as tiny invisible holes between the two

halves of the heart. But Galen's reputation gradually declined. It was transformative for medicine.

But Aristotle's reputation remained high; Padua, the leading medical school, continued to teach his opinion that the soul existed physically in the body, located in the heart. Which brings us to William Harvey who, dissatisfied with medical training Cambridge, went to study at Padua. Harvey too revised Galen. Galen taught that there were two blood systems: one based on the liver which produced blood to supply food to the body via the veins; a second based on the heart which heated up air and mixed it with blood in the arteries. Harvey proved there was one system, with the heart continually circulating blood around the body. He spent 30 years dissecting animals and experimenting before publishing his findings in 1628: the *Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus* ("An Anatomical Exercise on the Motion of the Heart and Blood in Living Beings"); or *De Motu Cordis* for short.

It was a slim volume, poorly printed and in poor Latin; but as Fara said it "*reorganised the body*". This wasn't anatomy; it was *physiology* – how things worked. Valves had been discovered in the veins, but were believed to monitor food-carrying blood from the liver. Harvey showed their true purpose: tiny one-way gates, to ensure blood returned to the heart to be recirculated through the arteries. In other words, part of a single, unified circulatory system.

Yet the revolutionary Harvey also looked to the past. He was an Aristotelian. He saw an underlying unity between the circular motion of the planets and the human blood. Conservative physicians rejected his theory because it made a nonsense of their humours-based treatment of bleeding patients. His own patients deserted him and he retreated into research.

Harvey followed Aristotle in other ways: that the womb was the source of women's mental and physical complaints; and that women were dominated by "cold/wet" humours, so were weaker thinkers than "hot/dry" men (see Session 2). Most scholars and physicians believed this. Therefore so did many women. They advised their daughters against becoming poets or mathematicians on health grounds. In the 1660's Doctor Thomas Willis questioned this belief. He suggested that women, like men, were controlled by their brains not their wombs, and he reported that there was no discernible differences between the brains of males and females. Gender discrimination continued unabated.

Harvey founded a science circle who were both Royalists in the Civil War and experimentally minded scholars, based at Oxford University. It included ***Robert Boyle*** (inventor, chemistry, physics, alchemy), ***Christopher Wren*** (architecture, astronomy, mathematics and physics), and ***Robert Hooke*** (inventor, physics, astronomy, geology, meteorology, architecture). As this suggests, their interests ranged widely. The age of modern scientific exploration was in full sail, even if the ancient Greek captain Aristotle hadn't yet quite taken his leave.

A clockwork universe?

However Aristotle's whole worldview was about to be challenged. Central to this was ***Rene Descartes (1596 – 1650).*** Descartes is better known as a philosopher than as a scientist, particularly his philosophical formula, *cogito, ergo sum* – "I think therefore I am". Troubled by the fact that philosophers couldn't prove beyond all doubt that *anything* existed (e.g. it could all be a dream), he suddenly had the insight that, if I'm having these thoughts, then "I", at least, must exist.

But we shouldn't conclude from this that Descartes was an isolated, interior sort of person. In fact he was a deeply engaged scientist/natural philosopher and did experiments with light and the weather.

Further, Descartes championed two new 17th century ideas. First, that the universe could only be explained through mathematics (see Copernicus above). Second, the universe should not be seen as organic. This rejected the ancient, Aristotelian idea that the human body was a microcosm of the cosmos. Instead the cosmos was now seen as a *machine*. And the best available example at the time was the mechanical clock. As Fara says, "*clockwork imagery dominated thought during the 17th century*." Thus we find Galileo in church gazing at an altar lamp as it swung like a pendulum and timing it by counting his own heartbeats. He went on to devise a new law of physics and propose the pendulum clock. From this context it was a natural step to the clockwork universe and God as the Divine Clockmaker.

To Descartes, the logic of this was that God, having created the universe, let it run of its own accord, according to the laws he had created. He didn't need to intervene constantly to keep it in existence (although He could and sometimes did, with the occasional miracle and supernatural event). The church objected to this apparent reduction in God's role and the suggestion that human bodies were also like clockwork machines. Descartes wisely kept his head down and

only after 30 years of thought and research did he publish *Principles of Philosophy* in 1644. Fara calls it "*the first mechanical version of the cosmos*".

What was this machine cosmos made of? Descartes theorised that there were three sorts of matter: the sort we see and feel; the sort that fills what we see as empty space; and a third sort that fills all the gaps in between the other two. Descartes' was a truly tightly packed cosmos! He visualised matter everywhere, swirling about in whirlpools, first set in motion by God, then moving only if pushed or pulled: a billiard ball universe.

The ghost in the machine

Descartes rejected all theories of invisible powers. Everything was mechanical. Magnets made things move by causing the smallest particles to enter them. Bodily organs were machine parts. But a big outstanding question remained: how could this account for the mind and consciousness? For language, reason and moral thinking?

Descartes of all people ("*I think therefore I am*") could hardly defend the idea that humans were mindless machines. But how could mind – an *immaterial* thing – interact with a *material* body, like a ghost in the machine? Descartes also believed in both the existence of the human soul (located he believed in the pineal gland in the brain) and in life after death. This dilemma – "*Cartesian dualism*" philosophers call it– was never resolved. Philosophy ("I think therefore I am") told Descartes he was essentially mind and spirit. But science told him that he dwelt in a machine-like body. He never worked out how to resolve this. We still haven't.

God's Creation

The church disliked the idea of a mechanical universe on the obvious grounds that it seemed to leave no room for God or spirit. Robert Boyle suggested a solution. A humble watch is complex. It can't happen by chance. It needs a watch maker. The universe is infinitely vaster and more complex than a watch. Therefore it too must have a maker. Further, it was capable of operating by itself according to "*certain laws of local motion*". Surely this was proof not just of God's existence but of his awesome power and splendour.

This "Argument from Design" was widely accepted as conclusive until the 19th century. During the later debates over Darwin's theory of evolution through natural selection, the human eye was cited as yet another example of a degree of complexity so great that it must prove God's existence.*

*But perhaps not conclusively. Why did the Designer allow short sightedness and cataracts? Also, modern evolutionary theory has shown how the eye *could* have evolved.

Another issue was that to fully reveal the rich complexity of God's Creation, better scientific instruments were needed. This was another driver of scientific progress during this period. It was also a key area where those who worked with their hands (artisans) were just as crucial as the abstract thinkers (scholars)*.

*When William Gilbert, Elizabeth I's physician, invented a better ship's compass, he made use of all kinds of practical knowledge from experienced seafarers; he never acknowledged their contribution.

When science began, the first scientific instruments were devices developed by artisans and craftsmen for practical purposes, weighing food, surveying land, navigating, assessing valuable metals, measuring time, making herbal remedies. These were *mathematical instruments*. Then came reading glasses and seamen's telescopes, *optical instruments* using lenses to augment the power of the naked eye. Finally came *scientific instruments*, specifically developed for natural philosophers doing research and experiments: barometers, thermometers, electrical devices, air pumps.

In 1665 The Royal Society published a book by Robert Hooke called the *Micrographia*, full of engravings of detailed microscopic images,: strong, beautiful, heavily armoured fleas; insects' dramatic compound eyes; sharp blade-edges; full-stops; the cells of cork. The louse opened up to four times the size of the book. It was a popular sensation.

But some objected on religious grounds. Wasn't human sight part of God's creation and therefore perfect as it was? Didn't the microscope made it inhuman and unnatural and therefore incapable of leading to true knowledge? Hooke defended it, arguing that the Fall of Man and his expulsion from the Garden of Eden had made human senses imperfect, no better than those of a beast, and therefore incapable of seeing God's creation in its true perfection. The microscope remedied this.

Hooke and Boyle used air pumps to conduct dramatic scientific demonstrations which became hugely popular entertainments. They involved creating a vacuum which extinguished candles or made ringing bells inaudible. Some involved killing birds. Modern research ethics would hardly allow this today; but a famous painting of 1768 shows a demonstrator, with his finger on

the stopcock of a globe, deciding the life or death of a white cockatoo. Air leaks often spoiled the effect, perhaps to the relief of some small creatures.

Newton's apple

It was Newton's theory of gravitational attraction that made him the hero of modern science. He published it in 1687, in *The Mathematical Principles of Natural Philosophy.* The story that Newton was inspired by a falling apple was not recorded at the time, but Newton told it just before his death, reminiscing with a younger friend and later his biographer, William Stukeley, over a cup of tea. Voltaire claimed he heard it from Newton's niece. (In neither version does the apple hit him on the head). The poet Byron popularised the story in the 19th century. As Cathy tells us, on the site of the National Physical Laboratory in Teddington, Surrey where she used to work there is an apple tree grown from Newton's original (in Lincolnshire). The story has echoes of the Garden of Eden.

Newton's theory of gravity (meaning "weight") literally held everything together: the planets and the sun; science and mathematics; the work of his predecessors. On that last point, he quoted the ancient aphorism, "*if I have seen further [than others], it is by standing on the shoulders of giants.*"

This famous quote sounds modest and noble. Yet it is double-edged. He said it In a letter of 1675 to his rival Robert Hooke. Hooke was a man of very slight build with acute curvature of the spine. Their rivalry was bitter; Is and Hooke accused Newton of stealing his ideas without acknowledgement. What then was Newton thinking, writing "*standing on the shoulders of giants*" to Hooke of all people?

Newton was contradictory. He devoted much time to studying and writing about the Bible and was at pains to include God in his cosmos. One modern historian commented that it was good that such an eminent expert on religion should spare the time to do some science. His interest in Alchemy and magic have been noted, and he preferred old-school Greek geometry to the new-fangled algebraic mathematics of Descartes. Fara sums up: Newtons' *Principia* (1687), supposedly the foundational text of modern science, was in fact "*rooted in the past as much as looking forward to the future*."

It took time for his model of the universe, so compelling in hindsight, to be generally accepted. What persuaded people was comets. Previously they were seen as unpredictable, miraculous warnings from God about humanity's sinfulness. Several appeared in the 1680's, including Halley's. Newton

predicted them. He had studied them obsessively and his endless calculations succeeded in imposing mathematical regularity on the apparently miraculous.

The Royal Society refused to finance the publication of the *Principia*. Halley did. Newton deliberately made his book difficult; he wrote it in Latin and packed it with complex Euclidean geometry, *"to avoid being baited by little smatterers in mathematics*." He elucidated three new universal laws of motion. The "*universal attractive force*" of gravity held things together, whether atoms, apples, comets or billiard balls. All was described in mathematical language, such as the inverse square law (the closer two objects are, and the heavier, the more strongly they attract each other). Unlike Descartes, Newton envisaged vast tracts of empty space, even space within apparently solid matter. Sceptics asked hm, how could gravity attract through empty space? They accused Newton of resorting to occult forces, which the mechanical universe was supposed to have eliminated. And what exactly *was* gravity, apparently a force somehow inherent in matter? Didn't this blur the matter and spirit? Didn't it deny God? Newton's strongest critics were religious.

In the 18th and 19th centuries Newton's reputation rose to dizzy heights. In all branches of science everyone wanted to emulate him, to reduce complexity to a few fairly simple natural laws. The fact that Newton had done it generated great optimism. This was not always justified.

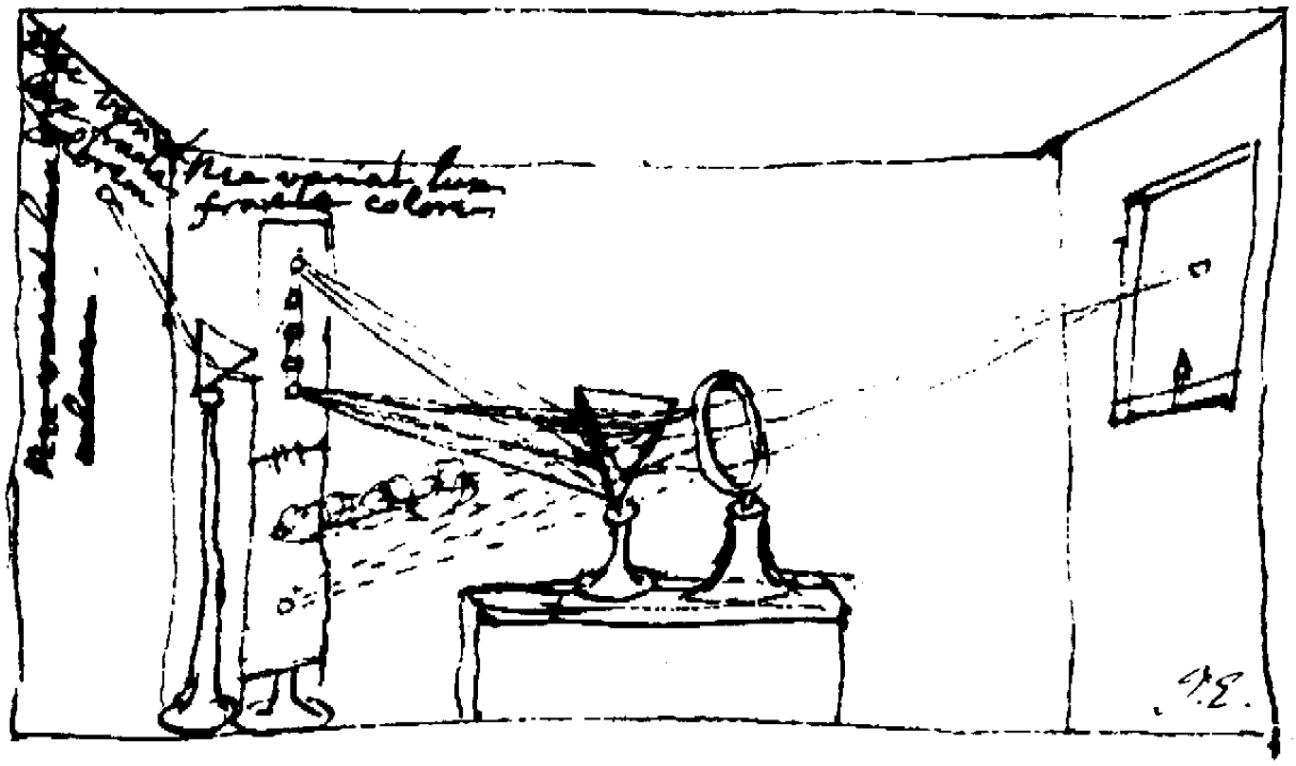
Conclusion: the Scientific Revolution revisited

After 1500, the voyages of Columbus and global exploration triggered an explosion of knowledge. Global scientific networks were created exchanging specimens and ideas. Illustrated books and new scientific instruments appeared. Magic encouraged the idea that scientists should seek control, not just understanding. The cosmos was increasingly envisaged as a machine rather than a macrocosm of humanity. All this stimulated scientific exploration, innovation and discovery.

However to call this period "*the* Scientific Revolution" is an exaggeration. Modern science didn't emerge fully formed from this period, nor did it end with Newton. As we've seen in previous Sessions, science emerged from the *totality* of history. It didn't rely on just a few great heroes in one particular place or time.

The justly famous scientists we've looked at in this session were not heroes, but were shaped and driven and buffeted by history like everybody else. Further, they share the stage with other less familiar names from other times

and places as well as skilled and intelligent artisans, alchemists, monks and magicians. This does not detract from their story or their achievements. It makes them more remarkable, not less.



A chink of sunlight enters. It is focused by a lens and passed through a prism. Separate rays of rainbow colours emerge. The rays are passed through holes in a screen. One is passed through a second prism. It emerges to shine on the wall, its colour unchanged. This proves…what?

SESSION FIVE

INSTITUTIONS

How 18th century science ceased to be a gentleman's pursuit

If the 16th and 17th centuries were the "the Scientific Revolution", it seems odd that it seems to have run out of steam in the 18th century. Did the supply of heroes suddenly dry up? Is that why it was a "quiet period" in the history of science? The answer is that science doesn't progress through revolutions made by heroes. Instead, as Patricia Farr says. we need to look at the totality of historical change and consider how science relates to wider society, to business, industry, war, medicine and government.

If we look at the 18th and early 19th century from this perspective, we find that far from being a "quiet period" for science, major developments took, both in the place of science in society and in science as a discipline. Science gained a collective identity and a voice. People began to see science as a career. Scientific knowledge and science itself were reorganised.

PART ONE – SCIENCE IN SOCIETY

Scientific societies

The reputation of science stood high in 1700. Newton was increasingly hailed as a genius for the way he had synthesised the science of the heavens. Thinkers became optimistic that this could be done in all areas, even including the study of human society. Historians call the 18th century "the Age of Reason"; philosopher Immanuel Kant1724 - 1804 called it the age of "the Enlightenment". This suggested that science and reason had triumphed over religion and superstition.

Further, alchemy and magic had encouraged scientists to aim to change the universe, not just understand it. This expanded their collective vision and ambition. They realised that to gain a strong collective voice they had to combine. Their response was to form *scientific societies*.

This began in the mid-17th century. The first societies were set up in Rome and Florence, associated with Galileo and his students. Then in London in 1660 the influential *Royal Society* was founded by royal charter. Its mission was to promote experimental science in the spirit of Francis Bacon: its motto was *nullius verbo* – take nobody's word for it. The newly restored monarch, Charles

II, was pleased to be its patron. Newton was happy to have a platform to publicise his work beyond his Cambridge circle. He became its President and dominant figure, but as Fara says, "*it was the Society that put science into society*." Similar societies sprang up across Europe such as the French *Academie des Sciences* in 1666.

These prestigious societies put science on the map. In 16th and 17th centuries science was a private activity, conducted behind closed doors in university scholars' rooms, aristocrats' dining rooms and artisans' workshops. This changed during the 18th century. Science entered the new public sphere: coffee houses, lecture halls, gentlemen's clubs, museums and freemasonry lodges. Improved printing presses brought daily newspapers, review journals and more books. New ideas, new entertainments and public debate enriched intellectual life across Enlightenment Europe. It was the birth of "public opinion". Political power gradually shifted away from absolute monarchs to government ministers. In towns across Europe and America societies were formed to discuss literature, science and politics.

In this environment the *Royal Society* consolidated its place as the leading voice of science. Lead by Boyle, Hooke and Wren, it met at Gresham College, a Thameside navigational college specialising in mathematics. It moved to the Strand, a centre for instrument-making. Its "*ideological figurehead*" was the late Francis Bacon (d.1626) whose vision was that science could transform society for the benefit of everyone. And the *Royal Society* claimed to be democratic. In practice it was run by an elite of educated aristocrats, "*a new scientific priesthood*" (Fara). Its elected Fellows came mostly from the privileged classes, with a tiny number of artisan instrument makers, and no women.

However its influence spread widely. Its *Journals* and summaries of its experiments were published and widely read. Prominent scientists published their letters, such as the American Ben Franklin. Collectors exchanged specimens, minerals, and instruments. What was actually circulating, of course, was *ideas*. And women were among those who could participate in this wider public scientific discourse. Thus although they were excluded from the universities and the Royal Society, they nonetheless found ways to participate in the intellectual ferment of 18th science.

Joseph Banks 1743 -1820

The French were generous in funding science, providing prizes and even salaries for researchers who met in the royal library. The British were much stingier. It was hard to get funding for science unless it had a practical, profitable purpose. However the President of the *Royal Society* in the late 18th and early 19th century, the aristocratic Joseph Banks, was adept at squeezing money out of wealthy backers and the government. Banks was a botanical collector and explorer. He established an unrivalled network of contacts and exchanged specimens of plants globally. He helped developing colonies to grow wheat and barley and raise sheep and cattle, thus, it is said, changing the appearance of the earth.

Banks intermingled science with the growth of overseas trade and empire-building. He himself sailed as a botanist to Australia with Cook and helped found the Penal Colony. He persuaded the East India Company to finance a Pacific mapping expedition by promising it would also allow some commercial espionage on the India market. Scientific expeditions were useful for reconnoitring potential colonies. Fara says, "*It was often impossible to distinguish between commercial espionage, diplomatic activity and scientific investigation*." Banks grew close to George III. Science grew on the back of empire. Bank's example encouraged scientists to go on exciting voyages, as Darwin later did. He worked tirelessly to promote science; 20,000 of his letters survive and he was President of the Royal Society for 40 years. And in his own way, he helped make it a little less elitist. Although he was not a great scientist – Fara calls him "*the first great scientific administrator*" – Banks was instrumental in raising the profile and status of science.

Banks was also instrumental in breaking down barriers. In 1801 he opened a new society, the *Royal Institution*, with a mission to promote not just research but also public education in science. Humphrey Davy later became its President, and Faraday, who later took over, his assistant. Davey was both a serious scientist – he invented the Davy lamp and discovered several new elements – and a flamboyant showman and self-promoter. He later became President of the *Royal Academy*. However, significant barriers remained to people of modest backgrounds. The *Royal Institution* ran popular demonstrations of chemistry experiments, but only the more affluent could afford to attend them.

Further, despite the progress made in the 18th century, practitioners of science still lacked a clear identity. Even the name "scientist" had not yet been invented. Echoing Francis Bacon, Davy defined their purpose clearly enough:

"*to interrogate nature with power, not simply as a scholar, passive and seeking only to understand her operations, but rather as a master, active with his own instrument*." But Davy also warned that ambitious scientific speculators often promised too much. Mary Shelley echoed this warning in her famous novel (*Frankenstein or the Modern Prometheus,* 1818). Its true message was not that scientists were gaining God-like powers, rather that flawed and reckless charlatans like Victor Frankenstein were undermining the uncertain reputation of science. Despite the hard sell of science, not everyone was buying.

PART TWO – SCIENCE AS A CAREER

At the beginning of the 18th century, science was still restricted to the charmed circle of privilege and wealth. Aristocratic and gentleman scientists looked down on anyone for whom money was a consideration. Although middle class people began gaining entry to the Royal Society, the old guard of aristocrats and admirals resisted. But the rising popularity and profile of science attracted people of modest circumstances to seek ways of making it pay enough to sustain a living. Artisan instrument makers had always had to do this. Now others tried. Far from being a "quiet period" in the history of science, the 18th century saw a significant breakthrough: the appearance of the concept of a scientific *career*.

This wasn't just in science. Artists, writers and musicians were similarly striving to establish a collective identity and create a career structure. In France the state gave many scientists salaried positions, but in Britain to live and work they had to market their books and inventions. Being elected an FRS – Fellow of the Royal Society – helped. Collectively they all helped to make science a force in society.

Britain's first salaried position in science was the Directorship of the British Museum which in 1756 went to Gowin Knight, a physicist and inventor of high-quality steel magnets and better compasses who'd persuaded the navy to buy them. He was also an ambitious social climber. As Director he restricted access to the museum. Similar moves were afoot at the Royal Society, where personal recommendation was made a requirement, no problem for well-bred university graduates but it excluded many qualified instrument makers. Typical was Benjamin Martin, who had to live off his inventions, books and lectures. People like him worked tirelessly to persuade many of the importance of science, only to be excluded by the Royal Society.

Science as theatre

The need to "sell" science to society influenced researchers towards practical, profitable things like Gowin Knight's compasses. However the search for marketable science took a more surprising turn. Growing trade and industry created both a new consumer society and new forms of popular entertainment. Unexpectedly science became a popular and fashionable form of *popular entertainment*. Historians of popular culture seem to have overlooked this. 18th century science became a branch of the theatre.

The starring role was *electricity*. Researchers, called "*electricians*", came up with some spectacular effects: glowing jets of water, electrified insects, glasses of spirits set alight, a line of real soldiers made to jump up in the air, even a (safely) electrified boy attracting metal filings to his hands while hung up by his feet. Audiences loved it. Electrical entertainments filled the theatres. On the plus side this led to the accidental discovery of the *Leyden Jar* which could store electricity. On the minus side there were accidents, even fatalities. But the 18th century was the age of the electrician, not just in entertainment. Lightning rods, endorsed by Ben Franklin, found their way onto high buildings, churches and ship-masts. Electric-shock therapy was in demand as a remedy for flu, toothache, paralysis and insanity.

Women in science

Women played an active part in this upsurge of science. A growing market developed in introductory science books. It occurred to publishers that there could be demand for such books specifically aimed at women readers. Such books would use a device like a knowledgeable if patronising brother who explained everything to his receptive and grateful sister.

But women seized the opportunity and started writing them themselves. Some became best-sellers. One was written by Jane Mercet; she and her husband, a physician and chemist, were research collaborators. It was called *Conversations on Chemistry.* One of its readers was a teenage Michael Faraday. The son of a blacksmith, he became one of Britain's greatest scientists. Later he said that Meret's book had helped inspire him to become a scientist. Women writers played a major part in popularising 18th century science and educating the public in its principles.

PART THREE – REORGANISING KNOWLEDGE

Systems of knowledge

The 18th century Enlightenment, the “age of reason”, loved encyclopaedias which aspired to be “maps of knowledge”. Ephraim Chambers, a self-taught bookseller, was one of the first to try to marshal the whole of knowledge alphabetically, with his *Chambers’ Cycolpedia,* 1728. It had its quirks; under *Rational* you would find *Religion* and *Metaphysics,* while *Mathematics, Optics and Astronomy* included *falconry, alchemy* and *sculpture.* He also introduced the *arts/sciences* divide.

Chambers was superceded first by the Scottish *Encyclopaedia Britannica (*1768*),* then by the monumental French *Encyclopaedie* (1751 –72). This became the Bible of the Enlightenment, eventually reaching 28 volumes. In the rush to finish, there was some cross-referencing to articles that never got written. Limited space was given to Theology, while the sections on Mathematics and Science (“Natural Philosophy”) were lengthy. It laid the foundation of today’s academic subject disciplines.

Science too began to reorganise itself, to move from a collection of facts and observations into a system of *knowledge.* This process began in the 18th century, for two reasons. The age of exploration had created a mass of new scientific information which needed to be assimilated. And for science to gain public acceptance and approval, it had to be intelligible.

Classifying plants

The process began with ***botany***, a popular branch of science, and also one deemed one “appropriate” as a pursuit for women. The age of exploration had brought to light many new plants, and collectors avidly exchanged specimens. But there was a problem. The system of classifying them dated back to Aristotle. A new system was urgently needed.

Aristotle’s ancient classifications or “taxonomy” of plants was outdated. Naturalists had since discovered that plants reproduce sexually, and many new varieties were coming from overseas. But getting everybody to agree on a new classification system was a nightmare. For example, a major row blew up between the Dutch and the French over whether a particular French spice was a *true nutmeg*. John Ray of Cambridge was the first to devise a new system. He invented “petals” to replace “coloured leaves” and agonised over the distinction between “shrub” and “tree”. Rather than try to define a plant’s “essence”, he said you should consider several features at once. But his book got so big, the publisher had to drop the illustrations!

The victor turned out to be ***Carl Linnaeus (1707 – 1778***). His plant classification system is still in general use today. He was Sweden's equivalent to Joseph Banks (above), a botanist who sent collectors out to gather exotic specimens. He worked mostly from his garden in Upsalla, a small university town. He had a great flair for self-publicity. His system is based on a single criterion: *the number of the plant's reproductive organs*. He classified a plant according to how many male stamens it had in its flower, then by how many female pistils. This had the merit of being both rational and simple.

But many naturalists were horrified. Botany was considered a suitably decorous pursuit for women. Yet here was Linnaeus talking about "*bridal beds of flowers", soft scents", brides and bridegrooms"* and *"nuptials*". From this perspective, Linnaeus' system reflected the patriarchal assumptions European society. Note how (obviously) male characteristics took precedence. Another criticism was that his system was narrow, focusing entirely on the flower. Although it ultimately triumphed, it was challenged. A French botanist, George Buffon, a Newtonian mathematician and Director of the King's Gardens, proposed an alternative, based not on the appearance of a plant, but its parental origin. But it didn't catch on.

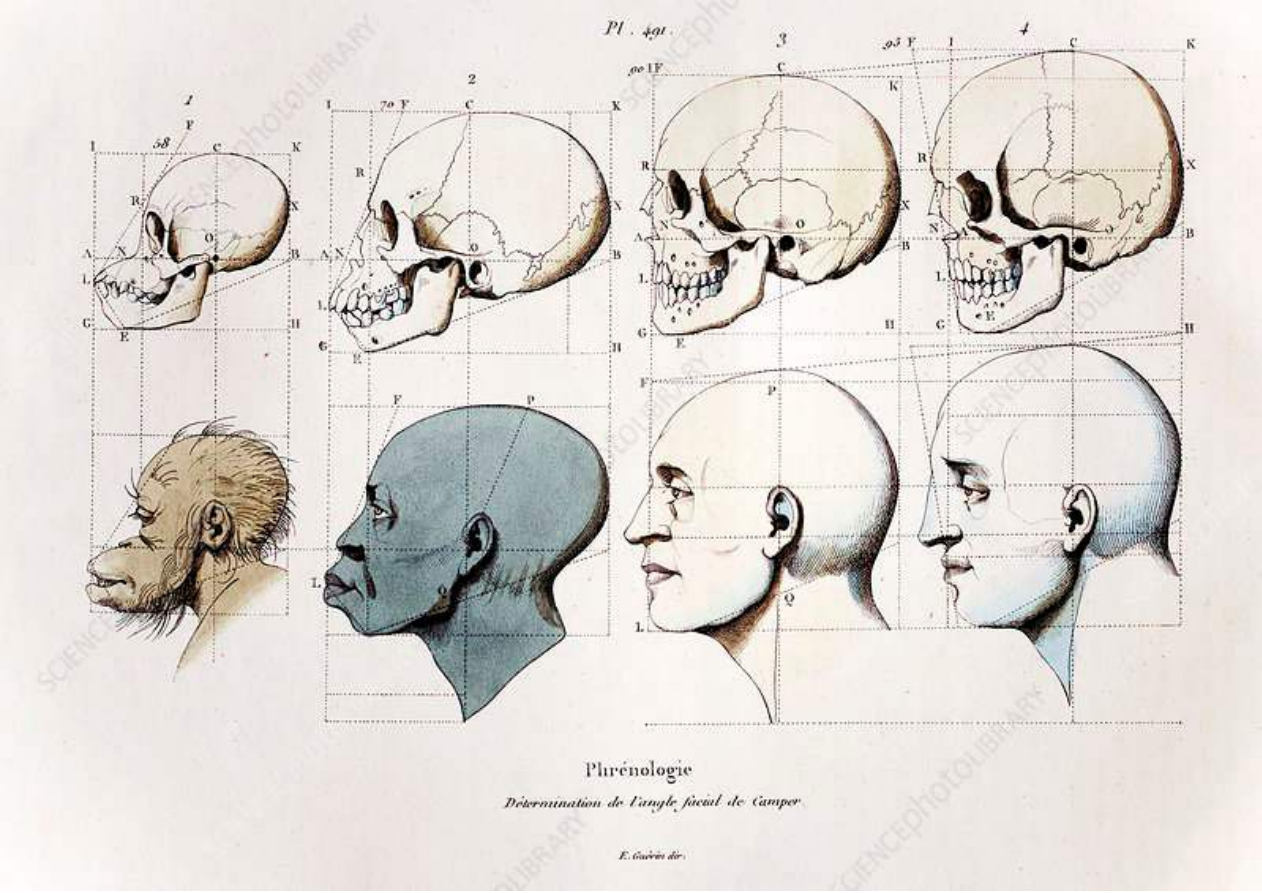
<u>Classifying humans</u>

Cook's discovery of the new continent of Australia in 1770 provoked further debate about classification. The discovery of a new, fifth, continent inhabited by new peoples, triggered many questions about how *humans* should be classified. How did humans relate to primates? How should races be ranked? How did white women rank with black men? Was slavery acceptable? Advocates of abolishing slavery argued from the equality of all races. Slave owners replied that Africans were a different species.

Could naturalists settle the matter by scientific observation? ***Pieter Camper, 1772 – 1789***, a Dutch anatomist, drew a range of skulls, measured and ranked from primates to Africans, Asians and Europeans. Camper decided to rank them according to the angle at which their faces sloped back. His resultant drawings portrayed an apparently seamless progression from crude ape to Greek god. Although supposedly mathematically and scientifically objective, it was clearly based on aesthetic criteria, with the ideal being the then familiar and much-admired Greek ideal of male beauty.

The problem is that the origin of this ideal was not at all scientific. It was *aesthetic*. It came from a hugely influential German art critic and historian called ***Johann Joachim Winckelmann (1717 – 1762).*** Echoing Plato, he

described mature Greek art, especially its representation of the male form, as “ideal beauty”, that is a degree of beauty that excelled anything in nature. Nonetheless, at the time, Camper’s drawings were widely accepted as objective. Ideas of European ideas of racial superiority were emerging. Racial prejudice thus gained “scientific” respectability from a powerful artistic image which confirmed existing prejudices and beliefs.



Disciplines

The revolution in chemistry was part of a process by which science defined itself more systematically by agreeing on its many different branches and specialisms, what we now call its various *disciplines.* A revealing word: it was about controlling what did and didn’t count as “science”.

These scientific disciplines had very different histories. *Astronomy*, *optics* and *mechanics* originated in the medieval universities. *Chemistry* originated in *alchemy* and *medicine*. *Biology* was also new (the name is 19th century) but originated with herbalists, merchants and collectors, often women. *Geology,* also new (named in 1807), originated with farmers, miners, soldiers and surveyors, canal and railway builders.

Collecting geological specimens was a middle-class craze. But there was more to geology than that. By challenging the Bible creation story, geologists opened the way to the theory of *evolution*. *Electricity* was the craze of the18th century, while *magnetism* was an ancient, God-given power and a mystery. In 1820 the two were linked by a Copenhagen physics professor called Hans Oersted. He noticed a compass needle twitch near an electric current. Faraday confirmed the link. And it worked in reverse: a current moved a magnetic needle, but also rotating a coil of electrical wire around a magnet created a current. *Electromagnetism* was born. It was the discipline that dominated 19th century science. Truly, science had many mansions.

Lavoisier and the revolution in chemistry

The story of chemistry is a good case study on how the scientific disciplines emerged. It owed much to ***Antoine Lavoisier (1743 – 1794)*** who published the *Traite Elementaire de Chimie* (*Elementary Treatise in Chemistry*) in 1789. It was the first book of modern chemistry. It introduced the chemical names and symbols we recognise today.

Lavoisier's great rival was Joseph Priestley, the leading English chemist. They discovered oxygen at about the same time, by heating powered mercury, but Priestley pipped him at the post. However because Priestley didn't understand burning, he didn't understand oxygen.

Priestey shared the theory that things burn by releasing a fiery substance called *phlogiston*. When metal ores were heated, he said, they absorbed phlogiston, leaving behind metal. When metals are heated, they released phlogiston. He discovered that things burned better in his new gas than they did in ordinary air; so he called it *dephlogisticated air*.

But other chemists using more accurate chemists' scales found that Priestley couldn't be right. When metals when heated they *gained* weight, not lost it. Lavoisier rightly concluded that Priestely had got everything the wrong way round. The new gas, he said, was a fundamental element and part of air. He promptly renamed it, *oxygen*. When iron ore is heated, oxygen is released. When metal is heated oxygen is absorbed. *Phlogiston* was no more. Burning was *oxidising*. So Priestely gets the credit for discovering oxygen. But it was Lavoisier who named* it and understood it.

*The name oxygen means "acid-forming" because Lavoisier believed it was crucial to acids. He waw wrong. So his name is as inappropriate as Preistley's!

Lavoisier was an aristocratic tax collector. As an accountant, he liked order and precision. French scientists loved algebra; English ones didn't. in his book, Lavoisier gave every substance a new, Latinised name: "*Epsom salts*" became "*magnesium sulphate*". Much more precise. But apothecaries weren't so keen; nor were English scientists who disliked Lavoisier's approach as over-planned. They favoured the unexpected observation, the surprising discovery.

By this time even some French scientists were critical of Lavoisier for over-complicating things and for generalising from too few facts. He became dominant not because he was right, but because he was persuasive. He worked on key influential people and campaigned hard for his ideas through books, lectures, plays and pictures. But his downfall was sudden and shocking. Despite his fame, in 1794 the French Revolutionary government accused him and 27 other tax-collectors of fraud. All were guillotined. Appeals for clemency on the grounds of Lavoisier's contribution to science were ignored.

He is often hailed as "*the father of chemistry*" who single-handedly made it a modern scientific discipline. In reality, he owed much to his wife and collaborator Marie-Ann, his supportive research team and the work of predecessors. He was one of the many who contributed to turning alchemy into chemistry.

Early chemistry was known for its practical projects: better dyes, bleaches, medicines, fertilisers, cement and coal gas. Lavoisier himself manufactured ingredients for gunpowder when France couldn't import them during wartime. Chemists could bulk-produce sulphuric acid for industry but couldn't explain the theory behind it. Even so, by 1800 chemistry was well on the way to becoming an established scientific discipline

Pseudo-science

Another aspect of defining the scientific disciplines was claiming the power to decide what *wasn't* true science. This is well illustrated by the pseudo-science *Mesmerism*. This was created by an Austrian physician ***Franz Mesmer (1734 – 1815).*** He ran a clinic in Paris in the 1780's treating patients by passing "magnetic fluid" through the body. He used a magnetic baton, an impressively intense gaze and lots of theatrical hand movements. It seemed to work and both he and the myriad of other therapists who sprang up commanded high fees.

French scientists and physicians, feeling their status threatened, united against it. A royal committee was convened to investigate. It concluded that although Mesmer wasn't actually acting fraudulently, he couldn't explain *why* it worked. Therefore it must be fake, Its few successes were put down to the patients' strong belief in the treatment. Nowadays it might have been designated "alternative medicine". But then it was officially condemned and Mesmer declared a charlatan – harsh given that he was a qualified physician!

Mesmerism was subversive in several ways. It was a "democratic therapy" (Fara); it could be practised by ordinary people, undermining the status of the educated, qualified elite. It also enlisted the patient's own emotions and imaginations in effecting a cure, undermining the supremacy of reason. It threatened traditional hierarchies. Banning it reasserted their power. Here was another, perhaps less noble meaning to Francis Bacon's aphorism, that "*knowledge is power*".

Laplace – a Newtonian cosmos

Finally we need to look briefly at ***Pierre-Simon Laplace*** **(1749 – 1827**), a French physicist and gifted polymath. He attempted to reorganise not merely scientific knowledge, but the universe itself. He did not succeed.

Laplace conceived of a sparse, rational and material cosmos, created by God, but then left by Him to run along by itself with no further Divine intervention being necessary. When asked – by none other than Napoleon – where is God in your scheme of things? – he grandly replied, "*Sir*, *I have no need of that hypothesis*." Laplace reorganised the cosmos along the lines indicated by Newton. There were particles and nothing else. Particles attracted one another in precise, predetermined ways. Gravity was sufficient to explain everything.

Heat, light and electricity, he said, were made of special particles in the form of weightless, invisible fluids. These repelled one another, but attracted ordinary particles. In this force-driven universe, particles bounced around along their logical, predetermined paths. Measurement and mathematical equations explained how everything worked.

So much so that Laplace took this to its logical conclusion. Imagine that at a particular moment in time you could record the position, trajectory and speed of every single atom in the universe. You could then easily calculate the *future* position of each. In other words, *theoretically you could predict the future*. This was a staggering claim, because if the future is theoretically knowable, then

everything that happens is determined in advance. We live in a *determinist* universe. Therefore we have no free will.

Obviously to know the exact point and trajectory of every atom in the universe at any particular moment is a pretty big task. Potentially, it could require a device as big as the universe itself. But the theory seemed impeccable. However, as we'll see later (Session 7), twentieth century quantum theory would identify sub-atomic particles whose behaviour was so weird that they were in an absolute sense unpredictable (e.g. they can be in two places at once). Theoretically, this restores randomness, unpredictability – and therefore free will – to the universe.

Laplace, like Lavoisier, was domineering and strong-minded. He schemed to get supporters onto important committees and into positions of influence, and made sure that all the prescribed textbooks taught his theories. But it didn't last. He overreached himself. His group's insistence on defending Newton's view that light was made of a stream of particles offended the broad consensus that light was a wave. Criticisms of Laplace began to be voiced and increased in volume. The idea that absolutely everything in the universe could be explained by the short-range attraction and repulsion of particles was simplistic and unsustainable. His boldly hypothetical approach was losing favour to meticulous observation.

Laplace stranglehold on French science ended. By 1825 his group had broken up. However his broad commitment to the mathematical approach to science endured; eventually scientists everywhere had to adopt it, even in Britain. And the metric system, which he helped to devise and implement, would later become the foundation of the global system of measurement. But after Laplace, France lost its lead in theoretical physics for good.

PART FOUR – DEFINING THE SCIENTIST

The birth of the scientist

A final, decisive step in defining science's place in society was agreeing what to call it. "Science" did not yet have its modern meaning. In Jane Austen's *Pride and Prejudice,* Sir William comments that dancing is "*one of the first refinements of polished societies*." Mr Darcy disagrees: "*Every savage can dance*." Sir William replies, "*I doubt not that you are an adept in the science yourself, Mr Darc*y." In similar vein, John Ruskin, a Victorian art-critic, listed the five "*sciences*" that are worth studying at university: *morals, history, grammar, music* and *painting*. He specifically *excludes* chemistry, electricity or geology.

As Fara says, the modern meaning of science and the division between arts and sciences was not yet fixed.

The big moment arrived in 1833. At a meeting of the *British Society for the Advancement of Science,* delegates were joking about the lack of an umbrella word for those engaged in it. Coleridge the poet rejected "*philosopher*". William Whewell (pron. "Hugh-ell"), an astronomer, thinking of the word "*artist*", suggested "*scientist*". It was slow to catch on. Stuffy Victorians preferred "*man of science*" or "*naturalist*" or "*experimental philosopher*". The Americans loved *scientist* straight away. This only made others suspect that it was a "*barbaric Americanism*". It wasn't universally adopted until the early 1900's.

Nonetheless Whewell was pleased to get his proposal passed. He was worried that science was splitting into so many specialisms that their lack of an overall name would weaken their collective influence in competition with writers, artists and musicians who were also seeking a collective identity at the time. This mattered because scientific research was getting bigger and more expensive, so gaining state or industrial funding was increasingly essential.

As Fara explains, "*the gentlemanly men of science became victims of the own success because it was partly through their own efforts that science became more democratic*." Their success in selling the importance of science had increased public understanding. Science "*ceased to be the preserve of gentlemen. As research grew and education expanded, new opportunities for paid employment as lab assistants, museum curators or astronomical calculators arose. Very gradually science became a paid profession open to many rather than an all-absorbing but expensive occupation for the leisured classes*."

<u>Conclusion – science and scientists</u>

To sum up, the 18th century was far from being a quiet period for science. It gained a collective identity, influence and a voice in society through prestigious scientific societies like the *Royal Society* and the *French Academie des Sciences.* Science was part of the ferment of new ideas of the Enlightenment, in coffee houses, in theatres and in print. Joseph Banks became a global science entrepreneur, cadging money by merging science with trade and empire. People began find ways of using science to earn a living. Scientific knowledge was reorganised. Carl Linnaeus classified plant life. Camper classified human skulls. Lavoisier reorganised chemistry. Laplace reorganised the cosmos according to Newton. Science was reorganised into new scientific

disciplines. And to cap it all, in 1833 “scientists” gained their modern name. This was decidedly not a quiet period. Science came of age.

SESSION SIX

THE MARCH OF PROGRESS

How the 19th century search for absolute truth ended in relativity

Overview: 19th century science

So great was the reputation of Newton that throughout the 19th century scientists were inspired to apply his approach to all the sciences and achieve absolute, objective truth in all fields. Yet, *subjectivity* kept creeping in. And at the turn of the century, the practical problem of synchronising global time resulted in an unexpected outcome: Einstein's *Theory of Relativity*. Far from revealing absolute truth in a few simple laws, this introduced new levels of strangeness.

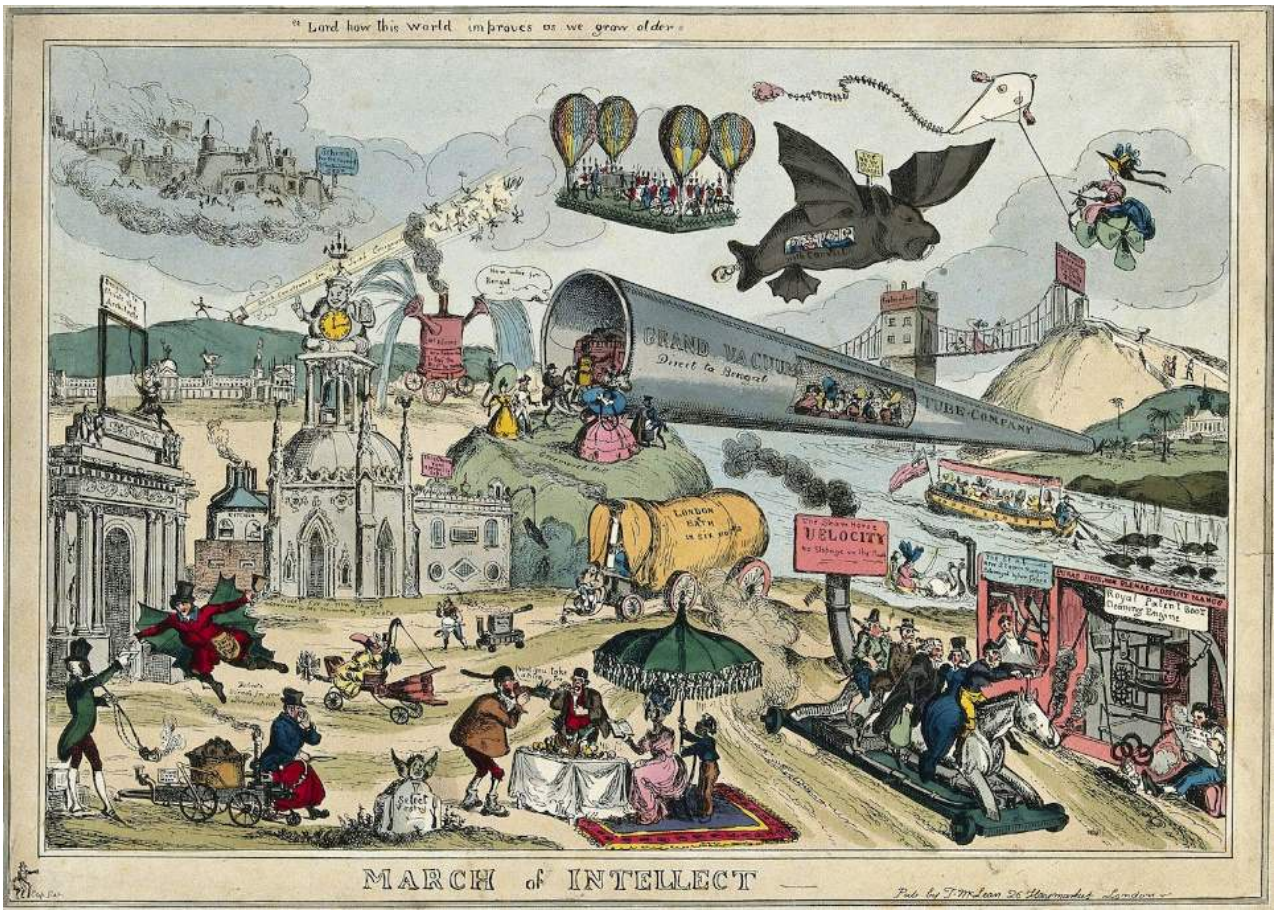
Newton unveiled

Margaret Thatcher, Britain's only scientist prime minister, used to walk to school past a statue of Isaac Newton, also educated in Grantham, unveiled in 1858. His statue portrays him in university robes, single-minded, dedicated and methodical. The Victorians saw these qualities as the key to progress, building up knowledge up step by gradual step. This was the traditional narrative of the history of science, with Newton as its greatest hero. It wasn't Just scientists that Newton inspired. Just as he had succeeded in imposing law and mathematical order in astronomy, so 19th century thinkers were resolved to unite *all* knowledge in a single system which explained everything. Not just the cosmos – heat, light, mechanics, electricity, matter – but also history and human society. All could be revealed through the discovery of a few, simple laws.

One of the reasons that faith in progress was so strong in the 19th century was that the new sciences of geology and evolution suggested that God had left his creation *incomplete*. The world we see is not the one He created. Geologists said that as the earth cooled from its original hot, molten state, so swirling clouds of dust condensed to form the solar system. Naturalists said that God created life, but not in the forms that currently existed. Plants and animals had evolved. Darwin's theory of Natural Selection would explain how. In other words, God's Creation had *progressed* from its original state.

The March of Intellect

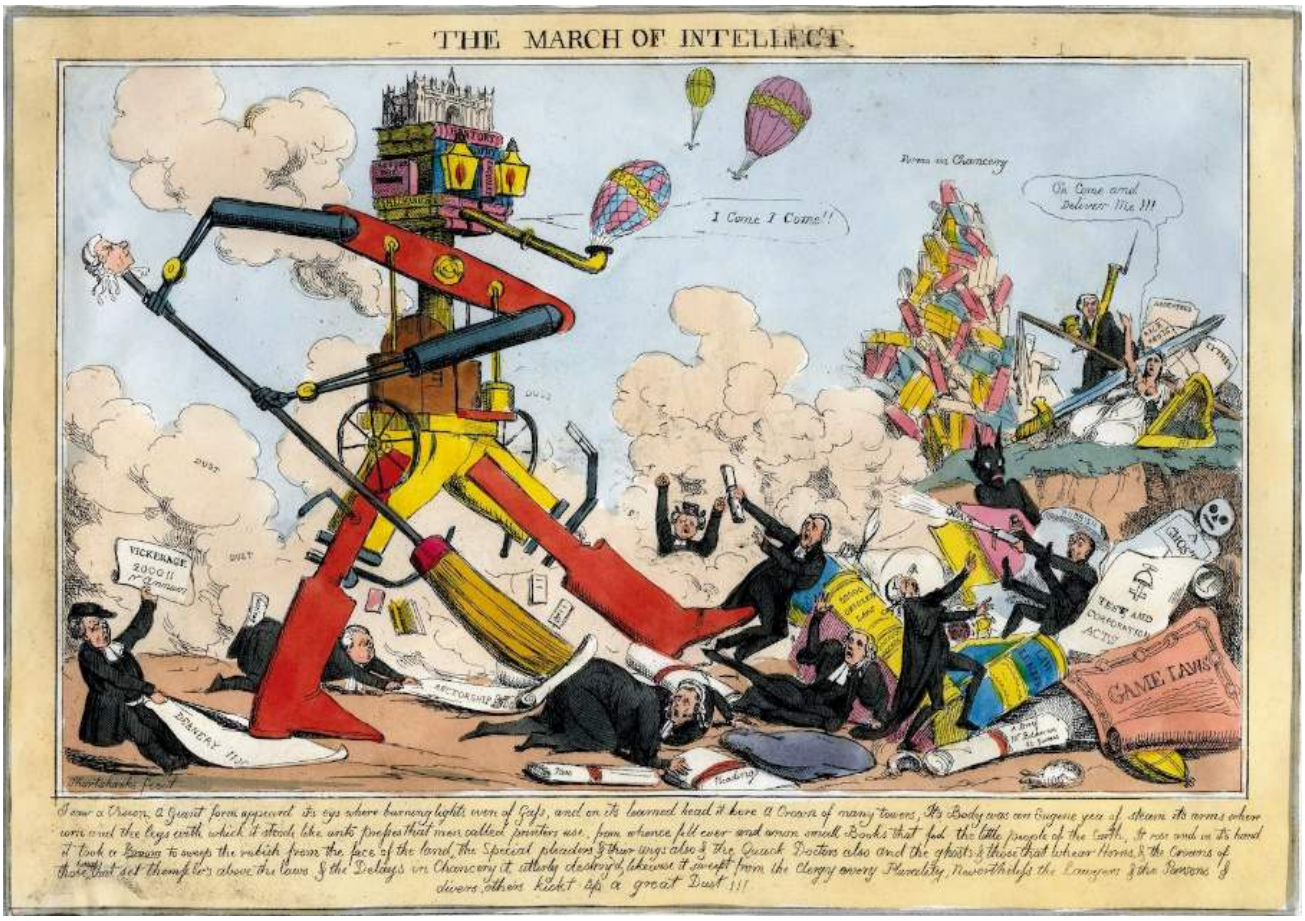
But not everyone believed in progress. In a series of satirical caricatures called *The March of Intellect,* published in Britain by William Heath in1828-9, the whole idea of scientific and technological progress is mocked.



Heath mocks the craze for new inventions. He shows conveyer belts in shop windows, machines that clean boots and do all the housework, multi-seated steam-powered horse, flights to Bengal propelled through giant vacuum tubes and postmen flying around with winged capes. In a second caricature, a gigantic, steam-powered automaton rampages through society, shouting "*I Come I Come!!*" Its giant broom sweeps aside all resistance. It's a Frankenstein monster of new knowledge, with a "*learned head*" made of books on history and philosophy and mechanics manuals. Its eyes are gas-lit. It smokes a pipe blowing out hot-air balloons.

Underlying the humour are serious anxieties, particularly among the elite. By learning too much, people are getting ideas above their station and losing the work ethic. Lazy, overdressed women window shop and smoke; the boot-cleaner reads the paper letting the machine do his work; people are travelling wherever they like. These were modern manifestations of the ancient fears of

the haves against the have-nots, intensified by the rise of science, technology and industry.



Many feared that that change and scientific “progress” were helping to destabilise society and threatening to unleash forces of anarchy. As these caricatures suggest, the “march of intellect” – scientific progress – wasn’t universally welcomed. Fear and anxiety were mixed in with the optimism and excitement.

Scientists and the March of Progress

But the *March of Intellect* continued, apparently unstoppable. In 1831 the *British Association for the Advancement of Science* was founded to give scientists a unified voice and a platform to promote their work and importance. This first generation of 19th century scientists had to carve out careers for themselves. One of the most famous was Thomas Huxley, a forceful campaigner for Darwinism (below who earned the nickname “Dawin’s bulldog”. Even he lacked job security and had money problems. Darwin himself had independent wealth and worked at home. Cambridge physicist Lord Rayleigh recounted how every day he had to clear his scientific apparatus off the top of

the piano for family prayers. Lord Kelvin's laboratory was a converted coal cellar. Not until the end of the 19th century could a school-leaver aim to become a professional salaried scientist.

Scientists realised that they needed a strong collective voice to persuade wider society of the importance of their work. But they also believed that nobody outside their own charmed circle was capable of grasping the true significance of their work. Their "unified voice of science" was not an inclusive one. It excluded less privileged groups who, despite their contributions, were written out of the history of science. One such excluded group were technical assistants, who built apparatus, organised labs, and repeatedly ran experiments. Another were the wives of scientists like Mary Lyell.

As the wife of famous geologist Charles Lyell, and like many science wives, Mary collaborated in his research and edited and illustrated his books. She organised his all-important mineral collection, became an expert on shell classification and even trained her plucky maid how to kill and clean snails. Their honeymoon was a geological expedition. Last session we mentioned the largely forgotten science author Jane Mercet (Session 5) who inspired the young Michael Faraday.

And there were other women scientists who were "written out" of the story. One was ***Mary Anning (1799 – 1847)*** who made a living by collecting and selling fossils in Lyme Regis. Many of her dinosaurs are exhibited in museums, without acknowledgement. Yet she was mere collector: the importance of her work is considerable. She not merely pioneered the new scientific discipline of ***palaeontology***, she also proved the existence of ***animal extinction***. But because this discovery was not published, it was never formally recognised. Yet it completely transformed the status of geology, which it turn enabled Darwinism. Ditto the group of working-class weavers of Manchester who were also amateur botanists, scouring local hillsides for botanical specimens, meeting in local pubs to discuss botany, their specimens eagerly sought by "expert" botanists. Such unacknowledged figures were of immense importance to the history of science.

Mary Somerville (1780 – 1872) Is another neglected women scientist, now recognised as one of Britain's greatest. She was a ***mathematical physicist*** and author of an introduction to science (Session 5). Unable to attend university, her research was nonetheless considered original enough to be ***published in the Transactions of the Royal Society***. Since she was barred from attending as a woman, her research paper had to be read to the Fellows

by her husband. The Society eventually recognised her by installing a bust of her in the entrance hall.

Although was excluded from science labs and university scholarship, Mary Somerville's writings had a profound effect on science. Henry Brougham asked her to edit a book by Laplace on astronomy, to make it more understandable. Instead she wrote a completely new book which helpfully explained to British astronomers the ***complex mathematics behind Laplace***. In a further book she explained the nature of modern physics. As well as being a ***great synthesiser of scientific ideas,*** she was an expert on the science of light and of electromagnetism. She added illustrations to make her books more accessible to general readers. Her ***Connexon of the Physical Science*s (1834**) became a classic. Its theme, the unification of all the sciences, summed up Victorian thinking. Whewell praised it enthusiastically. Fittingly, it was his review that saw the first appearance in print of the new word he'd just invented – "*scientist*".

The world as a laboratory

Scientific progress was also on the march globally. And If anybody globalised it, it was ***Alexander von Humboldt (1769 – 1859)***. As we saw last session, botanists Joseph Banks and Andreas Linnaeus had made the world their garden. Humbolt went one better: he made the world his laboratory. He was a German polymath, geographer, explorer, adventurer, naturalist, explorer, and philosopher: the polymath's polymath. A larger-than-life figure and independently wealthy, he became the impresario of mid-19th century global science.

Humboldt's approach was hands-on. Rather than have specimens shipped back to study at leisure, he went off to South America to see for himself. He was analytical and used the latest instrumentation to make precise measurements: air pressure, magnetism and plant distribution. He pioneered new ways of presenting data visually, such as plotting temperature on a graph as *isotherms.* (In similar fashion, the geologist Charles Lyell presented the vertical distance below the earth as a timescale into the distant past).

Humboldt was the first to appreciate the importance of the equator as a north-south dividing line of temperature, climate and more. North America, he thought, resembled Europe, while the South was rich in resources but less suited to development (although he saw the potential of guano on the Suth American cost and helped turn it into an export industry for fertilizer and explosives). His travels made him a heroic figure and became a model for

other scientists such as Darwin. He became influential, but was not objective. He believed in European superiority and imperialism. He and his followers saw themselves as conquering the wilderness and bringing civilization to the savages. Although he learned from indigenous people, as Fara says, he and his followers "*concealing their dependence on local experts, took over the knowledge of their guides and presented themselves as lone scientific discoverers*."

The electric telegraph

19th century global science was given a great boost by the invention of the electric telegraph. The American Samuel Morse (of Morse Code) is credited with its invention in 1844, but several pioneers developed different systems, one as early as1823. Morse's system prevailed because he was good at getting financial backing and navigating the patent system. In Britain private railway companies ran telegraph wires alongside their track; soon an underwater cable linked Britain and France. Its potential benefits were huge, but international cooperation was imperative. Here, the British had built-in advantages: a global colonial empire, skilled electricians and the industrial resources to manufacture cable. As a result, British electrical standards were adopted globally. Once again science was driven by trade and empire.

The telegraph was like a vast global nervous system. It strengthened the grip of the European empires, enabling them to gather information world-wide, and issue commands from the centre. The telegraph also boosted research into the nature of electricity and how it flowed. French and German scientists focused on the idea of electrical current as a flow of particles. But British scientists, beginning with Michael Faraday, pushed science in another direction, as they observed peculiar things happening *around* the wires carrying electrical current.

It was Faraday who had made the original revolutionary suggestion: that what they were observing were *electro-magnetic fields*. This concept became a central research concept in modern physics. British scientists came to dominate this field. Its star was the charismatic William Thomson, Lord Kelvin. In 1866 he laid the trans-Atlantic telegraph cable. He agreed with Humboldt: "*When you can measure what you are speaking about and express it in numbers you know something about it, but when you cannot measure it, you have scarcely, in your thoughts, advanced to the stage of science.*"

Objectivity/subjectivity

Thus, objectivity in the style of Newton remained the goal. Fara says that he "*epitomised a pervasive if unattainable scientific stereotype – the selfless genius who measures the universe as though he was an external observer*." But the cultural movement of artists and thinkers known as *German Romanticism* questioned this. They rejected the scientific view of the universe as a machine which could be viewed objectively. The great German writer, philosopher and polymath ***Johann Goethe (1749 – 1832)*** (also a scientist of geology, biology and optics) argued that we were inescapably involved in the observations we made. Objectivity was a myth.
And indeed, it seemed that the more 19th century science tried to be objective, the more subjectivity kept breaking in. Goethe was right: every time you make an observation of the world, you have to make a selection, a choice. Illustrations of skeletons or plants created to put in science books were idealised images. The new scientific instruments like stethoscopes and x-ray machines seemed completely objective, yet they required expert interpreters to make sense of what they showed. Again, subjective human judgement crept in. The same was true of photographs, a word invented by astronomer John Herschel in 1839. Astronomers found it invaluable. Photographs of planets, swirling nebulae and flares around the sun during an eclipse, were popular in newspapers. But these too involved selection. Only a tiny selection of the immensity of the heavens could be captured and presented photographically.

Darwin's cousin, Francis Galton, and others used photographic portraits to study deviant human types like criminals and the deranged, and also different races. Galton produced composite photographic images of the "typical" criminal, with receding chins and long arms, and of geniuses with thin bodies and bulging brows. The claimed these were objective. But to modern viewers these images appear riven by unspoken assumptions and prejudices. Mental qualities and psychological tendencies were inferred from selected physical features. Galton moved on to campaigning for social engineering policies to prevent the lower orders from outbreeding the elite and so weakening the race. Such thinking later informed Nazi anti-Jewish policies. There was nothing objective about this.

Social reformers found a similar issues with statistics, They collected them avidly to reveal the objective laws and patterns that governed human affairs. This worked well enough *en masse*; human behaviour seemed to follow big, regular statistical patterns, for example trends in suicide rates. But where did this leave individual free will? In 1873 James Clark Maxwell, a Scottish scientist at Cambridge, drew a comparison between the behaviour of gases and human populations. The behaviour of a gas depends on the average

velocity of its individual molecules. But these molecules moved by chance. Did this also apply to human life? Objectivity seemed as elusive as ever.

Stretching time and space

Surely of all the 18th century scientific disciplines, at least geology would be naturally objective. Not so. It was riven with deep and bitter controversy. Geologists like James Hutton and Charles Lyell said that the earth had evolved over very long eras of time. This conflicted with the Biblical six-day creation story. Geology told a very different story, of unimaginably long time periods in which land was pushed up by earthquakes and eroded by wind and water. Some Biblical scholars tried to fudge this; "six days" really meant "six long geological eras"; or Noah's Flood explained why some land was once beneath the sea.

Geologists were themselves divided. French geologist ***Georges Cuvier (1769 – 1832)***, noting that different fossils were found in different strata, concluded that different eras must have been separated by violent catastrophes which wiped out those animals. But in Lyell's *Principles of Geology* (3 vols, 1830-3) he countered this *catastrophism* with a contrary view, *gradualism*. He argued that big changes were wrought by very small, very slow changes. *Gradualism* prevailed. While theological scholars had studied Biblical genealogies and calculated the age of the earth as around 6,000 years old, Lyell stretched this out into unimaginably long eras. Further, to the immense disappointment of Christians generally, geological gradualism had no apparent meaning: no pattern or purpose, no direction or destination; no *teleology*.

As well as time, *space* was also being stretched. More powerful 19th century telescopes revealed unimaginably distant vistas of stars and nebulae. Just as burrowing into the earth was to go back in *geological* time, so viewing distant star systems was to journey back in *stellar* time. Geologists and astronomers were suddenly having to add lots of zeroes to their dates and distances. These continuous adjustments were deeply unsettling. They seemed to diminish the place of humanity in the cosmos. Fara calls them, "*a major transformation in European thought*." Carl Sagan called them "*Copernican demotions*". The poet Tennyson kept up with scientific developments, and struggled with the apparent lack of purpose in an ever-vaster cosmos.

Evolution before Darwin

The idea that life was an evolutionary process started long before Charles Darwin. He published his *Origin of the Species* in 1859 which set out his theory of evolution by *Natural Selection*. But a book about evolution by

Darwin's own grandfather Erasmus Darwin had been published in 1803. Erasmus believed that God had created creatures who were capable of improvement, much as he had improved himself from a country physician to successful writer.
A French naturalist called **Jean Lamarck (1744 – 1829)** agreed that life forms had the capacity to continually improve themselves, He believed that as the earth cooled, new life forms had appeared by *spontaneous generation.* He also said that characteristics developed during an individual creature's lifetime could be inherited by their offspring, thus launching an influential and long-lived idea, but a fundamentally mistaken one.

As we saw above, Georges Cuvier, his Paris rival, refused to accept evolution. He disputed that life changed. Life forms were stable. The odd thing about Cuvier was not that he rejected evolution, but rather that he kept discovering things that *supported* it! - that animals should be classified by their internal structure, not their external appearance (e.g. vertebrates/ invertebrates, with/ without a backbone); that it was better to classified animals into four different groups rather than a hierarchy; and that creatures seemed perfectly fitted to their own habitat (an observation used by some anti-evolutionists as proof of how much God cared for the animals He had created!)

Cuvier also noticed that the deeper the rock layer and the older the rock, the less familiar were the fossil creatures. Despite all this, *he still rejected evolution*! Life changed, he argued, not because it evolved but because sudden environmental catastrophes made some creatures extinct: *catastrophism.* He is perhaps unique in the history of science, coming up with brilliant discoveries and observations which helped his opponents to prove *their* theories!

<u>Charles Darwin 1809 – 1882</u>
Meanwhile Darwin bided his time. The son of a wealthy physician, he trained as a clergyman intending to concentrate on his hobby, bugs and geology. But then following Humboldt's example he grabbed an opportunity to sail to the Galapagos islands, taking Lyell's geology book as his travel guide. Everywhere on his travels he saw *change*; in coral reefs, fossils, even the European colonists he met who had adapted to their new colonial environment. On his return he became a full-time naturalist. But he was in no rush to publish his own ideas about evolution. He was painfully meticulous, devoting eight years to a study of barnacles. Gradually he arrived at his own theory: *Natural Selection*. He learned from pigeon breeders and farmers about selective breeding and how they select the features they want. And he noted

countless examples of *natural* adaptation: clover flowers that match different bees; dandelions light enough to be scattered far away; water beetles with fringed legs.

He was also influenced by the human society of his time. Economist Thomas Malthus had argued that population increases always exceeded food supply, resulting in famine and population fall. Darwin, living comfortably on his inherited wealth, saw how the industrial revolution created a booming economy but also, for many, struggle, suffering and death; people starving, emigrating and dying from the diseases of squalor. Ironically it was competitiveness that drove Darwin to publish in 1859; he realised that others were thinking along similar lines to him and might beat him into print.

The originality of his *Origin of the Species* wasn't that life evolved, but that it did so according to *Natural Selection.* The competitive struggle to survive in a hostile environment meant that even a small inherited advantage was enough to increase that creature's chances of survival. Over the immensities of time that geology had discovered, these changes are handed down through the generations, eventually accumulating to create a new species better adapted to its habitat.

Darwin's first edition was a best seller and eventually would earn him a reputation to rival Newton. But soon the hostility broke and became so virulent that, together with his poor health, it made Darwin a recluse in his country house. A clergyman called him "*the most dangerous man in England."* Without powerful friends rushing to its defence, Fara says, the *Origin of Species* could well have been "*criticised into obscurity*." The big issue was the absence of God. *Natural Selection* had no plan, no Designer, no moral purpose to promote spiritual growth, no teleology; just chance. Darwin's *Origins* hardly mentioned humanity and didn't mention apes being our ancestors.

The suggestion that humans had were descended from animals rather than being created separately by God was more than just a scientific theory. It touched our very human essence and our place in the world. That place, according to both Aristotle and Genesis, was at the top of the hierarchy of life. The 19th century descendants the eternal right to their privileged position at the top of society. On the other hand, political radicals and reformers welcomed evolution. It represented change. If the natural world could evolve, so could society. Tradition and privilege could be challenged. Society's wealth could be redistributed. Science, religion and politics fuelled the passion. There was little room for objectivity here.

Yet the passion was heightened by a scientific issue. Natural Selection was arguably the greatest scientific theory of the 19th century, But it couldn't be definitively *proven*. Darwin was aware of this. He called *The Origin of the Species* "*one long argument from beginning to en*d." In the book he piles up example after example in support of his theory. But given the nature of evolution, he couldn't give *definitive* proof. Experimental verification was impossible. What was the mechanism of evolution? How did the first life forms appear? How did evolutionary change actually originate and occur? Nobody knew, including Darwin. Could the human eye have evolved? Didn't such complexity need a Designer?

Darwin left all these awkward questions to his supporters such as Huxley to face. Even the catchy title "*survival of the fittest*" was invented by someone else, the philosopher Herbert Spencer. Only later did Darwin publish his own views on how humanity fitted into Natural Selection.

Darwin's writing sometimes becomes emotive and genuinely lyrical, as in his final sentence: "*There is a grandeur in this view of life, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and wonderful have been, and are being, evolved.*" This to Darwin's credit. But it was hardly objective proof.

"Darwinism" continued to make waves. It triggered an irrational dread of its opposite, *degeneracy*. Could humanity and civilization *regress* as well as progress? Darwin shared these fears. They inspired the authors of *Dracula* and *Jekyll and Hyde*, Galston's eugenics (above) and Nazi racial purification policies. Darwin also believed that women were inferior. Like the "lower races", their strengths were intuition and imagination. They were vain, shallow and superficial, easily impressed by the male peacock's feathers. On the other hand, many misogynists were uncomfortable with the key role Natural Selection gave to women. In America "Social Darwinism" would be used to block political reforms to help the poor or restrict big business on the grounds that "Darwinian" competition might be cruel, but it was the way of nature. The Nazis used it to justify creating a master race.

Yet by 1900 the storm began to abate. Evolution, despite its gaps, was broadly accepted. But the mechanism of evolution remained a mystery. Lamarck's belief that *acquired* characteristics could be inherited persisted; even Darwin considered it possible. People found it easier to accept the idea of parents passing on their chosen qualities than that inheritance was all down to blind

chance. The discovery of DNA as the hidden mechanism of inheritance belongs to the next century and a later session. But the story of Darwinism reveals how crooked the path of scientific progress was, and how elusive was the quest for objectivity.

Making waves

Physics also made progress, but also failed in its quest for an objective, Newtonian "theory of everything". The leading British physicists were ***William Thomson (Lord Kelvin, 1824 – 1907***), a Scottish professor who brought northern industrial values into the laboratory. Thomson, a wealthy polymath, was interested in the efficiency of machinery which led him into the study of heat and energy; these were united in the study of *thermodynamics*. He contributed to the *Second Law of Thermodynamics* which is complex but derives from two common sense observations: first, heat can't move from a colder to a hotter body by itself; it needs a push (e.g. a fridge motor). And second, no machine is ever 100% efficient; some energy is always lost, either as friction or heat, and once lost, it is "*permanently unavailable*" for useful work.

The law is bad news in that eventually everything in the universe will cool down to the same temperature. All molecules will stop moving. All organisation will disappear. Everything will be uniform. Information will cease to flow. This so-called "heat death of the universe", known as *entropy,* was fictionally portrayed by H.G. Wells in *The Time Machine.* Thus physics, unlike evolution, has a direction. But not a very cheerful one: ultimately, everything winds down.

The other leading physicist was ***James Clerk Maxwell (1831 – 1879),*** another Scot and founder of the Cavendish Laboratory in Cambridge. Maxwell was interested in Faraday's observation that when magnetic and electrical fields intersect, a flow of *electromagnetism* results. He predicted that this flow would travel in waves, like light. But how? Maxwell suggested that the whole of space was filled with an invisible electro-magnetic ether; he visualised a highly complex honeycomb of lines of force with hexagonal whirlpools of fluid swirling as tiny particles were thrust aside by the electromagnetic flow…
There were gasps of disbelief when he presented this theory. To European physicists he seemed to have replaced the cool reason and order of Newton's universe with a crazy energy-packed, vibrating cosmos. Maxwell hastily backtracked: it was only meant to be a *conceptual* model, he explained.

However German physicist ***Heinrich Hertz (1857 – 1894)*** thought Maxwell might be basically right, but not about the ether. In his laboratory he managed

to create the electro-magnetic waves that Maxwell could only predict. Somehow, he reasoned, they were able to leap across empty space, like a wave passing through fluid, or even like light-waves. In fact, Maxwell's equations had predicted that they would travel at the speed of light. So they did, and for good reason: they *were* light; or to put it more accurately, light waves were themselves a type of electromagnetic wave.

These were major advances. Yet neither Maxwell nor Hertz saw any practical application; electromagnetic waves were just *there*. But they were wrong. Those with a long-wavelength were soon renamed – "*radio waves"* – and their immense potential was suddenly grasped. a new global telegraph system without any cables. As one pioneer put it, radio waves (from the Latin *radius*, like the spoke of a wheel) could pass through walls or London fogs. And across oceans. The British government gave investment to an Italian inventor, Marconi. In 1901 he succeeded in transmitting an airborne "wireless" message across the Atlantic from Cornwall which arrived instantaneously to a receiver in Newfoundland.
In that moment everything changed. The globe shrank. The British empire gained a new means of control over its far-flung colonies. And twentieth century "big science", whether linked to private industry as in Britain, or to the state as in Germany, or to both as in America, made its first appearance.

Time: the final frontier
Radio, like the telegraph, require international standardisation. This wasn't easy to agree. The French wanted to resurrect the metric system. The British opposed. Their surveyors showed that the metre wasn't the exact measure based on the size of the earth that the French claimed it was. Instead they succeeded in getting agreement to adopt British electromagnetic standards as established at Maxwell's Cavendish laboratory Britain.

But there was still a missing link. The global standardisation of *time*. This was even more contentious. Until the mid-19th century, residents of towns still had local time and set their clocks by the stars and the sun. Railways began moves towards standardising time. In Britain, *London time* was sent out daily by telegraph from Greenwich observatory. Similarly French railways used *Rouen time*. This was 5 minutes behind Paris time, so all the Paris station clocks had to be set 5 minutes earlier than clocks outside. The USA opted for a system of different time zones, the sensible solution eventually adopted globally.

Standardised time was particularly important to map makers. Measuring the gap in time between two places on the same latitude (N/S) but different longitudes (E/W) enabled surveyors to calculate the exact distance between them very precisely. Longitude had always been problematic. Latitude was easy to measure (see Session 3) but longitude was all but impossible. The astrolabe couldn't do it*. To find their longitude, sailors needed to compare their shipboard time with the exact time at another known longitude. The only practical answer was for ships to carry accurate, reliable and robust chronometers (imagine using a pendulum clock on the heaving deck of a sailing ship). Clockmaker John Harrison spent years developing them and succeeded in 1765; he then spent several more years arguing with the British government longitude commissioners about payment.

*In theory it's possible without a clock, but only with very difficult observations (e.g. Jupiter's moons) plus really complex maths. Maybe if a ship carried Leibniz (the inventor of calculus)?

Standardising global time was achieved in 1884 by an international committee which agreed numbers for the lines of longitude. Again, the British prevailed; Greenwich was agreed as marking the line of zero degrees longitude. The French refused to agree, and only came into line in 1911. As Fara put it, the world now ticked with the same clockwork rhythm. World maps changed too: before, each country put its own capital city in the middle. Now they put Greenwich.

Patenting time

But map makers still weren't satisfied, They were under pressure to produce ever greater accuracy. Radio messages might be received more or less instantaneously, but even a fractional delay could mean big errors in distance on a map. What they wanted was for global time to be absolutely *synchronised* not merely standardised. But how? Inventors set to work on ideas and patent applications poured into the Swiss patent office. Many of these passed across the desk of a young German theoretical physicist who'd got a job there: ***Albert Einstein (1879 – 1955)***. This led him to ponder on the nature of time and thus inspired his great scientific theory: *Relativity*.

When years later Einstein gave his first lecture on Relativity in Oxford, the audience gradually slipped away. You couldn't blame them, said one scientist: if his maths didn't defeat you, his German certainly would. Einstein's 1906 article on relativity had attracted only limited interest. It had no footnotes or references. Only in 1919, when experimental proof appeared during an eclipse

(below), did he suddenly become a celebrity: the man who dared to challenge Newton, and win. Over the decades, other supporting experimental evidence gradually emerged. Einstein came across as an eccentric, unworldly figure. Yet he was a skilled self-publicist. He lectured enthusiastically, and had a knack for the quotable aphorism. He once explained relativity by pointing out while an hour spent with a pretty girl felt like a minute, a minute sat on a hot stove felt like an hour. "Everything is relative" became the popular catchphrase of the 1920's and 30's. He once asked a journalist, how come nobody understands me yet everybody likes me?

Relativity overturned Newton's universe. It was published in two parts; the *Special Theory (*1906*)*, then the much more complex *General Theory (1916)* which made everything even weirder. Time and space were no longer fixed. Time varied according to where you were and how fast you were moving. Your position in space could only be defined relative to someone else. Only one quantity remained constant: the speed of light. Gravity made light curve when it passed near a large body like the sun. Punch magazine had a cartoon of a policeman's torch shining around the corner. Also, travellers on a really fast spaceship would age slower than those they left behind. Punch printed a limerick:

"There was a young lady called Bright,
Who travelled much faster than light,
She started one day
In the relative way,
And returned on the previous night."

Relatively true?

In 1919 Cambridge astronomer, Arthur Eddington announced that he had experimental proof of Relativity. An expedition to West Africa to observe an eclipse of the sun In 1917 was a perfect opportunity to test Einstein's claim that light from a distant star would be deflected by the sun's gravity it passed it by. If careful observation of the star showed a shift away from its predicted position, it would confirm the theory. This is exactly what happened. Or was it? On the day, cloud, mist and mosquitoes hindered the photography. It is known that Eddington was selective in the photographs he released, those which confirmed Relativity. Others were discarded. He also used his astronomical contacts to gain their support. Many, especially the Americans, were sceptical. Another complication was that in 1917 Eddington, a Quaker, was in conflict with the War Office over his claim to be a conscientious objector. His participation on such an important scientific expedition helped his case.

There's no suggestion that Eddington deliberately falsified the result or that Einstein was wrong. Later experimental evidence confirmed Relativity, while modern researchers have vindicated Eddington. But as Patricia Fara says, what is really striking about relativity is how such a complex and abstract scientific theory, which so radically transformed perceptions of the universe, came out of a highly *practical* enterprise: synchronising global time. Yet another demonstration of how science is driven less by individual heroes and more by the totality of history. And also that scientific theories triumph not because they are the
absolute, objective truth, but because enough people believe that that they are.

SESSION SEVEN

INVISIBLE REALMS

How 19th and 20th century science revealed hidden worlds

Last session we saw how 19th century physics searched for Newtonian objectivity and certainty but found instead the controversies of evolution and the weirdness of Relativity. In this session we'll see how scientists in the 20th century took this even further. As Fara says, "*However closely they searched, ultimate causes always stay elusively beyond their grasp.*" Instead, in biology, medicine, the atom, inheritance, the unconscious and the sub-atomic ("quantum") world, scientists kept discovering new hidden worlds, previously unsuspected realms of strangeness. What lay at the heart of these "invisible realms"?

PART ONE – LIFE SCIENCE

Scientists who specialised in biology (a word invented in Germany in 1800) faced the toughest of all scientific questions: what exactly *is* life? How did it begin? There were two schools of thought. Some thought the essence of life was *spiritual,* when a soul or spirit is infused by God. Others thought that life must be *material*, a rearrangement of fundamental matter. *Materialists* were suspected of godless, even dangerous, tendencies: hence the horror at Dr Frankenstein's creation. Improved microscopes revealed minute micro-organisms and the structure of cells. But what did it all mean?

Darwin skirted round these issues. The *Origin of the Species* seemed to be based on the assumption that at some point in the past, life must have spontaneously generated, at least once. ***Louis Pasteur (1822 –1895),***

France's greatest scientist, opposed this idea. He was called in by French beer and wine makers to investigate why micro-organisms appeared in wine or beer and sent them bad. It was generally believed that they were evidence for the theory of spontaneous generation. But Pasteur proved otherwise. He took two samples of sugared yeast-water. One he boiled to make it sterile, then sealed it off from the air. Result: no micro-organisms appeared. In the other, non-sterile liquid, they did. Conclusion: they must have got in from the atmosphere. They didn't spontaneously generate. They were already there (a rival scientist got the opposite result, but was found to have used non-sterile straw in his "sterile" sample). French science, via Pasteur, a devout Catholic, had found against spontaneous generation. This suggested that God, not science, must have created life.

But German science, via ***Ernst Haeckel (1834 – 1919)***, , a pioneer of embryology, disagreed. He defended Darwin and called religion "*intellectual servitude and falsehood*." Better microscopes had advanced cell theory and identified the nucleus and chromosomes in jelly-like cytoplasm, but what were their functions? Life remained a mystery. How could the sperm and egg become an embryo, so that a few cells turn into an independent living creature?

When Haeckel saw that embryos developed along predetermined lines, he mistakenly thought that they *recapitulated the entire ancestry of the species inside the womb*. He used photographs to show the similarities between the early embryos of eight different species, from fish to humans. Then at a later stage they diverged. The photographs all looked so convincing, it seemed self-evident – but it was simply wrong.

PART TWO – MEDICAL SCIENCE

As we've seen, medicine was largely ineffective. The best physicians could offer most patients was a comfortable death. Mary Wortley Montague brought the technique of smallpox inoculation from the Ottoman empire, but most medicine was tailored to the individual. Physicians treated their usually wealthy patients by studying their personal constitution. The poor had only apothecaries or village wise women.

Improvement began after the French Revolution. More hospitals were built. Patients were grouped together and doctors began to see illness as entities in themselves, not extensions of individual patients. But hospitals were dangerous; the causes and prevention of infection were unknown. The rich continued to hire physicians to treat them at home. Thus the medical

profession was resistant to the emerging idea of science-based medicine and laboratory-made drugs.

Epidemics of smallpox and other infectious diseases killed huge numbers, their causes guesswork. Poisonous miasmas? Invisible toxic atmospheres? These were believed to cause different diseases according to the state of health of the individual.

The 19th century saw a fight-back. Pasteur's discovery (above), published in 1861, that micro-organisms from the air caused contamination of liquids opened the door to the idea that such tiny germs also caused diseases and infections. After this, the story of 19th century medical science seemed like a succession of victories. Vaccines developed, particular germs identified for specific diseases, anti-septic surgery, then first lab-produced chemical drugs. Death rates in Europe and America fell. Patients had a real prospect of being cured for the first time in history. But some diseases, such as malaria and influenza, went unchecked. And even the story of the victories was often played out in some confusion.

In the 1790's Edward Jenner, a country surgeon, sensibly listened to local farmers and dairy maids and introduced ***vaccination*** with harmless cowpox to prevent deadly ***smallpox***. His testing methods (injecting a boy with cowpox, then smallpox) were highly suspect. Also Jenner couldn't explain *why* it worked and in the absence of any theoretical explanation, making it difficult to defend against its many critics. Vaccination was fiercely resisted throughout the 19th century. It was painful; it risked causing infection; and it seemed sacrilegious to contaminate the human body with matter from a sick animal lower down the scale of life. Cartoons showed women giving birth to calves or growing ox-faces. Government of the time followed the principle of *laisser-faire*: the state had no right to compel individuals, even for their own good.

Meanwhile international trade, travel and migration spread epidemics world-wide. ***Cholera*** reached Britain from Asia in 1831. Doctors had no clue how it spread or what to do. Many blamed clouds of miasma hanging over filthy overcrowded slum towns. The mood was one of helplessness and doom. Hospitals overflowed. Epidemics kept returning. Governments began to make modest improvements to living conditions, but these too were resisted.

The collection of date eventually showed how cholera was transmitted: by infectious drinking water. A London doctor, ***John Snow***, mapped the incidence of cholera cases to specific water pumps. Yet this alone wasn't proof; it might

have been carried by air borne from piles of dirt near the pumps. And what caused the other diseases of the slums? But at least over cholera, Snow was vindicated.

Dr Joseph Lister (1827 – 1912) is generally credited with making surgery safer by using a carbolic acid spray over his surgical instruments. He was hailed as a hero, a view he strongly encouraged. But other measures like whitewashing, ventilation and keeping patients apart in hospitals, were already coming in. And Lister's achievement was not quite so great as it looked. He continued to operate in blood-splattered clothes and didn't bother about clean sheets. It also seems that his spray was originally designed to counter miasmas, not germs, a fact he did not dwell on after germs were discovered.

Pasteur's researches opened the door to germs, but the pioneer of bacteriology was ***Robert Koch (1843 – 1910)***, a German doctor. He identified the germ that caused industrial Europe's biggest killer, tuberculosis. He also developed the technique of growing solid cultures in Petri dishes (named after one of his lab assistants) under very controlled conditions, and also microscopic photography. He devised "*Koch's Postulates*", experimental procedures needed to identify beyond doubt which bacteria caused which diseases.

Death rates from infectious diseases plummeted, but not only due to the scientists. Other boring things impacted on overall death rates, such as better diets, better sanitation, the introduction of health education, and more hospitals. But medical science was a key factor. It no longer viewed the human body as a collection of humours in need of balancing, but a collection of cells vulnerable to invasion by invisible, deadly micro-organisms. This was a fundamental change.

The traditional vision of medicine as bringing humans and their humours back into harmony with the universe was replaced by a military metaphor of attack and defence. A cartoon of 1899 – also the high point of European empire – showed an "army of the interior", white-coated blood corpuscles passing through the wall of a vein to fight off an alien attacking bacteria. To hammer home the point, a parallel drawing showed British soldiers braving a hostile river to capture colonial territory from menacing black bacterial-looking demons up on a cliff top.

This new militaristic metaphor for medical science also carried over into fears linking immigrants to disease. In the early 20th century the American

government set up medical screening of immigrants. Western scientists were also sent to India and elsewhere to combat epidemics which could travel to Europe. These western campaigns often caused offence: male doctors examining women, mixed castes in hospitals, Muslims forbidden to go on pilgrimage. There are parallels here to 19th century vaccine resistance in Britain.

The victory over infectious disease was not total. Infectious diseases were easier to fight in the laboratory than in the real world. Koch couldn't explain why only 10% of those exposed to the TB bacillus actually caught it. Statistically it was clearly more prevalent in poor industrial areas, but what was the precise cause and effect? Stigma was also involved. In the18th century TB had romantic associations: struggling poets and artists, whose aesthetic sensibilities were as delicate as their physical constitutions. But in the later 19th century TB had gained shameful associations, a mark of poverty and failure. Sufferers were isolated in large *sanatoria,* as if they were somehow tainted or culpable. Stigma also clung to syphilis, its spread however blamed on women (indeed the name comes from an ancient Greek temptress who lured Hercules into sin). Moral crusaders castigated prostitutes for spreading it, not their male clients. In the later 20th century stigma was attached for a time even to cancer (euphemistically referred to as "the Big C"), as well as to AIDS (blamed on male gay people) and more recently obesity and smoking dependence, blamed on fecklessness.

However it's important to appreciate that this stigmatising process did not originate in science. It came from the wider power structures and attitudes of societies which had become dominated by mass industrialisation and imperialism. Science was exploited to justify and reinforce existing structures of power and inequality. Science did not create these structures; it was used by them. If indeed "knowledge is power", then power itself can also use and abuse science for its own non-scientific ends.

The new medicine: chemical and quantitative

From the mid-19th century medical science began to view the human body differently: as a *chemical machine.* Laboratory science radically changed medicine. Remedies were decided upon not by physicians examining the patient for surface signals, but by research chemists delving deep beneath the surface and revealing invisible entities. Powerful microscopes could now be used to identify the various micro-organisms responsible for infectious diseases and also to help investigate ways of destroying them. Diagnosis moved from the patient's bedside to the hospital laboratory. It was as if sick

people were being incorporated into scientific research. Illnesses were diagnosed by standard tests on anonymous tissue samples.

In short, attention shifted from patients to diseases. This inevitably carried some potential risk to care and empathy with suffering patients. Fara says that "*chemical physiologists started to regard patients as mini-laboratories*" and illness "*as a type of experiment*." New chemical remedies required trials, which could involve making people sick under controlled conditions. Pasteur injected a teenager bitten by a rabid dog with an untested vaccine for rabies, even though it was uncertain whether he had been infected.

The other side of the new medicine was to develop an array of instruments to numerically measure "normal" body functions: heartbeats, breathing, temperature, blood pressure, acidic levels in the stomach, minerals in the bones. Some processes were invasive, such as blood samples; some even required surgery. Being ill meant deviating from *normality* – which now was defined not in relation to the patient's own internal balance of humours, but to the statistical normality of the whole population. Thus, early 19th century Paris hospital grouped patients in the same large wards according to their symptoms, and treated them collectively.

Illnesses and drugs were classified, measured, monitored and recorded. Medical science became "quantified", enabling age-old killer diseases to be conquered. Diabetes is a good example. Its cause was narrowed down to the pancreas, then to the chemical hormone insulin. This was mass-produced from the 1920's, making diabetes a condition which could be lived with. Insulin was investigated by Dorothy Hodgkin using *crystallography*, the use of x-ray refraction to reveal atomic structures and properties; it won her the Nobel Prize. She also investigated penicillin. This is the wonder-drug associated with Scottish physician and microbiologist ***Alexander Fleming (1881 – 1955)*** who discovered it by accident in 1928, when he noticed that a strange mould seemed to be killing the laboratory bacteria he was researching.

The story has become legendary, but is an odd one. There was no way of making penicillin in any usable quantities. Fleming's research went largely unnoticed. It has been suggested that he lost interest and even abandoned researching it. What seems more likely is that, unlike many "heroes of the history of science", he was not much good at showmanship and self-promotion. Only when two Oxford scientists, an Australian Howard Florey and German-born Ernst Chain, led a team to research how penicillin could be chemically isolated and purified it, could it be produced on a significant scale.

This was in time for World War II when the British and American governments grasped its huge potential for preventing deaths from battlefield infections. American drug companies devised techniques for its mass production. Only now was Fleming acclaimed as a hero, though he rightly shared the Nobel Prize with Florey and Chain.

Chemical drugs also transformed attitudes to health. Rather than accepting the prospect of chronic, debilitating sickness, people "*began to demand and expect longer, fitter lives*" (Fara). Doctors had a new role: to preserve well-being. In the 1960's, "*for the first time doctors were mass-producing a drug for the healthy, rather than for the sick*." This was the *contraceptive pill*, which was strongly promoted by American feminist Margaret Sanger to give women control of their own reproductive health. The trials were disorganised and prolonged, taking 40 years from the initial idea to approval in America in 1957. Side effects turned up; even so within two years it had half a million users, soon tens of millions. An interesting contrast was the story of another new drug, Viagra, in the 1990's. This was rushed through in a few months from inception to going on sale.

PART THREE – ATOMIC SCIENCE

Since the ancient Greeks natural philosophers/scientists had speculated about the basic structure of matter. Was matter continuous or made of particles? If it was made of particles, then what were *they* made of? This was the fundamental unanswered question of physics: the nature of the material universe. Many ancient Greeks thought it *was* made of particles, and the gave them a name – *atoms* – Greek for "indivisible". This was It was the ultimate " hidden realm". At the turn of the 20th century a diverse group of physicists , Crookes, Thompson and Rutherford, stumbled their way into it and gained humanity's first inklings of what lay within it .

It began with strange discoveries in their laboratories. In 1896 Professor ***Wilhelm Rontgen (1845 – 1923)*** stunned the world with an ***X-ray*** of his wife's hand, "*her wedding ring eerily floating around her finger*" (Fara). Rontgen discovered X-rays by accident when working with gas-filled electrical discharge tubes (like Crookes, see below). Sealed packets of photographic plates kept getting "fogged". He found that the new "X"-rays had a neutral electrical charge (Crookes' cathode rays had a negative one). Soon life-saving X-ray machines had become standard equipment in hospitals. Rontgen got a Nobel Prize. X-rays got a popular song:

"*I hear they'll gaze*

Through cloak and gown
And even stays,
These naughty, naughty
Rontgen rays."

In the same year came more weirdness in another chance discovery by French physicist ***Henry Becquerel (1852 – 1908)*** in Paris. He observed ***radioactivity***. Some ***uranium*** crystals in the laboratory kept producing an image on photographic plates. He was baffled. An obscure Polish research student called ***Marie Curie (Manya Sklodowska) 1867 - 1934*** took it on as a research project, also recruiting her husband Pierre. Their researches revealed two more "radioactive" elements which they called *polonium* and *radium.* They pioneered the study of radioactivity. Marie helped to create mobile X-ray machines for the trenches and received two Nobel prizes. She became France's most famous professor until her death from leukaemia, almost certainly resulting from being exposed to radiation in her work. Her coffin was lined with lead and her notebooks stored in lead boxes. Inevitably, as a woman scientist she was often portrayed as eccentric and dowdy, and praised for being a worthy assistant to her husband.

A third strange observation was made in 1906 by a British physicist and chemist ***William Crookes (1832 – 1919).*** Like Rontgen (above) he was experimenting with a *discharge tube* (or *cathode ray tube* ,"cathode" meaning a negatively charged electrical connection). These were tubes containing low pressure gas through which electricity could be passed, causing it to glow (they were the ancestor of neon signs and fluorescent lights). He demonstrated it by installing a tiny model paddle wheel on tiny rails*. When he switched on the current, it sent the paddle wheel trundling along the tube, apparently pushed by a stream of particles of some kind. Crookes called it "*radiant matter*", He had no idea what it was; nor did anyone else.

*Crookes was regarded as eccentric by colleagues for investigating spiritualism. He answered his critics by asking, how can you discover anything new unless you only investigate what you know is possible? This of course goes to the heart of science. Sometimes it must completely challenge the accepted wisdom.

J.J. Thomson, the head of the Cavendish Laboratory, was intrigued by Crookes "radiant matter". His investigations led him to suggest rightly that it was actually a stream of sub-atomic particles; a colleague called them ***electrons.*** Another Cavendish physicist, Ernest Rutherford, son of a New Zealand farmer, who'd spent ten years working on radioactivity, came up with a bold suggestion about the flow of electrons: could it be that certain types of

atoms were inherently unstable. and as they disintegrated they emitted rays and streams of particles.

Rutherford's big moment came in 1909 with his "streaming experiment", conducted with Hans Geiger (of the counter). They fired a beam of alpha particles given off by radioactive elements at an extremely thin sheet of gold foil. When the beam hit the sheet, it didn't go straight through the metal as expected, but was scattered in different directions. On a hunch, Rutherford put a Geiger counter on both sides of the foil. It showed that some of the alpha particles were being reflected back from the wafer-thin screen.

Rutherford memorably said that that moment "*was almost as incredible as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you*." Why was he so shaken? He spent 15 months reflecting on what had happened before publishing his conclusions. Atoms of metals, he explained , were not densely packed. The had small, heavy nuclei which were very widely separated from one another by (on the sub-atomic scale) vast distances. Thus the stream of light alpha particles went through the wafer-thin mesh, but if one of them happened to hit a small, hard nucleus, it bounced back.

Rutherford was right. This was an earth-shaking moment in the history of science. Here was the beginning of an answer to the great unanswered question, what was the fundamental nature of the material universe? In 1909, Rutherford, following on from Crooke, then Thompson, had the beginning of an answer. He became the first ever human to gain an inkling of what truly lay *inside* an atom. His famous "scattering experiment" enabled him to correctly deduce the atom's basic internal structure.

Rutherford and the Cavendish laboratory physicists spent the next 20 years further investigating the internal structure of the atom. They discovered further sub-atomic particles, *neutrons* and *protons*. They built *linear accelerators* to produce high speed beams of these particles. They were able to split nuclei by bombarding them with neutrons. Few areas of physics can have had as much long-term significance. Yet in a public lecture given just before his death in 1937, Rutherford said, "*the outlook for gaining useful energy from the atoms by artificial processes of transformation does not look promising*." In fact, in 1945 the Second World War was ended by two atom bombs, and in 1956 Calder Hall atomic power station opened.

Organising the elements: the Periodic Table

Long before scientists revealed the hidden world of the atom, they had long realised that whatever atoms were like, they must determine the differing nature of the various elements. Back in 1803 John Dalton coined the term "atomic weight", the idea that the relative mass of elements must reflect difference the different masses of their atoms. This was taken further by ***Dmitrii Mendeleev (1834 – 1907)***, a Russian chemistry professor at St Petersburg university. He devised the so-called ***Periodic Table.*** He said the idea sprang into his mind in 1869 (at that time there were 56, with new ones being discovered all the time).
Mendeleev had the idea of arranging all the known elements in a table to look for patterns.

When he lined up all the elements *horizontally* according to their atomic weight, it revealed matching groups of elements *vertically;* they had similar chemical properties (metals/non-metals, reactivity etc). Mendeleev called this pattern the "*Periodic Law*". Crucially, he claimed it was *predictive*. He claimed that he could identify gaps in the table and use them to predict the existence and properties of elements *as yet undiscovered*. Scientist were sceptical – until his prediction was fulfilled – *gallium* in 1875, and *germanium* in 1886. The discovery of further elements which filled in other gaps, and the gaining of further knowledge of the actual structure of the atom, confirmed the principle while also refining and rearranging the details, of the Periodic Table. This revelation of a deep underlying mathematical pattern to the elements that make up the universe was one of the great achievements of modern science. The modern version we use today is different from Mendeleev's, but he was the first to fully grasp the concept.

<u>The atom revealed</u>
As the structure of the atom was gradually elaborated, scientists understandably modelled it on something they were familiar with: as a miniature solar system. Danish scientist Niels Bohr, considered second only to Einstein, said that electrons moved around the nucleus on fixed circular orbits which held a maximum number of electrons.

By 1959 a total of 30 different types of sub-atomic particles had been discovered. They were found by using *cloud chambers*, sealed transparent chambers of supercooled vapour. As electrically charged particles were passed through them, they left a visible trail. In the second half of the 20th century scientists organised all the sub-atomic particles into the neat and tidy *Standard Model*. Then the American Murray Gell-Mann predicted from experimental work the existence of yet another, the *quark,* named from an

avant-garde James Joyce novel. The sub-atomic realm was invisible no longer.

PART FOUR – THE SCIENCE OF INHERITANCE

Darwin's account of evolution was the best so far. But no one knew what the *mechanism* of evolution was. *How* were evolutionary changes inherited? Gregor Mendel, a central European monk and a contemporary of Darwin, did some low-tech but painstaking research on garden pea plants. He bred tall and short plants together and discovered a mathematical pattern. The first-generation offspring were all tall. But a generation later the ratio was 3:1 tall to short. Tall seemed "dominant", but the "recessive" short resurfaced. What was going on?

An American embryologist called Thomas Hunt Morgan took Mendel's work into the laboratory, studying fast-breeding fruit flies and their wing shape and eye colour. He and his group's painstaking research showed how such characteristics were linked to a specific line of genes located together on the tiny threads in the cell nuclei, which other scientists had termed "*chromosomes*". Morgan succeeded in linking these physical entities inside cells with Mendel's ratios. Suddenly, the invisible mechanism of evolution, like the invisible structure of the atom, became a little less opaque.

Hunt's conclusion however was to reject Darwinism! Living creatures, he said, carried within them the innate capacity to make small, beneficial changes. There was no need to bring in the ruthless Darwinian competition of Natural Selection. This was such a backward step.

Other researchers didn't agree. Mathematicians looked at patterns in large populations and showed how, as Darwin said, tiny, accumulated changes could bring about big evolutionary transformations. Russian naturalists showed through Natural Selection grey peppered moths adapted quickly to a change in their environment. Worsening industrial pollution turned trees black, making the moths visible to predators. A recessive genetic variation now emerged to change the colour of the moths from grey to black.

But then, in the 1940's, a Russian naturalist called Lysenko completely muddied the waters. He denied Natural Selection and genetics and said that in crop plants like wheat environmental influences could be directly inherited via the cells. This returned to Lamarck's idea (see Darwin, previous session). It was nonsense. But it mattered because Lysenko enjoyed the unqualified political support of the then Russan dictator, Stalin.

When in 1940 Lysenko was made head of the Soviet Academy of Sciences, Russian scientists were ordered to recant their belief in genetics and Natural Selection. Those who refused were purged, facing dismissal, imprisonment or execution. *Lysenkoism* became official Soviet policy, based on the idea that wheat could easily adapted to grow in much colder regions of Russia. Catastrophic crop failures and famines resulted, including the great China famine of 1959. The failure of Lysenkoism was all part of a gradual accumulation of evidence suggesting that Hunt was wrong and Darwin was right. Definitive proof for Natural Selection was still lacking. But Darwinism was winning the argument.

The science of inheritance caused controversy in another context: the early 20th century *eugenics movement.* This referred to policies designed to improve population quality by manipulating human reproduction to encourage inherited characteristics thought to be "desirable. "Positive" eugenics aimed to encourage the educated, successful and wealthy to have more children. "Negative" eugenics aimed to restrict the "undesirable" from having children, by persuasion or coercion.

Eugenics was blown up as a reputable policy by its association with Nazism its attempt to create a master race by purifying it from "racial impurities" by the mass murder of Jewish people. However before the Holocaust, eugenics was popular and considered respectable all over Europe and America. It was viewed as necessary to prevent the opposite of human evolution – genetic regression. Both Francis Galton, Darwin's cousin, and Leonard, Darwin's son, supported eugenics. So were mainstream celebrities such as George Bernard Shaw, H.G. Wells and Sir William Beveridge, the architect of the welfare state. So was virtually everyone you could name in mainstream public life.

But even at the time, there were doubts about the scientific validity of eugenics. Galton documented how gifted people often had gifted offspring. But could they be sure that this was due to a superior biological inheritance? Or could social factors such as a stimulating family environment, first-rate schooling and privileged access to university, be part of the explanation? Nowadays we recognise this as the "nature/nurture" debate. Is intelligence inherited or environmental? It has never been resolved.

Even so, from the later 19th century to as late as the 1970's, many European countries such as Sweden and many American states implemented eugenics policies, including compulsory sterilisation for some individuals and groups.

Eugenics was not science's finest moment. And as with Lysenkoism, it showed the difficulty of being objective where issues of human inheritance were at stake.

PART FIVE – THE SCIENCE OF THE UNCONCIOUS

Another "invisible realm" revealed by science was the groundbreaking investigations of the unconscious mind by ***Sigmund Freud (1856 – 1939)*** a Viennese neurologist**.** In 1886 he gave up lab work dissecting dead brains and converted his Vienna practice into a new sort of lab investigating the live brains of his patients. He devised new instruments to reveal their unconscious minds, such as free association and dream analysis. When the patient/subject became
uncomfortable – a "point of resistance" – the influence of the unconscious was revealed, like the tip of an iceberg, warranting further investigation.

Freud developed two related theories. First, a hypothetical model of the human psyche. It was dynamic, driven by both conscious and unconscious forces. The *id* (the *pleasure* principle) represented our primal instinctual drives and desires. The *superego* (the *morality* principle) embodied the standards of right and wrong we internalised from our parents and society. It strives for perfection, and its judgements fuel feelings of either pride of shame. The *ego* (the *reality* principle) was the conscious, rational, logical part of the personality. It mediated between the drives of the *id*, the morality of the *superego*, and the external world. Fara summarises: "*In Freudian minds, the primal instincts of sex and destruction are constantly battling against repressive, rational powers trying to impose conformity.*" Second, Freud developed the therapy of *psychanalysis*. "*Psychoanalytical techniques heal, Freud concluded, by exposing those hidden conflicts and so alleviating physical disturbances, which are visible manifestations of this unsuspected inner strife*."

People then and now were sceptical. The Viennese philosopher Karl Popper called it a pseudo-science. A true science, he said, cannot be *absolutely* proven, but it does offer the logical possibility of being *disproved* by relevant evidence. Freud's theory doesn't allow for this. No such evidence could be logically suggested. Many women were critical of Freud's theory. They liked the acknowledgement of female sexuality but objected to his neglect of the nurturing role of mothers in human development, his concept of "penis envy" and his dismissal of accounts of childhood sexual abuse (he claimed it was a female fantasy of seducing their fathers).

Others criticised the lack of an evidence base. Psychoanalysis, though expensive, didn't seem was any more effective than any other treatment. Freud generalised from a narrow sample, all of whom were privileged Viennese. He had many disciples in Europe and America, although many defected, developing their own distinct versions of "Freudianism". Only in Britain was support limited; his emphasis on sex was the problem.

What transformed things was war. In the First World War, soldiers with no physical injuries suffered from "shell shock", displaying symptoms like blindness, paralysis and memory loss. Doctors, ignoring the traditional belief that "hysteria" was a female condition, applied a broadly Freudian approach, dropped any references to sex and applied the concept of repression. They assumed that the soldiers' trench experiences generated feelings of terror and disgust which they pushed down into their unconscious, reappearing later as physical symptoms.

When the Second World War broke out, medical science was prepared. Psychiatrists were recruited in advance and were able to treat soldiers and return them quickly to the battlefield. Postwar, this idea was initially taken up for industrial workers to increase their productivity. Then, as Fara says, there arose "*a new secular faith of wellbeing, self-examination, and inner improvement*" – another example of therapy for those who were not actually sick.

What was Freud's legacy? Whether or not Freudianism was a true science is not perhaps the main point. Although most psychologists today employ a more eclectic approach, and despite the limitations of Freud's model of the mind, he created new ways of thinking about minds and bodies, families and sexuality, health and sickness. He made unconscious drives and urges and childhood sexuality topics of conversation. As Fara says. "*science is not the only route to progress*." "*His therapy was not a panacea but it encouraged people to reflect on themselves, their lives, hopefully to improve them*." Freudianism also influenced the wider culture, particularly art, literature and popular culture. The poet W.H. Auden sums up best. In 1939 (*In Memory of Sigmund Freud*):

"*If often he was wrong and, at times, absurd,*
to us he is no more a person
now but a whole climate of opinion
under whom we conduct our different lives".

Whether Freudianism was science, a hypothesis, an arresting metaphor, its influence as "a climate of opinion" was far-reaching and profound. Fara concludes that, on balance, Freud benefitted civilisation more than Einstein.

CONCLUSION – THE QUANTUM REALM

"*Quantum*" refers to the sub-atomic world (it's Latin for "the smallest part"). Physicists who first studied it were astonished to find that in this previously invisible realm completely different laws seemed to apply compared to "classical" physics (non-quantum) world. German physicist ***Werner Heisenberg (1901 – 1976)*** used the phrase "*the uncertainly principle*" to describe this. For example, if you knew the speed of a sub-atomic particle, you couldn't know its precise location. Conversely, if you knew its location, you couldn't determine its speed. This blew Laplace's totally predictable universe (Session Five) out of the water. Danish physicist ***Niels Bohr (1885 – 1962)***, rated second only to Einstein, agreed: in the quantum realm, we were inescapably part of the system we were observing. We could not observe the quantum universe as objective, detached outsiders (this echoed Goethe and the German Romantic philosophers, Session Six). Everything scientists tried to measure in the subatomic realm, they altered. Their instruments influenced what they were trying to observe. Their very act of observation triggered one out of several possible outcomes. Bohr said that light was neither wave nor particle; sometimes it behaved like one, sometimes the other. How all this strangeness related to the classical (full-sized) world was anybody's guess. The universe was officially counter-intuitive. But the implication was clear: ultimately, absolute, objective knowledge was impossible. Probability was the best physics could hope for. Newtonian objectivity was finally banished.

Einstein refused to accept this. Relativity may have its weird features, but "*God doesn't play dice with the universe*." He confronted Bohr at a major physics conference held in 1927 in Brussels (see photograph, Session One). Every day at breakfast, Einstein raised a new objection. Every day at dinner Boer refuted it. Bohr had the best of it. But Einstein never gave up. He never resolved it.

The uncertainty in physics coincided with the general global insecurity as the Second World War approached. Soon, the physicists would be scattered, forced to flee from Nazis who condemned "Jewish physics". Heisenberg wasn't Jewish and agreed to stay in Germany and head the Nazi project to build a German atomic bomb. It failed. And after the war Heisenberg claimed he had only stayed so that he could covertly impede the work.

Historians are divided over whether to believe him. Some see evidence to support his claim. Others are sceptical. They cite several reasons why Germany failed to build the bomb: limited resources; lack of scientific understanding of what was required (including by Heisenberg); and Hitler's declining enthusiasm. Obviously, if Heisenberg *had* been engaging in covert sabotage, he could hardly leave evidence. But how ironic that despite all the historical research into this rather important question, the verdict remains uncertain.

Back in 1894, Albert Michelson, a leading American physicist, had said, "*The more important laws and facts of physical science have all been discovered and these are now so firmly established that the possibility of their ever being supplanted in consequence of new discoveries is exceedingly remote.*". How wrong can you be. Instead, as we've seen this session, whole new "invisible" realms were just waiting to be discovered. Each, in different ways, revealed to scientists that what lay at the heart of things was not final objective truth, but uncertainty.

Next
In our final session, we'll bring the story up to date, by looking at the emergence of "Big Science" and asking how far the history of science can help us understand the impact of science on society and its future direction.

SESSION EIGHT

WAVES – BIG SCIENCE AND THE FUTURE

How the modern state and industrial investment created today's "big science"

20th century science was ***Big Science***. Huge government and industrial investment in modern science brought major benefits, but also unintended consequences. Were these defects inherent in science, or due to decisions about how science was developed?

Big Science: the state and big business

In the 20th century, cutting-edge scientific research attracted massive funding from state and from big business. Such research grew into industrial-scale operations. This began in physics in the 1920's and 30's with research into the atom, warfare and space. Then from the 1950's the decoding of DNA and the double helix shifted the focus to the life sciences and genetics. More recently Artificial Intelligence has attracted massive funding into computer science.

This increase in funding and scale has generated new levels of understanding. Despite this, attitudes towards science remain ambivalent. It's not just that some of its most fundamental questions remain unanswered. More seriously, scientific advances are seen as double edged.

Revealing the secrets of the atomic nucleus revealed the potential for untapped energy but also for nuclear weapons of similar destructive power. Chemical pesticides produced more food but damaged natural ecosystems. More people were able to live healthier, more comfortable lives, but rising population levels and global warming spread alarm. The central debate goes all the way back to the birth of modern science, to Francis Bacon and the Enlightenment. Put simply, is modern science inherently flawed, or are the above problems the result of flawed political decisions about the way science is used? This question was first crystallised by the atom bomb. It is the big issue of Big Science.

Big science: war

Big science is not an entirely new idea. The ancient and medieval worlds built big observatories. The Victorians built big factories. But it was 20th century warfare that first melded science, the state and big business. An early example was the biochemist Chaim Weizmann, a Jewish exile from Russia who became a lecturer at Manchester university. In the First World War he specialised in fermentation and its potential for the industrial production of chemical substances. One of these substances was acetone. In 1915 the Allies suffered a shortage of artillery shells. Acetone was a vital component in their manufacture.

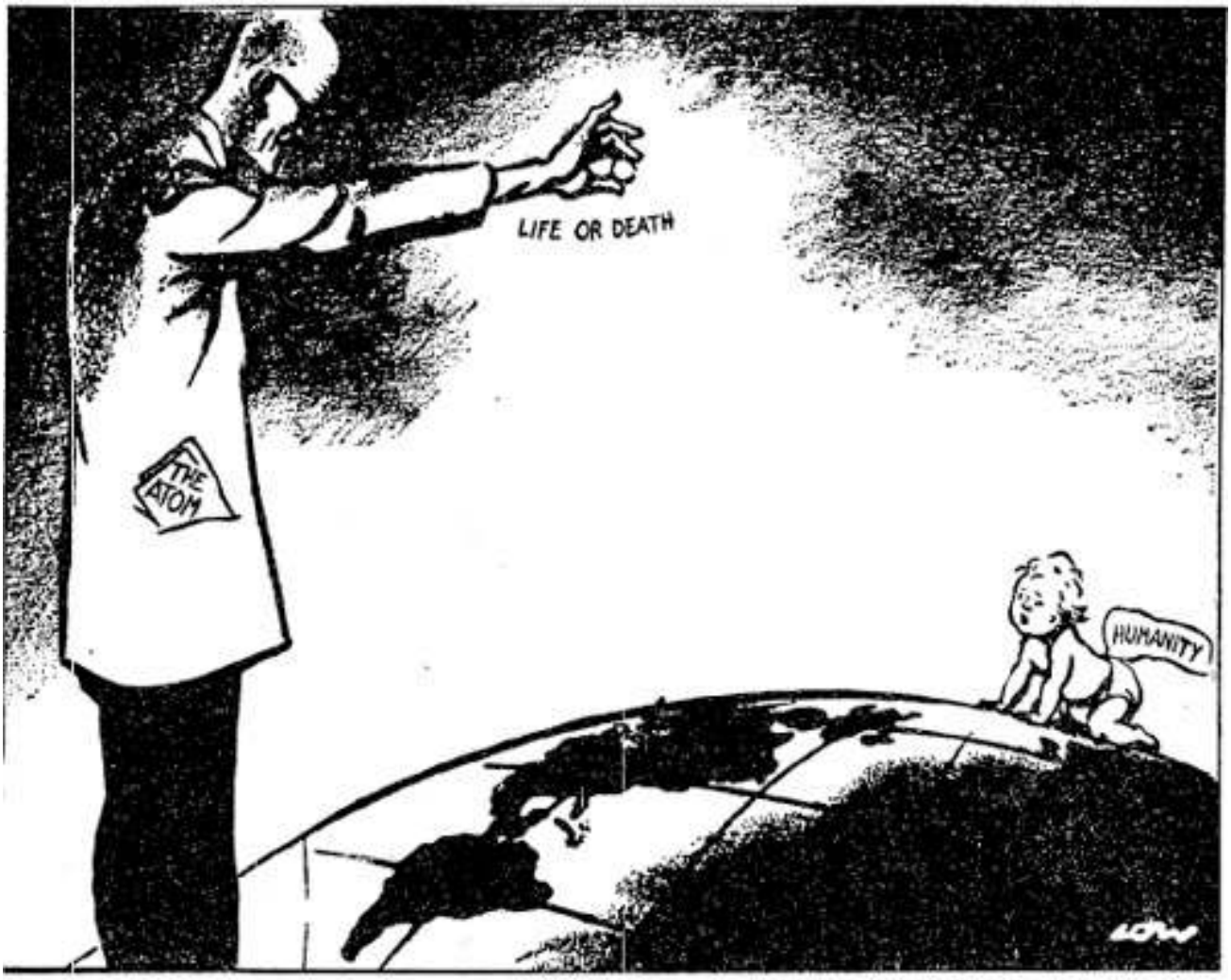
Churchill, First Lord of the Admiralty, heard of Weizmann's work and approached him. The outcome was the setting up of a major UK operation to manufacture it. Weizmann, a Zionist, used his leverage to press the government to support the Jews' campaign for a homeland in Palestine. They did, and issued the Balfour Declaration of 1917, a move fraught with repercussions for Middle East politics and world affairs. Here were the essentials of Big Science in microcosm: science, warfare and the state intertwined.

Big Science really took off in the 1920's and 30's, as physicists raced to understand the atom. At first they used naturally emitted neutrons from x-rays and radioactive substance, but the next step was to build large accelerators to blast particles into the nucleus of atoms to split them apart. These were

expensive. The American Ernest Lawrence, a physicist at Berkeley, California, pioneered the building of *cyclotrons*, circular machines which used electromagnetic fields to accelerate charged electrons and protons around at ever-increasing speeds. Lawrence thought on an ever-bigger scale, and persuaded electrical companies to invest. He became a scientific entrepreneur employing hundreds of research scientists, engineers and technicians.

By the later 1930's, with the Second World War looming, the race was on to break open the secrets of the atomic nucleus. Crucial to this was Lise Meitner, a Jewish physicist who left Nazi Germany for Sweden called, She was invited to work in America to help build an atom bomb, but declined. Yet it was her insight that made the atom bomb possible. Experiments with uranium were yielding baffling results. Lise Meitner worked it out: when the nucleus of a uranium atom was hit by a neutron, it split in two. This released massive amounts of energy. But crucially, it simultaneously emitted more neutrons. As these flew off and hit other nearby atoms, yet more energy was released, and yet more neutrons. The escalation was explosive and unstoppable, what was later called a "chain reaction". This insight showed that an atomic bomb was feasible.

International collaboration on nuclear physics suddenly stopped. In August 1939, a group of Jewish emigres from Nazi Germany enlisted Einstein's support in a letter to convince the American president that a Nazi atom bomb was now a realistic prospect and urging him to begin work on an American one. This proved a powerful motivator (even though the Germans seldom approached success). The British offered to share their atomic research with the Americans. Fara says, "*Sponsored by the state, scientists set out to create destruction*."



Low © All Countries (By Wireless to The New York Times)

"Baby play with nice ball?"

Annual American state funding for science rose from $50m to %500m. Much went to the Manhattan Project to build the bomb. General Grove was put in charge in 1942 and brought an impressive degree of military efficiency. He created a nation-wide network of industrial sites, some the size of small cities. Thousands of workers worked at accelerators and other instruments manufacturing materials with no idea of what they were. Grove's strict "need to know" basis was so tight that in 1945 fewer than 100 people knew the big picture. Atomic towns were set up with malls cinemas and fitted kitchens to conceal their purpose.

Meanwhile the scientists worked in experimental stations in Chicago and Los Alamos often under crude and dangerous conditions. They later spoke of their collective fervour; swept up in their shared expertise and enthusiasm, utterly focused on solving problems, it felt like the best time of their lives. They built

nuclear piles, the fission rate controlled (they hoped) by inserting cadmium rods, as the combined clicking of neutron counters swelled into a roar.

Once they knew it could work, there was a feeling of flatness, as they contemplated the consequences of their professional triumph. Then, at Los Alamos, Enrico Fermi, an Italian physicist, led a combined team of scientists, military experts and engineers in tackling the final problem: how to package nuclear fission into a transportable bomb. Los Alamos was a cloistered, self-sufficient industrial town hidden away in the desert of New Mexico. Grove put the physicist J. Robert Oppenheimer in charge of running the town, even though he had no experience of organising. He and Groves looked an ill-matched pair, the ruthless, workaholic general and the nervous, left wing intellectual. In fact they proved a dream-team. They ignored protocols, smashed their way through decision, spent a fortune.

When Germany surrendered in May 1945, the Manhattan project, so close to success, looked high and dry. But Japan fought on and anti-Japanese feeling ran high. So the switch was made. In July they tested an experimental device. Oppenheimer named the test *Trinity*. It was detonated early in the morning on an iron tower 100' high and 20' deep in cement. Buses brought in spectators. The detonation exceeded all expectations. Rabbits exploded 800 yards away. Temperatures reached 750 degrees at1,500 yards. Temporary blindness occurred at a range of 9 miles.

Oppenheimer recalled the saying of Vishnu in the Hindu scriptures. "*Now I am become death, the destroyer of world*s." Some said he strutted in his hat like a cowboy. Both he and Groves backed the American decision to use the bomb to force a Japanese surrender. Groves felt it would take two bombs to persuade them. Most of the scientists were elated at the success of their labours. But after Hiroshima and Nagasaki were bombed feelings changed. Photographs, casualty figures and accounts of radiation sickness shook them. One German émigré said, "*It seemed rather ghoulish to celebrate the death of a hundred thousand people even if they were enemies*." But the war encouraged strong patriotic feelings and opinion on the morality of the decision to use the bombs remains divided.

The Manhattan scientists became national heroes. After the war, some were unrepentant, even considering designing a new sort of bomb that would kill people (by radiation) without destroying all the buildings. Others worked on military funded projects but one unconnected to nuclear weapons. Others still switched to researching life sciences. One was Erwin Schrodinger, a pioneer

of quantum physics (last session; and in the Session One photo, he's the one standing behind Einstein, not wearing a suit; he loved the outdoors and always wore hiking gear. He was often refused entry to formal occasions). In 1945 he published a short book, *What Is Life*, urging scientists to search for the quantum equivalent of life sciences, the inner secrets of organic inheritance, growth and development. It began the post-war shift from physics to biology.

Ig science: the nature of life

In 1953 the headline story was the conquest of Everest. Less noticed was the short article published in *Nature* by two unknown Cambridge scientists, Francis Crick and James Watson. It stated, "*It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material.*" These understated words announced the discovery of the Holy Grail of evolution, the mechanism of inheritance. They did so by unravelling the complex molecules inside genes: the double helix of deoxyribose nucleic acid: DNA. It launched a new age of molecular biology.

The double helix became a cultural icon, as representative of science as the ancient twin snakes, the *caduceus*. Its discoverers were an unlikely pair. Crick was the scruffy intellectual, Watson the American boy-genius. He wrote a best-selling memoir, making himself the hero and downgrading the role of his boss, Maurice Wilkins and denigrating Rosalind Franklin (for not wearing lipstick); they published in the same edition of *Nature*. She took the photo which provided the crucial clue. Watson was given a sneak preview by Wilkins. Its X-shape suggested a helix. The bars and diamonds suggested a double helix or spiral. In a sense Watson appropriated her work. She was methodical and meticulous. Taking such photographs by crystallisation (passing x-rays through crystals) required great skill and patience to get a clear image. The dots on the screen then had to be interpreted. Frankin had worked in Paris, disliked British lab culture, and preferred to work alone.

Watson was a physicist not a geneticist and had no business to be involved. But he was aware that the race was on to crack the secret inheritance. He skimmed articles and research reports for snippets of information and picked the brains of any specialists he could. He picked up that nucleic acids not proteins were the key and one study that tipped DNA. Patricia Fara describes Watson as "*a scientific bricoleur*" (French for a *tinkerer* or *improviser*), "*an intellectual adventurer patching together snippets purloined from various disciplines*." He lurched from one wrong hypothesis to another, following flashes of intuition up blind alleys But he was lucky, and his "*enterprising*

panache" went with a passion for self-promotion. This re-wrote the traditional historical narrative of science: not so much a hero of science, more a cowboy.

Much painstaking work had established that in living things, strings of chemical units were arranged in a definite order. It all suggested that a code must be involved. It was about *information*: how do living cells pass on characteristics from one generation to another? Researchers used tiny, 2-molule viruses called *phages* (the reproduced every half-an-hour). It was a recent phage experiment that pointed to DNA. Watson and Frick borrowed only enough information to enable them to complete their 3-D jigsaw model of the DNA molecule, was compatible withal the data; they constructed it using crude lab clamps. It then took hordes of molecular biologists years to work put the detail, how DNA molecules could unravel into two separate strands then recombine with new partners to wrap themselves into a new, unique pattern. Here was the mechanism of Natural Selection, the hidden realm of biological inheritance, Darwinism's missing piece.

Biochemistry now emerged, Commercial companies moved in. Researchers were bound to secrecy. Patents were taken out. Big profits were at stake. But once again things proved messier in life than in the lab. DNA molecules weren't neatly packed with genetic information, but full of mistakes and repetitions, with "*a few effective genes scattered amongst the chemical detritus*." And after all, genes weren't responsible for everything. The nature-nurture debate resurfaced in a new guise. Environmental influences could trigger the chemical surrounding genes inside cells.

Another paradox emerged. If life is a battle for survival, why do organisms behave *altruistically*, for the benefit of others? Richard Darkins coined the idea of "the Selfish Gene". It was a not-very-accurate metaphor which Fara says "*solidified into reality*." It was individual genes that ceaselessly competed with other genes, not the individual who the genes belonged to. Behaviour that appeared altruistic was in fact calculated to held individual genes. It became the phrase of the hour. Critics wondered why everyone forgot that genes are molecules. They couldn't think. They didn't have "motives". They can't be "selfish" or otherwise. The whole idea was completely unscientific. But this touched the nature of human life. Emotion took over.

The mapping of the Human genome promised great medical benefits. Relatively were realised. Genetic interactions proved extremely complicated. There was no single gene for, say, heart disease, cancer, slimness, sexual orientation or intelligence. New ethical dilemmas appeared, Tinkering with

cells that would be passed on to future generations was risky. And while eradicating appalling conditions like Huntingdon's disease seems obviously right, taking responsibility for consciously shaping the inheritance that defined future humanity seemed too close to eugenics. Intentions might be good, but it was intensely political.

Big science: Planet Earth

James Watson, discoverer of the double helix, saw himself as a scientific outsider. He often proceeded by intuition and improvisation. The same was true of ***Alfred Wegener (1880 – 1930),*** the man credited with discovering plate tectonics. He died on an Arctic ice sheet, knowing that professional geologists rejected his grand theory. Wegener was a German meteorologist. He knew about ancient climates. He noticed that the edges of Africa and South America fitted like a jigsaw. He wasn't the first to notice, but he built a whole theory on it.

Unlike other geologists, he took a holistic, whole-earth perspective. As we've seen, geologists were divided between gradualists and catastrophists. He rejected both. Why was ocean floor rock thinner and more recent than that of the continents? Why did the geology and fossils match up on coasts either side of oceans? Wegener revived an old concept, of an ancestral supercontinent called *Pangaea.* 300m years ago it was most of the earth's land. By 3m years ago it had drifted apart and the shape of the current continents was recognisable. The specialists sneered. And Wegener's theory lacked a mechanism: *how* did all that happen?

Only after the Second World War did geologists start to take a holistic view. New specialisms proliferated; seismologists, meteorologists, oceanographers, all were trained physicists. They looked at the earth's internal structure and changes in its magnetism, the oceans, the atmosphere, space, the impact of the sun's magnetic storms. This was the new frontier of Big Science. The mining and extractive industries invested in it. Cold War rivalries were involved. Navies needed knowledge of the ocean floor for submarines. In 1965 a predicted pattern of striped magnetic bands along the seabed was confirmed. Wegener was vindicated. Continents were carried on top of giant plates in constant motion.

The timing was right. It coincided with Thomas Kuhn's book, *The Structure of Scientific Revolutions*. Sudden lurches in scientific thinking were back in vogue. Disillusion had set in with old science, with nuclear weapons and pesticides. Asteroids were discovered to have hit the earth and provoked

changes. The new theory of *continental drift* allowed Big Science to link earth and space.

Big science: space

Similar questions were being asked about space as about earth. Was the universe stable or explosively dynamic? The mathematics of Einstein's theory of Relativity implied an expanding universe. Einstein tried to evade this implication. Astronomers disagreed. Was there one vast galaxy, or several separate islands? (***Edwin Hubble 1889 – 1953***), a California astronomer, was interested in measuring cosmic distances. Hubble affected British aristocratic mannerisms; he'd served in the American forces during the First World War, was known as "The Major", and used phrases like "come a cropper".

He was helped by the work of Henrietta Leavitt who worked as a "computer", women who did bulk manual calculations and other menial computational tasks for low pay. She was employed to look at photographic plates of stars to determine their brightness. She exceeded her brief. She studied a special type of variable or pulsating ("blinking") stars called *Cepheids.* Through careful observation she worked out that the rate of blinking of each one was directly related to its brightness or "luminosity".

If a star appears brighter or dimmer it from the earth, it isn't clear whether this is because it really is brighter or dimmer, or because it is closer or further away. Leavitt's observations meant that when Hubble later saw Cepheids in other galaxies, he could tell their luminosity from their pulses, regardless of how bright they looked from earth. This gave him an objective way of estimating how far away they were. For the first time astronomers had a measuring rod for the distances of stars and therefore a handle on the size of the universe.

Leavitt was promoted and did further astronomical work. Hubble, who in effect appropriated her work, often said that she deserved the Nobel Prize. By the time anyone got round to proposing her, she had died of cancer. It is not awarded posthumously. Hubble went on to greatness. He showed that there were indeed multiple galaxies. He also showed that they were moving away from one another; the more distant they were, the faster they were moving way. Cosmic expansion was a fact. The idea of a steady state universe was disproved. It had begun as a point in space which expanded and continued to do so. Soon this was called the Big Bang, an ironic term coined by Fred Hoyle, a steady state man. How and why it occurred, and what came before, are still open questions. Modern cosmology has not banished God altogether.

It has however, via more powerful instruments such as radio telescopes, discovered more weird entities and invisible realms: *quasars, pulsars, black holes, worm holes, dark matter, gravity waves.* Were these physically existing things? Or rather mathematical, interim approximations of things we dimly apprehend but which still lie beyond our knowledge and understanding? Modern cosmology has as many questions as answers.

Big science: information

As Big Science became dominant, two conflicting ideologies emerged about information. One stressed openness, the free exchange of information and a collaborative approach. The other stressed secrecy to safeguard national and commercial security. During the Second Word War, the British, Americans and Germans each worked on computers for military purposes, under a cloak of secrecy. After the war governments, the military, big business and universities poured money into them. Typical was the Havard Mark II (1950), constructed in a university laboratory, sponsored by IBM and designed for the navy.

One of the first was unveiled by the Americans in 1946 - ENIAC – the *Electronic Numerical Integrator and Calculator.* This too was constructed by a university but controlled by the military. Specially for the press launch, they attached flickering lights. It filled a large room and although many times faster than the neurones of the brain it was less powerful than a modern laptop. It got very hot and needed 18,000 valves which often blew. Intruding moths and flies caused havoc; hence the origin of “debugging”. It wasn’t really a computer, more a giant calculator. It was designed to calculate shell trajectories. To make it do other tasks, it had to be rewired – a task carried out by women.

The computers developed by the British at Bletchley Park were also developed in secret. They were more versatile. By 1945 ten electronic *Colossus* machines *were* scanning coded intercepts from German U-boats. Unlike ENIAC, they were programmed to make make decisions between different options; failing this, they were programme to refer to a human operator, an early example of how computers would blur the distinction between machines and humans.

Alan Turing (1912 – 1954) worked there, the world’s greatest expert on the mathematics of decision-making. Few knew this; all was on a need-to-know basis. Turing was another scientific outsider. Educated at Sherborne, he was prosecuted as a gay man and regarded as a security risk because it made him

vulnerable to blackmail. He served a sentence of experimental hormone therapy and died in 1954 after eating a poisoned apple, possibly accidentally.

Turing's significance is that he thought deeply not just about how computers worked, but what they were and could be. He effectively conceived the modern computer, as able to switch from one task to another by being rapidly re-programmable. The death of a close friend persuaded him that the soul did not exist; and he was comfortable with the idea that computers would be capable of thinking. He devised the Turing Test; if a computer was programmed to answer questions put to it by a human, could they tell they were "talking" to a computer? If not, it was thinking – whatever thinking meant.

This blurring of distinctions between humans and machines and the ensuing debates were moved to a new dimension by the development of artificial intelligence (AI). Did computers model the brain, or vice versa? Governments invested heavily in AI during the Cold War. In 1997 a computer called *Deep Blue* beat the world chess champion, and *Alpha Go* beat the human champions at the complex ancient board game *Go.* using moves never previously seen by its human opponents. Virtual reality blurred the experiential boundaries between visual reality and computer simulations, useful for computer gaming and training pilots, firefighters and surgeons.

Turing and other pioneers of the information age tended to be utopian in their thinking. However the true potential of computers was not unleashed until they were linked together to communicate with one another. The first network was called *APARNET* (1969, after the *Advanced Research Projects Agency*)). It was designed to keep American military scientists ahead in the Cold War (the military preferred a network model to a top-down hierarchy in the belief that it could continue to function even after a damaging nuclear attack).

Tim Berners-Lee (born 1955) a computer scientist working at CERN (*Conseil Europeen pour la Recherche Nucleaire*, home of the world's largest particle accelerator) devised useful protocols for their intranet, such as hypertext links, to enable he and his colleagues to share information. This package was adopted for the internet and became known as the *world wide web*. "Tim BL" waived all copyright in the name of the free exchange of information.

These networking developments were transformational because they *redistributed* computer power from mainframes to consumers' own devices: desktops, laptops, hand-held tablets, pocket sized mobile phones and even to

wrist watches and spectacles. It was a new information age, a revolution as least as profound as the invention of the printing press.

But critics see dystopian aspects. Much of the information freely exchanged on the internet is worthless or harmful. Privacy has been eroded. Surveillance has become inescapable. Screens have become addictive, whether for gaming, checking for messages, scrolling or trolling. Whether the information age is a new heaven or a new hell is hotly debated, particularly on social media.

The *March of Progress* (Session Six) continues to be double-edged. Currently, competition to be the first in the field of computing and AI research is as fierce as ever and subject national commercial secrecy. Not all information flows freely.

CONCLUSION – THE HISTORY AND FUTURE OF SCIENCE

Enrich Fermi, the nuclear physicist, came up with Fermi's paradox. Given the billions of stars and therefore planets now thought to exist, does this not strongly suggest that intelligent life is not confined to Earth? But if so, why has no trace of this ever been detected? There are possible practical reasons; but one sinister suggestion is that the evolution of civilization and intelligence carries the likelihood of self-destruction.

Disillusion with Big Science triggered a view that science itself was fundamentally flawed. There is no consensus in this. For the disillusioned, Sir Francis Bacon is a key figure. He personified ("knowledge itself is power") a male-dominated type of science that sought to ruthlessly subdue, dominate and exploit the world and its resources. Patricia Fara argues that science is not the problem, but rather bad political decisions about how science should be used. However she admits that science can too readily become an instrument of control and coercion.

An alternative view was put forward by Andrew Marr in his *History of the World (*2012). He argued that whereas science had been very successful in uncovering the laws governing the material universe, this was not the case in the realm of human affairs. Many philosophers of knowledge believe in the saying that "*God gave physics all the easy problems*". By this view, unravelling the problems of the human realm is infinitely more complex . Finding simple, predictive laws as Newton did in science is all but impossible in human affairs.*

*However many scientists now think it's also impossible in areas of science such as the quantum realm. The above quote, though often repeated, cannot be attributed to any single person. The less snappy version would be: *"For conceptual and empirical reasons the quest for predictive theory rests on a mistaken analogy between physical and social phenomena. Scholars have long argued that prediction of complex human behaviours is too difficult empirically."* The basic idea is that while physics deals with more readily quantifiable and predictable phenomena, social sciences and the humanities have to grapple with the complexities of human behaviour and social systems, which are often highly unpredictable and difficult to model. See:
https://www.researchgate.net/publication/235737421_God_Gave_Physics_the_Easy_Problems_Adapting_Social_Science_to_an_Unpredictable_World

Most of the modern disillusion with science stems from Big Science. This arose in 20th century Europe and America. As we've seen, its historical roots lay in the opening of the Atlantic, the age of exploration, the rise of European colonial empires, the industrial revolution, and the increasing scale of warfare leading to the world wars and the Cold War. These changes resulted in a culture which drove the Europeans and Americans to pursue power over the rest of the world. History, not science, created this drive to power. Science was caught up in it.

As we've also seen, ancient and medieval China and the Islamic world prioritised other things. For China it was order, stability and food security across its vast land mass. For the Islamic world it was the welfare and spiritual purity of the *ummah*, the vast mass of the people of Allah. Thus we could argue that the problem isn't science, but rather the cultural priorities of a capitalist, profit-driven system created by industrialisation. This system conquered the world, but its need for continuous economic growth is not sustainable.

Thus the problems facing our civilization don't originate in science, but rather in a need for fundamental cultural change. We need to question, even discard, many of our most cherished assumptions. This will not be a small task, How do we go about making it happen?

Maybe it's true after all; maybe God *did* give physics the easy problems.