

QUANTITATIVE DYNAMICS OF HUMAN EMPIRES

Cesare Marchetti and Jesse H. Ausubel



FOREWORD

Humans are territorial animals, and most wars are squabbles over territory. A basic territorial instinct is imprinted in the limbic brain—or our “snake brain” as it is sometimes dubbed. This basic instinct is central to our daily life. Only external constraints can limit the greedy desire to bring more territory under control. With the encouragement of Andrew Marshall, we thought it might be instructive to dig into the mechanisms of territoriality and their role in human history and the future.

In this report, we analyze twenty extreme examples of territoriality, namely empires. The empires grow logistically with time constants of tens to hundreds of years, following a single equation. We discovered that the size of empires corresponds to a couple of weeks of travel from the capital to the rim using the fastest transportation system available. Emperors build roads for a good reason. And there is an anthropological explanation. Submission to the chief must be refreshed at least once every lunar cycle to make it last.

The territorial instinct also operates in the heads of rulers of states, who visualize a nation as an extension of their limbs (*l'état c'est moi*) and try to expand it with a panoply of rationalizations. In reality, the drive and objective are the same for a nation as for the individual: more land under one's control, thus, more power at hand. If a nation is vigorous and the boundary conditions are appropriate, the territorial expansion will produce an empire.

So we have anthropological machinery, basically subconscious, that organizes territory, leads to empires, and presumably inspires wars. Speed, as hinted, is the key to larger territories, and the use of the airplane permits a global empire, because now any place can be reached in less than two weeks. The idea has been seized by multinationals, which by all means have

become global. And, incidentally, once a month they have their top managers meet somewhere to refresh the hierarchy, although the formal motives are to coordinate business and exchange experiences. The political machinery is more viscous, and we may have to wait a couple more generations to see a global empire.

The fact that the growth of an empire follows a single logistic equation for hundreds of years suggests that the whole process is under the control of automatic mechanisms, much more than the whims of Genghis Khan or Napoleon. The intuitions of Menenius Agrippa in ancient Rome and of Thomas Hobbes in his *Leviathan* may, after all, be scientifically true.

We are grateful to Prof. Brunetto Chiarelli for encouraging publication of our ideas. This report expands moderately on C. Marchetti and J.H. Ausubel, *Quantitative Dynamics of Human Empires*, *International Journal of Anthropology* 27(1–2):1–62, 2012, and includes additional colorful maps and illustrations. We also thank Paolo Angeletti and Iddo K. Wernick for research assistance and H.Dale Langford for design and editorial assistance.

Jesse Ausubel

Director

Program for the Human Environment

The Rockefeller University, New York City

Cesare Marchetti

Senior Research Scholar

International Institute for Applied Systems Analysis

Laxenburg, Austria

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SUMMARY

Quantitative modeling of social systems shows a large component of automatic drives in the behavior of individual humans and human society. Studies of the formation and breakdown of 20 diverse empires operating over almost 3,000 years describe these processes with utmost clarity and paradigmatic simplicity. Taking territorial expansion as the basic parameter, we show that it can be represented in time by a single logistic equation in spite of the complicated sequences of events usually reported by historians. The driving forces of empire, leading to expansion and saturation at 14 days of travel from the capital, can be reduced to testosterone and progesterone.

MANY THINGS we humans do automatically and to which we pay little attention are in fact the result of millennia of evolution of human behavior. Territorial organization is an example important for our subject of creation of empires. Animals that can retreat in a protected area, like a cave, usually have a basic instinct determining how much time they can spend outside this area where the dangers are higher. Extensive measurements done by Y. Zahavi in the 1970s and verified since by Marchetti (alone and with Ausubel and Meyer) show that almost independent of geography humans spend about one hour or slightly more outside, e.g., traveling. It is dangerous to stay outside one's home base, which is protected by fortifications, alliances, intimate knowledge of the environment, and magic, which gives confidence. As medieval cartographers wrote, outside one's own area "Here be dragons."

The hour of travel or wandering defines fairly precisely the tiling of territory into patches of about 5 km diameter, the length a person can travel walking in one hour. The natural primitive area of control, by the famous πr^2 , is thus about 20 square kilometers.

At the center of a patch there is usually a village, so the grid of villages has basic spacing of 5 kilometers. If a village is successful and becomes, e.g., the capital of an empire, it will fill the original patch of 20 square kilometers,

but no more, with a maximum population of one million people, or 50,000 per square kilometer. Looking at old capitals like Rome, Susa, or Marrakesh, we find the rule is respected.

To change the size of the patch, one has to change the speed of movement. Cars since Ford's Model T have a mean speed about 40 kilometers per hour, so a city where cars provide the basic transport system can cover a patch with a 40 km diameter and thus an area of 1000 square kilometers. This scheme fits Mexico City, and its population is growing logistically to 50 million, or 50,000 per square kilometer. As these basic instincts have developed and operated over millions of years, we can be confident they will not change overnight.

These basic patches, villages, can be organized in clusters of seven, and the central one can have some special property, e.g., hosting a weekly market. Doxiadis (1968) showed that these clusters then can organize in a super-cluster of seven and have a city in the middle where, e.g., a monthly market is held, and many crafts and forms of commerce can find a place.

The game can continue up to a point until it doesn't interfere with another basic instinct. Social animals, including *homo sapiens*, have hierarchical organizations that have various purposes, one of them regulation of access to resources. Thus, if the pack kills a buffalo, there is no fight in consuming it.

Number 1 eats first and so on. We may define ethics as pre-agreed division of spoils. The hierarchy is continuously refreshed, with occasional or periodic ruffles to readjust the ladder. William Whyte in his insightful 1956 book, *The Organization Man*, neatly described the process for economic organizations such as GE and Ford. The fact is that written organograms or organization charts rarely correspond to real ones.

Anthropological invariants

- travel time budget of 60–70 minutes
 - area of control of a village, 5 km radius
 - tiling and hierarchy of villages
 - lunar cycle of 28 days and travel time of 14 days
-

Here we take a daring anthropological leap and assert that the mechanism that fixes the size of empires, and the functioning of business organizations, comes from the depth of time. Every month men in a community had a precious resource to share, the fertile women, who had the habit of synchronizing with the moon. Such a precious resource called for resetting the hierarchies every 28 days, as managers do under various disguises in the economic organizations with their monthly meetings. When the Czar wanted to reaffirm the belonging of Vladivostok to the Russian empire in front of the nervous emission of Japanese power, he built the very expensive Tran-Siberian *military* railway to send messengers there in just 14 days. Alaska was hopeless to reach in 14 days, so he had sold it to the United States.

Empires in fact have always had a maximum extent or distance from the capital of 14 days, and for that reason the administrations make miracles in speeding up the transport system. Rome had 90,000 kilometers of superbly paved roads for the horses and carriages of the messengers, and the Inca empire had 40,000 kilometers of unpaved roads for its chasqui runners, who could go in 14 days from the last frontier to the capital, Cuzco. The Persian empire had horsemen making 500 kilometers per day in relays.

Not all empires could afford or maintain the travel time rule, especially the very large ones. Britain had immense territories in India and Asia, and the Spanish empire was mostly on the western side of South America. The weak and dangerous solution was to have a Viceroy, a stand-in, to take care of the current affairs with appropriate local distances. As we shall see, the most

Assumption

Good definition of political control is collection of taxes or tributes, i.e., Empire = region within which sovereign collects taxes

Caveat

We cannot be sure of the truth of the maps of the historians (data about size of empires are uncertain)

Method

Fit data on size of empires to S-curves, in particular to Logistic Curve (cf. Lotka-Volterra model of growth, or diffusion of epidemic - system grows to a limit); many data from historian R. Taagepera

Definition

Growth time: time for process to grow from 10% to 90%: Δt

Midpoint: inflection point of growth process (time of most rapid growth)

unlucky or unwise empire was Portugal, whose government decided to go to Brazil when Napoleon menaced Lisbon. The Lusitanians even founded a Brazilian Empire. After Napoleon's demise, the Lusitanians returned across the Atlantic, and the Brazilian Empire declared its independence.

Empires are large structures incorporating a variety of cultures, customs, and crafts under the same roof. They have large means and naturally cradle advances in civilization stimulated by cross-fertilization. Culture can be exhibited, together with palaces, gold, and precious stones. The learned are

Twenty empires

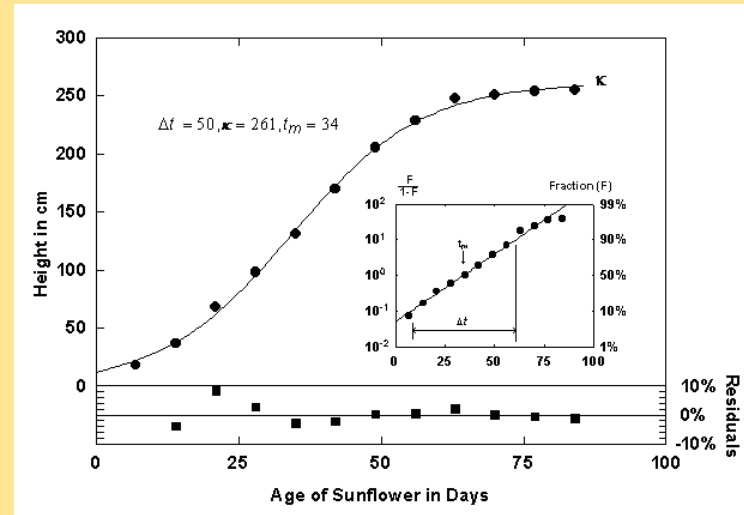
- | | |
|--------------------------|-------------------|
| • Achaemenid (Persian) | • Aztec |
| • Carthaginian | • Spanish |
| • Roman | • Portuguese |
| • Caliphate (Mohammed) | • French |
| • Frankish (Charlemagne) | • Mongol-Huan |
| • Seljuk (Turk) | • Manchu-Qing-PRC |
| • Ottoman | • Russian |
| • Delhi | • British |
| • Mogul | • USA |
| • Inca | • European |
-

Growth to limit

The sunflower offers a classic example of growth to a limit. Note the initial period of slow growth followed by a period of rapid growth culminating in a saturation region. The saturation value (κ) for the sunflower is 261 cm, representing the height that the plant will approach asymptotically. The midpoint (T_m) of 50 days represents the time at which the rate of growth of the sunflower begins to slow. (Data from H.G. Thornton, On the development of a standardized agar medium for counting soil bacteria. *Ann. Appl. Biol.* 9: 241–274, 1922.)

The growth time or time interval (dt or Δt) represents the amount of time elapsed between 10% and 90% of the growth to the saturation value. The residuals plot on the bottom represents the error, or difference, between the model and the observed data. (P.S. Meyer, J.W. Yung, and J.H. Ausubel, A primer on logistic growth and substitution: The mathematics of the Loglet Lab software, *Technological Forecasting & Social Change* 61(3): 247–271, 1999.)

A change of variables that normalizes a logistic curve renders it a straight line when plotted on a semilogarithmic scale. This view, seen in the inset, is known as the Fisher-Pry Transform (FPT). The FPT emphasizes the fact that social diffusion phenomena are frequently the result of market share, one process competing with and substituting for another. In the event that no competitor is identified, then the FPT representation offers insight into the saturation of a phenomenon or the maturation of the social process.



Growth of a sunflower fitted with a single logistic curve. The inset shows the logistic curve and the data linearized with the Fisher-Pry transform. The lower panel shows the residuals in percent deviation from the fitted curve. Source: Meyer et al., 1999.

also a visible ornament of the powerful. Similar mechanisms have been active at the level of cities since ever, and provided the first rung in developing modern civilization. In our perspective “modern” means the last 10,000 years, although humans were already much evolved earlier, as cave paintings and many other artifacts show. But, the city provided the network of services and interests that permitted complex operations to be performed and the formation of complex cultures.

The fact that empires, like cities, are born by basic instincts is transparent from their number. The Wikipedia article “List of Empires” offers more than 150, and more surely existed, now undocumented, for example in Africa. The Estonian and American political scientist Rein Taagepera offers data on about 80 empires.

Historians may of course differ on the precise extent of imperial control. We rely on the assessments of Taagepera, the most thorough scholar we have found in this field. While we recognize uncertainty exists in the data, we think the overall power and consistency of the findings mean that revisions of

the data would not affect the general findings. Definitions of empire typically involve concepts such as fealty and homage, which translate into payment of taxes and military service and other forms of submission or subjection. International relations and law experts describe empires as large sovereign entities whose components are not sovereign.

For each empire, we look at the shape of its development, in particular whether it expanded in the S-shaped or logistic curve that characterizes many biological growth processes, such as the increase in height of a sunflower or the number of persons infected in an epidemic. We look at the time the process required to expand from 10% to 90% of its completion. We look at the midpoint or inflection of the process, when the rate of growth peaked, one might say the time of peak aggression. And we look at the area the empire aimed to control, its niche. Sometimes we replot the data of the S-curve on a semilogarithmic chart where the final height or saturation is normalized to 100%, and the growth shows as a straight line that emphasizes the orderliness of the process.

EMPIRES

Achaemenid (Persian)	7
Carthaginian	10
Roman	12
Caliphate (Mohammed)	14
Frankish (Charlemagne)	16
Seljuk (Turk)	18
Ottoman	20
Delhi	22
Mogul	24
Inca	26
Aztec	28
Spanish	30
Portuguese	32
French	34
Mongol-Huan	36
Manchu-Qing-PRC	38
Russian	40
British	42
USA	44
European (Union)	46

Among events depicted in France's famed Bayeux Tapestry through almost 70 meters of embroidery on linen are Duke William II of Normandy's invasion of England in 1066 culminating in the Battle of Hastings.



ACHAEMENID (PERSIAN) EMPIRE



The Achaemenid (Persian) empire covered 5.4 million square kilometers with a Royal Road as the spine.

THIS HUGE PERSIAN EMPIRE (550–330 Before Christian Era [BCE]) at the height of its power encompassed approximately 5.4 million square kilometers, one-third more than the Roman empire at Rome’s peak. Sympathetic historians portray the Persian empire as a successful model of centralized administration with a government working to the advantage and profit of many. While the empire was divided into 23 provinces or satrapies to facilitate administration, the king kept overall control through a sophisticated system of couriers running and riding on robust horses day and night, winter and summer, over a well-developed network of imperial roads. The USA postal system adopted the Achaemenid empire’s motto. Within the 2,500 kilometers of highways, the most impressive stretch

A transport system to connect the empire within one month or lunar cycle

Imperial post roads connected the important cities. Along the Royal Road between Sardis and Susa there was a post station every fourteen miles, where the king’s couriers could obtain fresh horses, enabling them to cover the 1600-mile route in a week. “Nothing mortal travels so fast as these Persian messengers,” wrote Herodotus. “These men will not be hindered ..., either by snow, or rain, or heat, or by the darkness of night.” These words were at one time used as the motto of the United States Postal Service.

[Herodotus History 8.88, trans. G. Rawlinson.]

Achaemenid Empire



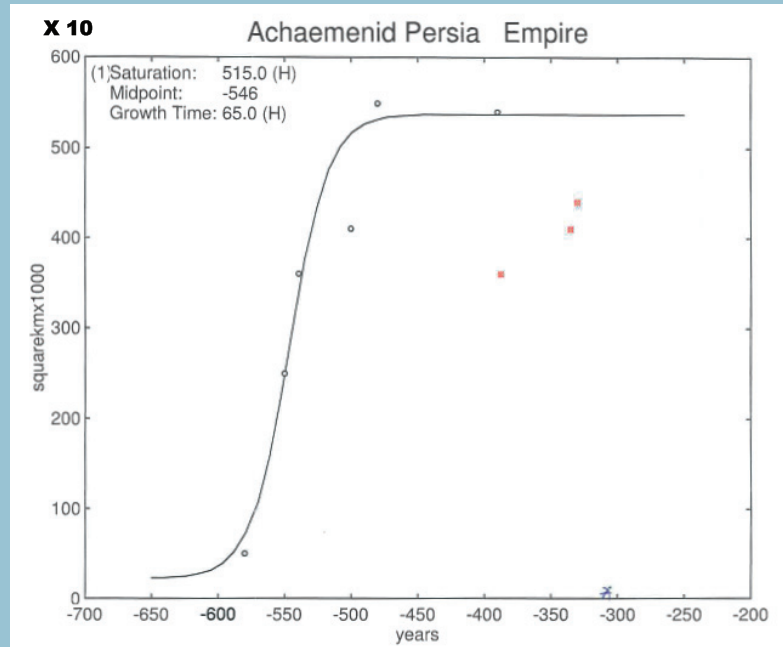
The Achaemenid (Persian) empire: a second view. This second map shows somewhat different boundaries, e.g., in Greece, the Crimea, Oman, and the northeast region. The differences suggest the limits of our approach.

was the Royal Road from Susa to Sardis, built by command of Darius I. Crucially, relays of mounted couriers could reach the remotest of areas in 15 days. Despite the relative local independence afforded by the satrapy system, royal inspectors, the “eyes and ears of the king,” toured the empire and reported on local conditions. With such an extensive empire a kaleidoscope of peoples was unavoidable and the Persians, like the later Romans, accepted diversity provided it was wrapped in recognizable Persianity.

The Achaemenid empire took 65 years to grow from 10% to 90% of its extent, with a midpoint of 546 BCE. Cyrus the Great reigned at the inflection point. Historians debate whether “the times make the man.” It certainly helps to work at the midpoint of growth. After saturation, the empire survived for more than a century. Rapid collapse

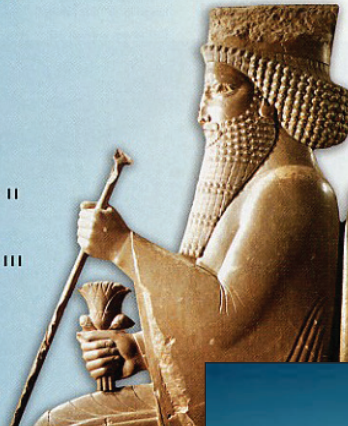
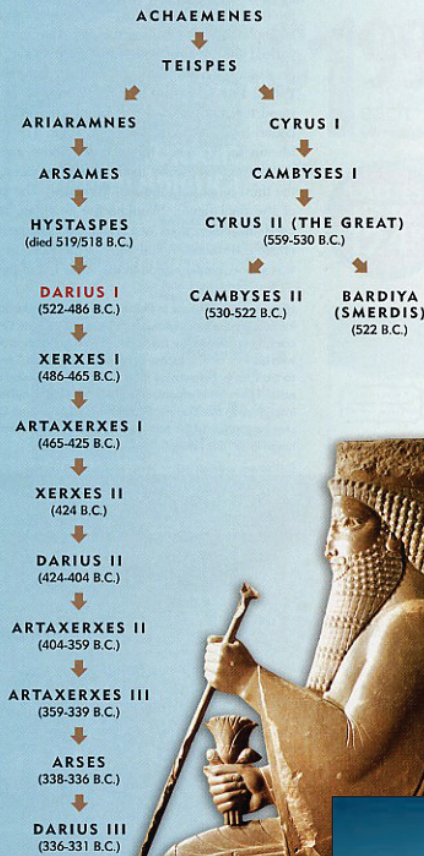
Year	Empire	Sq. km		Source
-580	Achaemenid Persia	0.50	0.50	Taagepera, 1979: 121
-550	Achaemenid Persia	2.50	2.50	Taagepera, 1979: 121
-539	Achaemenid Persia	3.60	3.60	Taagepera, 1979: 121
-525	Achaemenid Persia	4.10	4.10	Taagepera, 1979: 121
-500	Achaemenid Persia	5.50	5.50	Taagepera, 1979: 121
-480	Achaemenid Persia	5.40	5.40	Taagepera, 1979: 121
-390	Achaemenid Persia	3.60	3.60	Taagepera, 1979: 121
-387	Achaemenid Persia	4.10	4.10	Taagepera, 1979: 121
-335	Achaemenid Persia	4.40	4.40	Taagepera, 1979: 121
-330	Achaemenid Persia	0.00	0.00	Taagepera, 1979: 121

Spatial domain of Achaemenid empire. This example of an actual data set from Rein Taagepera is typical of those used in our analyses.



Achaemenid empire trajectory.

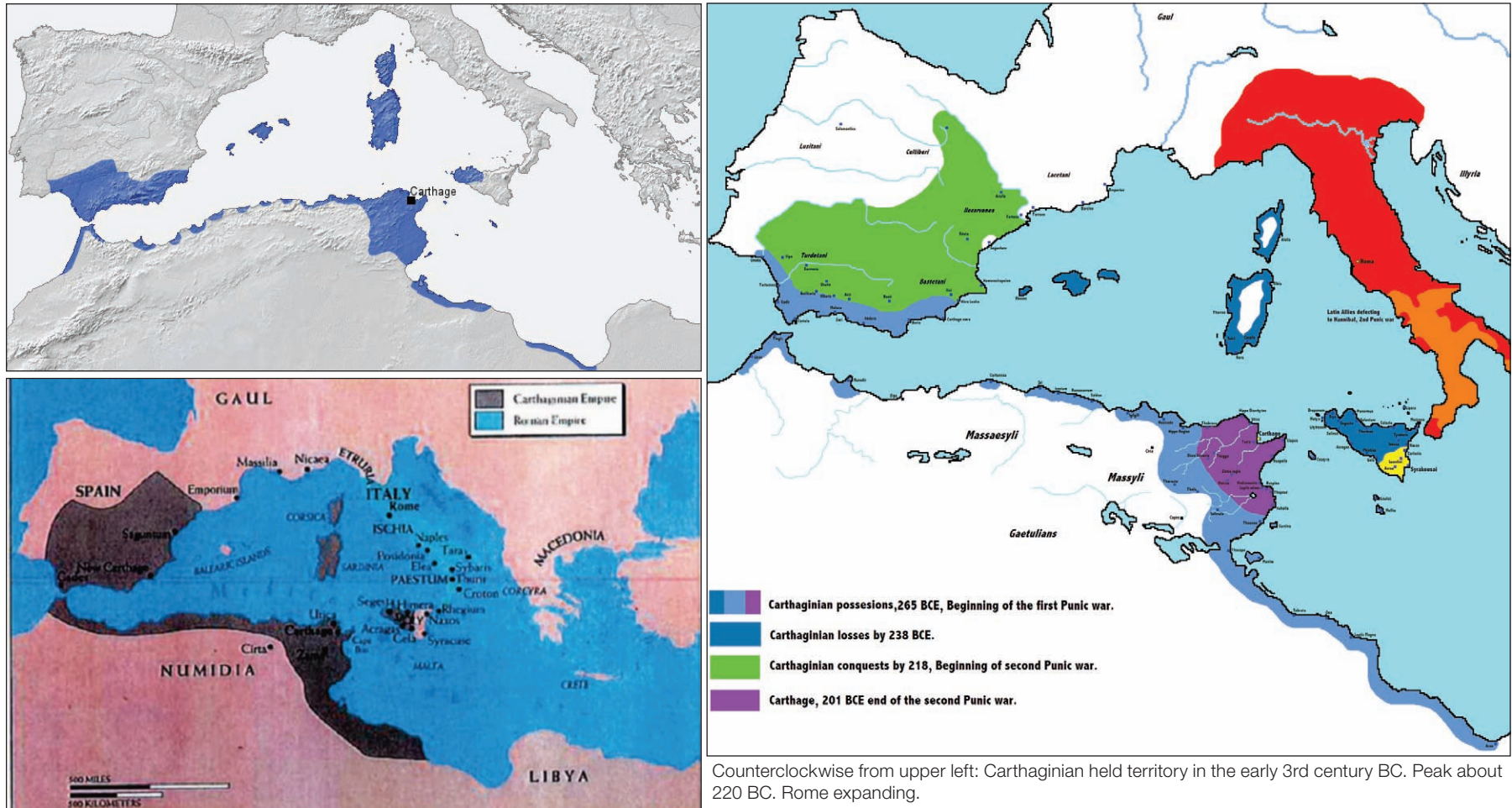
The Achaemenid Dynasty



The great stairway of the Apadana of Persepolis, ceremonial capital of the Achaemenian kings, begun under Darius I.

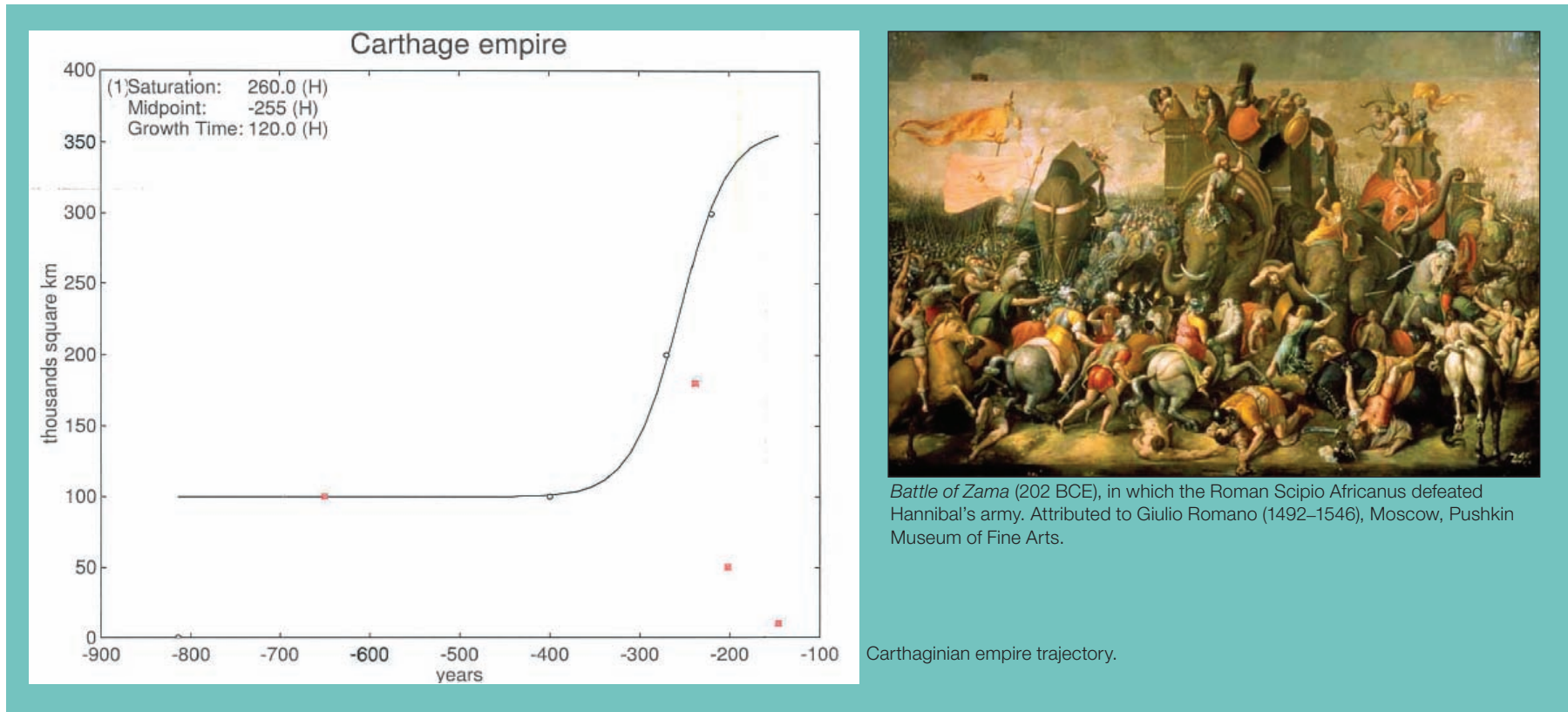
occurred between 350 and 300 BCE. The empire was well administered and had an ethical philosophy: speaking the truth was a basic principle inculcated from childhood, and telling lies prosecuted up to the level of capital punishment, which sounds curious in our times. The Persians were beaten in the battle of Thermopylae by a bunch of the most sophisticated liars of antiquity, the Greeks.

CARTHAGINIAN EMPIRE



CARTHAGE ORIGINATED AS A PHOENICIAN SETTLEMENT located strategically on the Sicilian channel, similar to Troy on the Dardanelles connecting to the Aegean and Black seas. Native to what is today Lebanon, the Phoenicians navigated superbly and thus flourished as traders.

The French historian Fernand Braudel (1984) remarked in *The Perspective of the World* that Phoenicia exemplified early a “world-economy” surrounded by empires. Phoenician culture and sea power peaked during 1200–800 BCE. The Phoenicians sailed northward as far as England, where they traded for



precious tin. Southward they explored the west African coast and perhaps even circumnavigated Africa.

A curiosity, Corsica, Sardinia, and western Sicily conserved Punic (Carthaginian) laws applied through underground organizations. The populations never really submitted to Roman laws. In particular they had secret tribunals operating according to Punic laws. The origin of the Mafia as we know it today can be traced back to these tribunals in western Sicily. History has long fingers.

While Carthage began spawning its own colonies in the 7th century BCE, its turn at empire awaited the 4th century. Carthage then grew over about 120 years, five generations, to its peak around 220 BCE. Its fast collapse and shrinkage characterize many empires, as we shall see. Its successor, Rome, was a newcomer that had popped up as a power only around

500 BCE. While Rome started its own aggressive territorial expansion only around 150 BCE, bickering occurred much earlier, and in fact the decisive wrestling match came around 250 BCE with Carthage, a vital but aging empire, and Rome a small energetic one just emerging.

The Carthaginian general Hannibal tried a final attack in Roman territory. He drove elephants through the Alps together with a mixed breed of mercenary soldiers, including the famous Numidian cavalry and its archers. Rome kept losing and fighting until it could overcome the invader. It finally decided to cut the danger at the root. “Cartago delenda est” became the conclusion of the speech of Cato the Elder in the Senate. In 149 BCE Carthage finally fell under the attack of Scipio and was thoroughly destroyed, its inhabitants killed or sold as slaves. A brilliant city and civilization were butchered, more or less the beginning of the Roman expansion and cruelty.

ROMAN EMPIRE



The Roman empire at the peak of Trajan 117 AD.

ROME PERHAPS BEST epitomizes empire. The Roman empire took long to build, 160 years, which probably contributed to its solidity, and expanded fully to the limits of the 14 days of travel. Rome paved the most remarkable network of roads in ancient history, about 90,000 kilometers. Rome also disintegrated slowly. Its law and administrative rules remain in use today in many political systems. Modern China

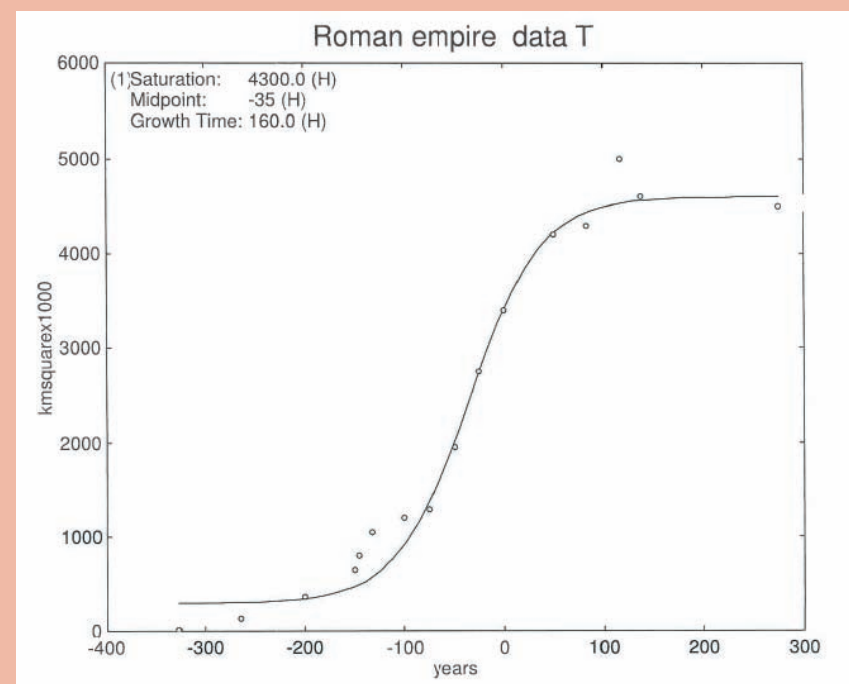


announced it will take Roman law as a reference to produce its own modern legal system.

Rome began as a small state covering only a tract of central Italy, but biting, consistent with its founding legend of Romulus and Remus fed by a shewolf. Rome finally won against Hannibal's invasion and brought the final destruction on the mainland of Carthage by hastily building a large fleet to bring its army there and reducing it to ashes and killing most of its inhabitants. As a popular general, Julius Caesar assumed control of a Republic and soon declared himself Dictator in Perpetuity and Imperator. A gang of senators murdered Caesar near the heated midpoint of Roman expansion, and other emperors completed the course.

A hypothesis is that the Roman empire grew in a period that geographers define as a climatic optimum. A rise of a couple degrees in mean temperature effectively expanded vegetation time and agricultural productivity. The rise happened all along the Mediterranean latitudes, but it was used in different ways. The Greeks built temples and nurtured intellectuals, providing the basis for our modern civilization. The Romans financed a professional army that built and kept the empire for a very long period of time after the logistic saturation had been reached.

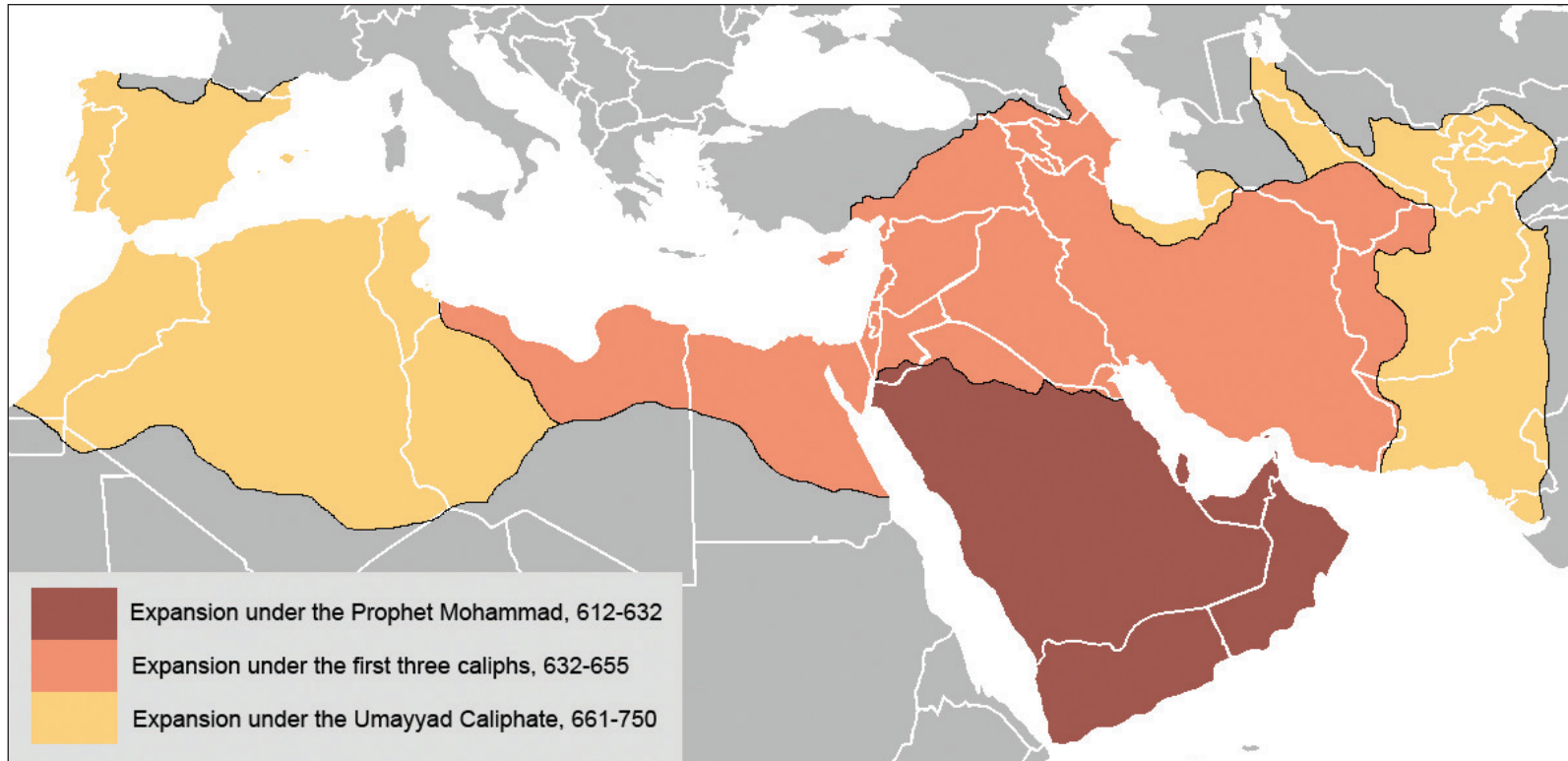
The fall of Rome came in pieces. The first important act was the split between east and west that we reinterpret as due to the persistent presence of pirates. They even captured Caesar. The 14-day connection with Byzantium and the Black Sea depended on fast sea travel in triremes. When piracy caused risk-averse functionaries to start choosing a land route that took almost a month, it precipitated a split of the empire in two. Our interpretation differs from history books, but it rests on basic anthropology and would be easy to verify.



Roman empire trajectory.



EMPIRE OF THE CALIPHATE

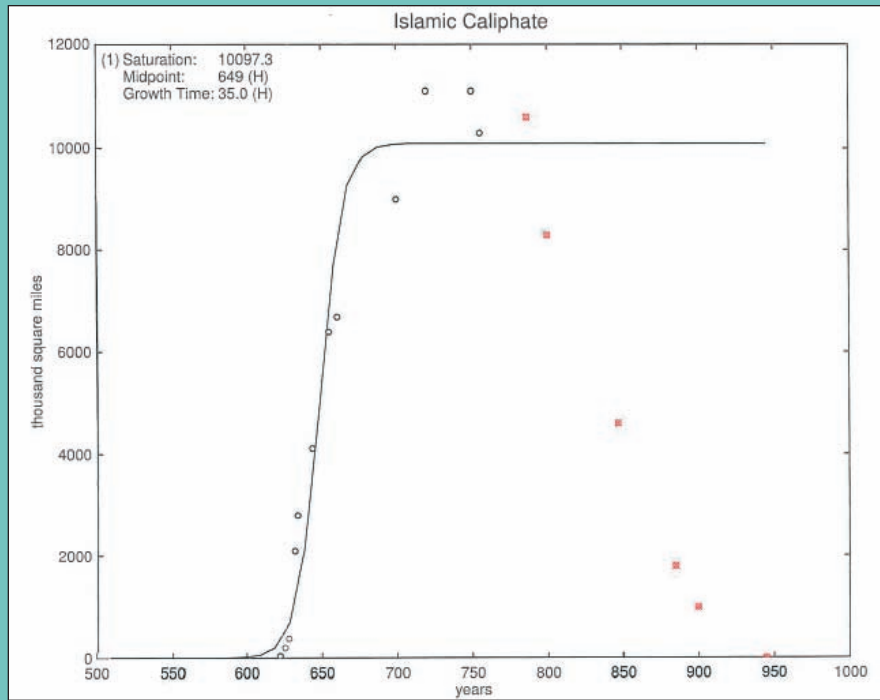


ISLAMIC RELIGION SUPPORTS conquering lands by war as a form of piety. Islamic soldiers attacked in testosteronic rage. Mohammed had stimulated them with the appreciated prize of 72 virgins in paradise, in case they died in battle. The ones that remained on Earth would marry, as a consolation, the widows of the dead soldiers. One of the last important aggressive operations was the crossing of the Pyrenees mountains to conquer France, but endangered and desperate Europe gave a deep bite to the Moslem invaders near Poitiers, not far from Paris, through the army of Charles Martel.

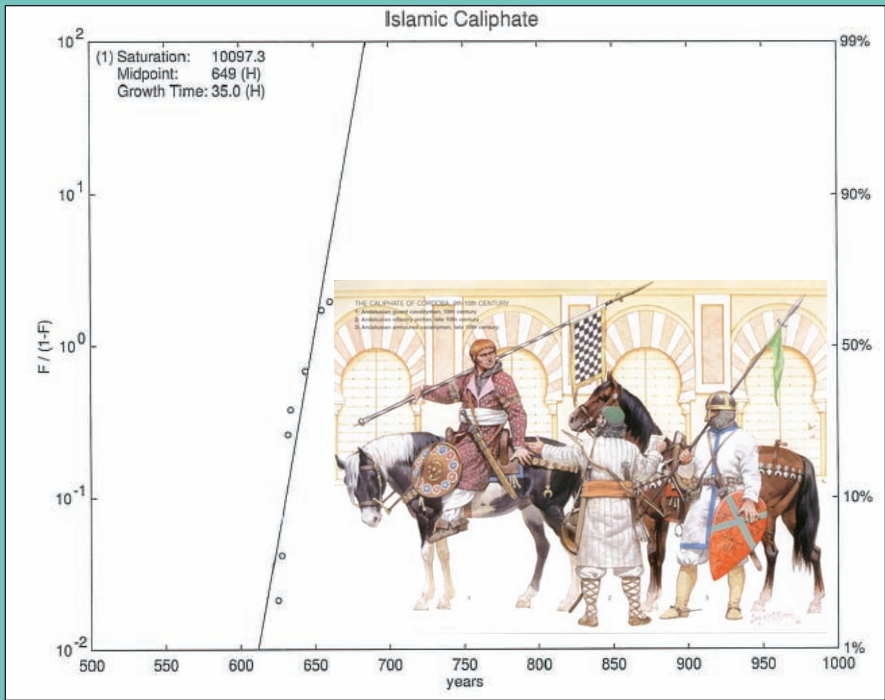
With the very short time constant of just 35 years and a midpoint of growth in about 650 CE, the early caliphs formed an empire more than twice the Roman and overlapping the oriental part of it. The Roman (and perhaps Persian) roads were an obvious attractor for the lines of expansion of the Caliphate, which in the end extended mainly west.

Having reached saturation, the Caliphate lasted about a century and a half, with strong oscillations in size, and finally crumbled due, as often, to internal instabilities that amplified external pressure.

Empire of the Caliphate



Islamic Caliphate trajectory.



The lance of Mohammed. Viewed in the linear (Fischer-Pry) transform, the empire Mohammed created resembled an upright lance of one of his warriors, almost vertical as a minaret, as the figure shows. The inset illustrates 9th-10th century warriors of the Caliphate of Cordoba (Angus McBride).

FRANKISH EMPIRE



WHEN THE WESTERN ROMAN EMPIRE dissolved definitively, around 476 CE, several relatively small regional organizations arose inside its borders, and the most vital of these, in particular the Franks in Austrasia, started fighting for growth. Finally an empire the size of western Europe was reassembled at the time of Charlemagne (768–814). The splendid monuments of the capital, Aquisgrana, and surviving gold and other artifacts show that little was lost with the fall of the Roman empire in culture and civilization. The Dark Ages appear to have been an invention of historians who perhaps simply lacked documents or other evidence. Notably,

the transport system remained good enough to move architects and artists out of Byzantium, that magnificent haven of Roman and Mediterranean culture and technology.

Dedicated warriors, the Franks saw the military potential of the stirrup to weld the horseman to the horse. They developed the heavy armored knights who were invincible for centuries, but very expensive, and necessitated confiscations of the land of religious orders to provide income. The huge horses developed for the knights had important fallout; they needed oats, which stimulated the serial cultivation of oats, beans, and turnips. The sequence in-

creased land productivity and provided valuable protein in the beans. Innovations that followed, in particular the heavy plow, vastly increased agricultural productivity per working peasant and created important surpluses. Second-choice horses, but more efficient than oxen, were used in agriculture.

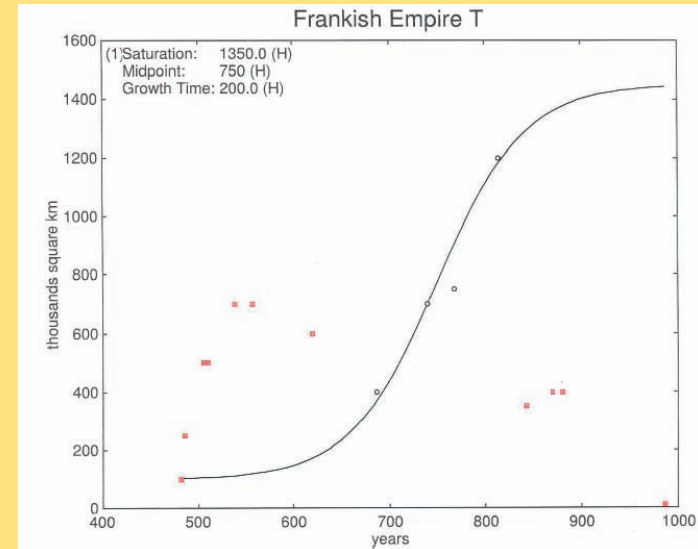
The metaphysical expenses for building the gothic cathedrals testify to this agricultural wealth. From the Benedictine monasteries, where monks read the book of Nature in parallel with that of Scripture, a wealth of technological innovations emerged that would put Europe ahead of competing political systems. With these revolutions the seeds of the future European military, political, and economic dominance were thrown.

From a strictly political point of view, post-Roman Europe was the seat of continuous battles that favored the military culture necessary for its survival, squeezed as it was by Huns from the east, Arabs from Spain, Turks from the southeast, and Vikings from the north. The new vitality was demonstrated when the Europeans started pushing back these converging forces and finally leapt out to conquer much of the world.

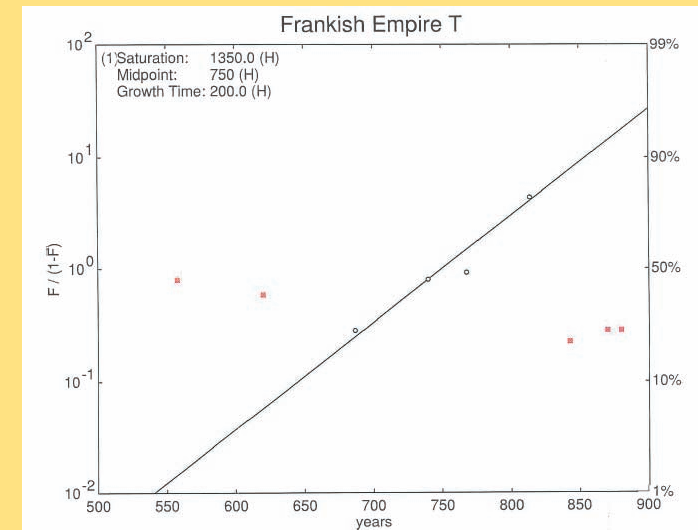
The logistic of the Frankish empire centers on 750 CE with a time constant of 200 years, notwithstanding many subdivisions and reunions due to the splitting of inheritances and war. Testimony that the system was in high gear approaching the center point is the victory against the Ummayyad Caliphate at Poitiers (732), which marked the beginning of the European revival. Importantly, the Frankish Empire represents the core of modern Europe and has remained the core of its defense and revival.



Pope Adrian I asks for help from Charlemagne, who wears stirrups. The Frankish empire peaked about 800 CE when Charlemagne was crowned Holy Roman "Emperor" by Pope Leo III on Christmas Day.



Frankish empire trajectory.



Frankish empire Fisher-Pry transform.

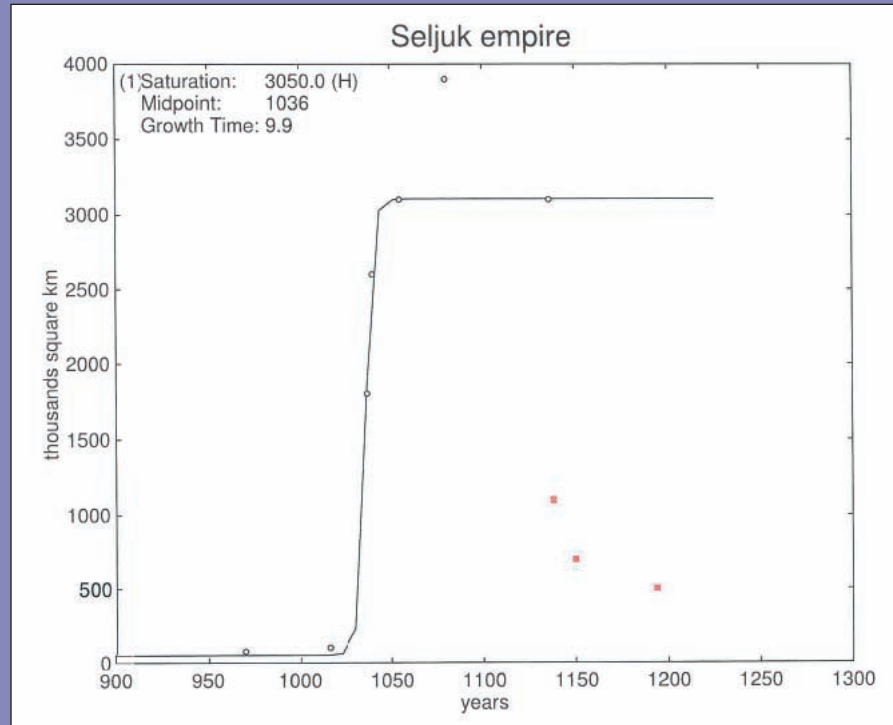
SELJUK EMPIRE



ORIGINALLY EDUCATED in the service of Muslim courts as slaves or mercenaries, the Seljuk dynasty brought revival, energy, and reunion to Islamic civilization hitherto dominated by Arabs and Persians. The potential of the transport system that coalesced various previous systems that ran from Turkey to China probably dictated the maximum size of the empire. In 1087, the Abbasid Caliph gave the Seljuk Sultan the title of “The Sultan of the East and West.” The relatively rapid end of the Seljuk empire was linked to the usual power squabbles between different potential heirs over division of land, and the fall was almost as fast as the rise of the empire. Some contribution to the fall came from the crusades that battered the Seljuk

western territories and resulted in establishment of islands of power linked to the Christian world.

Created shortly after the year 1000, the Seljuk empire had a time constant for its growth of only 10 years, although its final size was 4 million square kilometers, similar to the Roman empire. The extraordinary speed of creation may be understood through the spirit of these Moslem conquerors, who fought nonstop. According to Seljuk commentators, they brought to the Muslims “fighting spirit and fanatical aggression.” As remarked earlier, dying in battle guaranteed enjoyment of 72 virgins, and survival the widows of the dead. How powerful the driving force in a sensuous society!



Seljuk empire trajectory.



Two Seljuk warriors. Bas-relief from Konya, 13th century. Museum of Turk-Islamic Art, Istanbul, Turkey.

In the summer of 1071, two armies collided, the Byzantine—which consisted and of many foreigners (Frankish, Russians, Pechenegs, Uz, Normans)—and Seljuk led by sultan Alp Arslan (ruled from 1064–1072). The battle was fought in Armenia, near the town Manzikert, which is near Lake Van. It was thought previously that the battle occurred on 19 August 1071, but based on the data of the Byzantine short chronicles, the event was placed a whole week back, on 26 August 1071.

Turkish postage stamp, commemorating the 888th anniversary of the Battle of Manzikert, when Seljuk Sultan Alp Arslan (pictured on a white horse) defeated the Byzantine army.



OTTOMAN EMPIRE

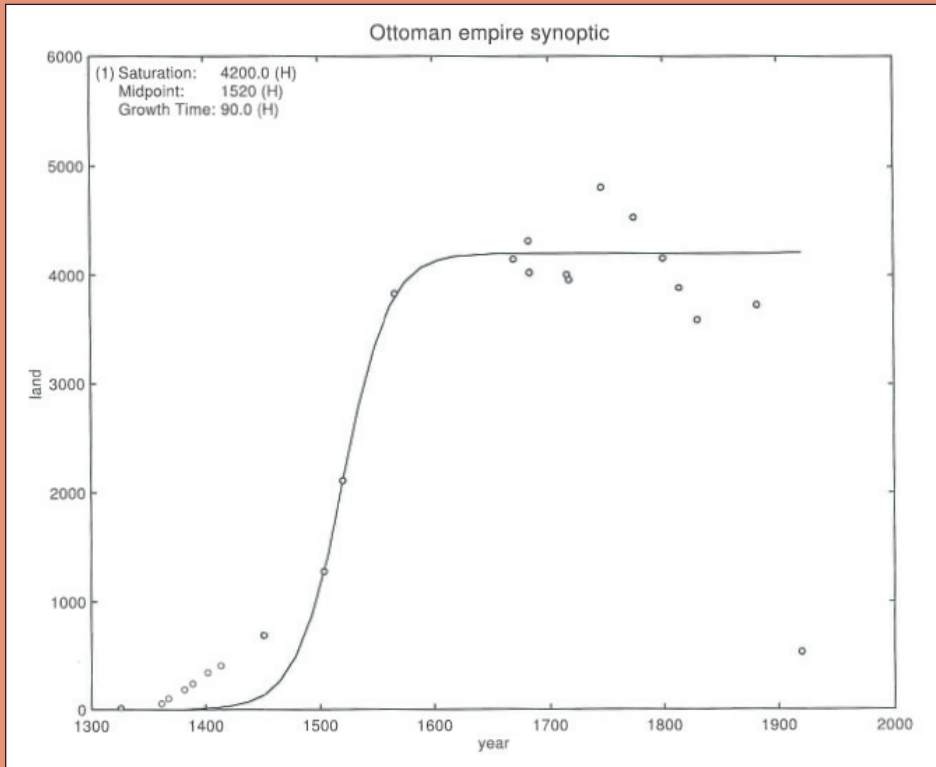


THE OTTOMAN EMPIRE GREW as one of a sequence of Moslem empires centered on the Anatolian peninsula and spreading out from there. With Constantinople as its capital and vast lands around the eastern Mediterranean, the Ottoman empire was, in many respects, an Islamic successor to the Eastern Roman or Byzantine Empire.

Interactions between the Eastern and Western worlds centered on the Ottoman empire for six centuries. Vigorous and aggressive during the period of Suleiman, the empire dreamed explicitly to conquer Europe, and the Ottomans made various starts via the Balkans and Hungary. When they eventually tried to access the Danube causeway to Europe locked by the fortress at

Vienna, they suffered defeat.

In fact, the period of renewed assertiveness came to a calamitous end in May 1683 when Grand Vizier Kara Mustafa Pasha led a huge army to attempt a second Ottoman siege of Vienna. Allied Habsburg, German, and Polish forces spearheaded by the Polish king Jan Sobieski swept away the Ottoman forces. The retreating army was almost destroyed in various battles by the new military star, the Italo-Austrian Prince Eugene of the Savoy family. In the final battle at Zenta, Eugene inflicted approximately 25,000 casualties, including the new Grand Vizier. The alliance pressed the advantage, and 15 years of warfare culminated in the Treaty of Karlowitz (1699), which for the



Jozef Brandt, *Battle Over the Turkish Banner* (circa 1672), 1905.

Ottoman empire trajectory. Turkish scholar Gungor Gunduz independently quantified the growth of the Ottoman and Roman empires and explored whether their durable growth corresponds to the golden ratio.

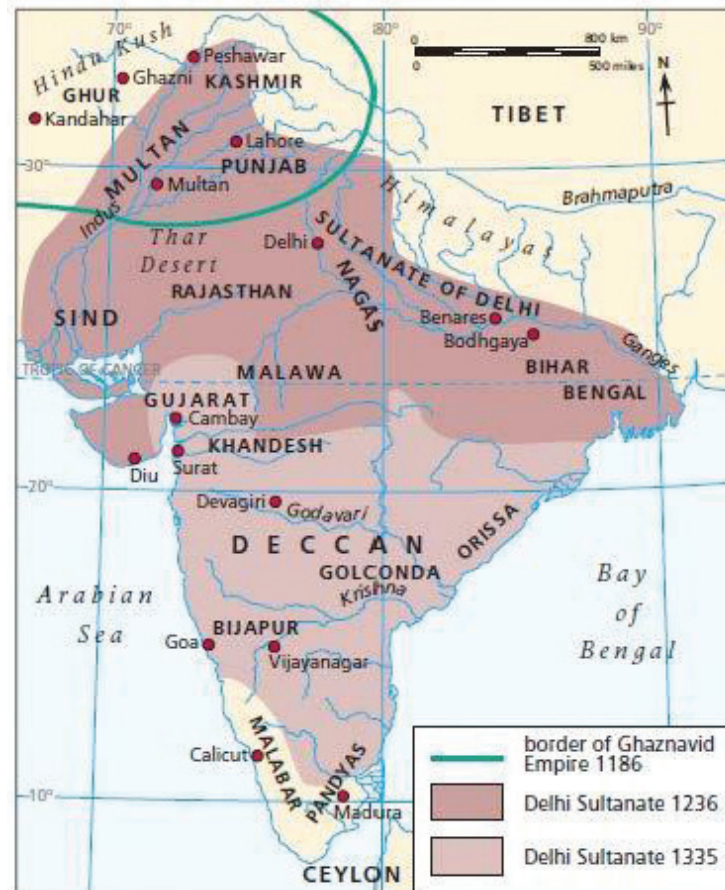
first time saw the Ottoman empire surrender control of significant European territories, including Hungary.

The time constant of the empire's expansion was 90 years, deliberate by the standards of Islamic empires, and the calculated center point of the logistic part of its expansion is 1520, the year that Suleiman the Magnificent initiated his long reign. The saturation size was about 4 million square kilometers, the now familiar number from the Roman empire. The area was almost inevitable, as the speed of transport differed little, and the empire had direct control from Constantinople. After reaching the saturation point, its size oscillated somewhat. Formally, we may interpret the oscillations as efforts

to expand followed by difficulties in control linked to inadequate messenger speed. Historical descriptions offer various causes, but the speed with which to assert authority consistently is subjacent and fundamental.

By 1700 the Ottoman empire had reached the end of its ability to conduct an assertive, expansionist policy against European rivals and was forced from this time on to adopt an essentially defensive strategy. Clever management subdued the internal fighting and instability linked to situations of nongrowth, and the empire persisted for an additional 200 years until an abrupt collapse around 1900.

DELHI EMPIRE

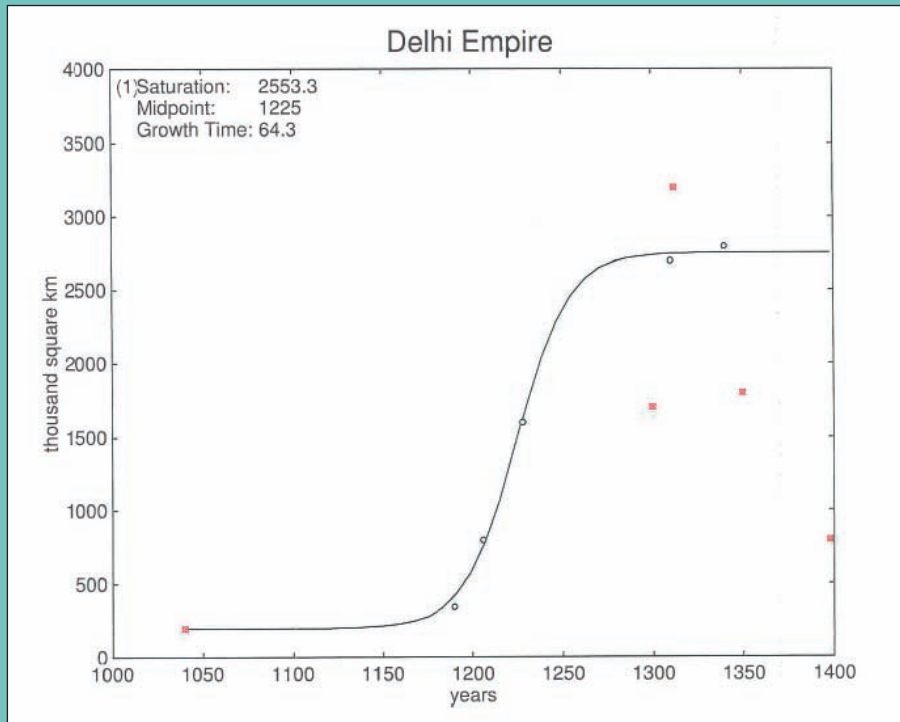


THE SECOND EDITION of Moslem occupation of the Indian subcontinent, the Delhi Sultanate began with an invasion led by Shahabuddin Ghori in 1175. It was expanded by the Mamluk, Aibak, who together with three other Mamluks, inherited part of Ghori's possessions. Albak had testosterone and started fighting to enlarge his territory that at saturation reached 2.5 million square kilometers. As usual with Moslem empires, the

time constant of the logistic is short, only about 60 years.

With a midpoint of growth in 1225 followed by just three generations at large scale, the Delhi Sultanate does not present any particularly remarkable aspects, but it boasted many monumental buildings in brick, some extant still today, in particular mosques, towers, and tombs, as well as elegant gardens. As for many empires, displaced stones are the legacy.

Delhi Empire



Delhi Sultanate trajectory.



Initiated in 1192 in Delhi by Qutb-ud-din Aibak, the first Muslim Sultan of Delhi, the Qutb Minar is the tallest brick minaret in the world. Carved with verses from the Qur'an, it is built on ruins of the citadel of prior Hindu rulers of Delhi.

MOGUL EMPIRE

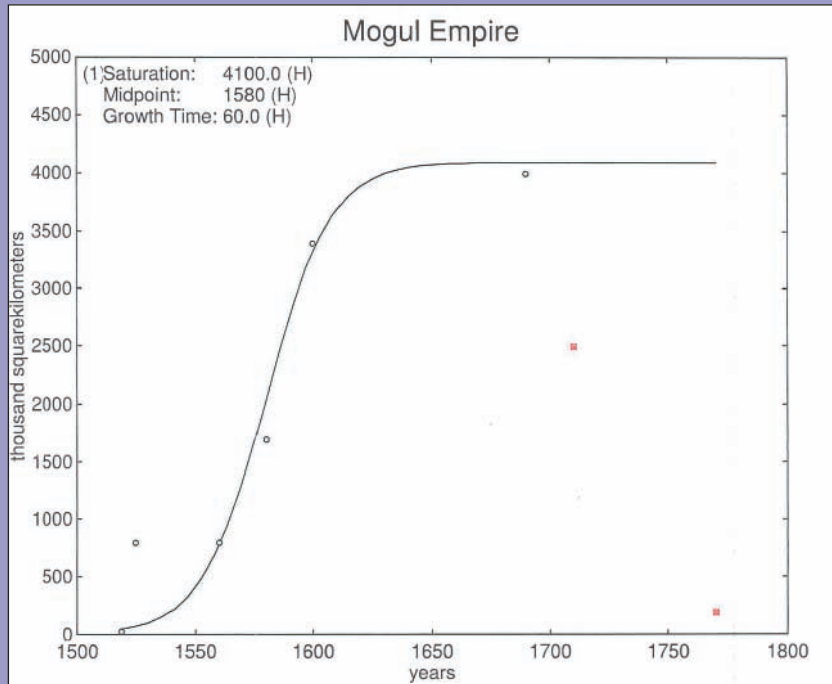


THE MOGULS INTERMINGLED Mongols with Turks, both aggressive. As we will discuss later, the Mongol Genghis Khan played the role of the great stud. Genghis' invasion left some vital bits and pieces of Mongol genetics in Europe and western Asia. He created millions of genetically recognizable descendants. The militant Mogul conqueror Timur or Tamerlane in the 14th century started a conquest that ultimately extended to the whole of northern India, Pakistan, and Afghanistan with the noteworthy exception of the Pashtun populations of Afghanistan that now make life so difficult for the western occupants.

The Mogul empire was culturally alert, fostering arts, architecture, and science. The 16th and 17th centuries saw a fruitful synthesis between Islamic

and Indian astronomy, where Islamic observational techniques and instruments were combined with Hindu computational techniques. The Indian bent for software may be genetic. Inevitably, the empire developed a road system and provided a single currency.

If the genetics were crucially Mongol, the culture was Persian and the religion Moslem. This imparted the empire the characteristic high speed of Moslem conquests, about 60 years, with the midpoint of growth in 1580. Led most famously by Akbar (1556–1605), who is said to have won his eighteenth military victory by age 21 or 22, the empire covered finally 4 million square kilometers, the Roman size, dictated by the speed of horses. The empire lasted at its maximum size about 100 years, time enough to build the Taj Mahal.



Mogul empire trajectory.



Mogul Troops Chase the Armies of Da'ud from an *Akbarnama*, ca. 1596–1600, Manohar (active 1582–ca. 1624). Opaque watercolor, ink and gold on paper. Freer/Sackler Museums of Asian Art, Washington, D.C.

Left facing page: Mughal emperor Shah Jahan built the Taj Mahal, completed around 1653, in memory of his third wife, Mumtaz Mahal.

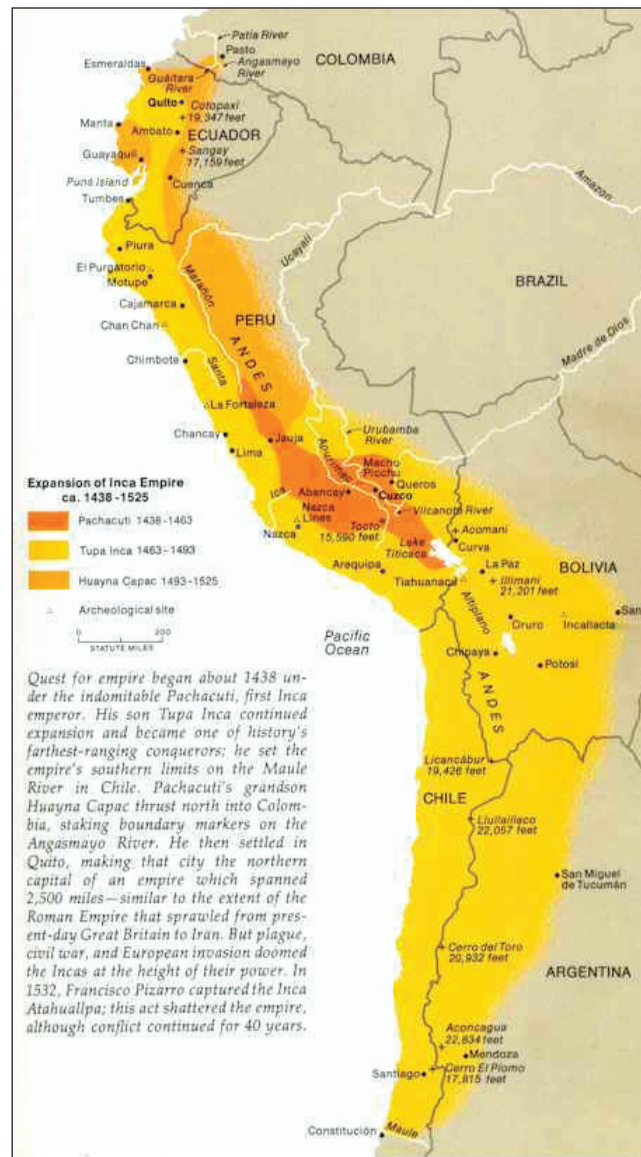
The end came by succession crises and attrition, rather symmetrically with growth. The new invaders, the English East India Company, arrived by sail. During its first century of operation, the Company focused on trade with the Indian subcontinent, as it could not challenge the powerful Moguls, who had granted it trading rights in 1617. In the 18th century, as the Moguls' power declined, the East India Company struggled with its French counterpart, the *Compagnie française des Indes orientales*. The British defeated the French and their Indian allies in 1757, leaving the Company in control of Bengal and establishing it as the major military and political power in India.

INCA EMPIRE

THE FIRST TRACES of the Incas can be dated at about 1250, when they appear to have been shepherds living in the area of Cuzco in the Andean highlands. The explosion of their empire came in 1445 when Inca Yupanqui started subjugating his neighbors. Conquest continued nonstop until the empire saturated at 2 million square kilometers, half the size of the Roman empire.

Attracted by precious metals, the Spaniards got enough of them to upset the economy of Spain and Europe, but the real treasure of the Inca empire was agricultural, especially highly productive plants including potatoes and maize that enriched the offering of staple foods in Europe and spurred its sprint to power.

At the maximum expansion, a message from Cuzco to the farthest place in the empire took just 14 days to reach its target. Lacking horses, the Inca transmitted messages by runners, the chasquis, who could cover 250 kilometers a day running day and night, in relay, aided by stone and rope bridges. The 40,000 km network of roads guaranteeing Inca communication included the Great Inca Road extending about 6,000 kilometers along the spine of the Andes and a 4,000 km coastal



road. Messages were coded in binary numbers represented by knots on a rope and encrypted by a password that the runner memorized and passed on to the next. The coded ropes were assembled in a sort of multifingered whip, the quipu.

The core growth time spanned a mere 25 years, inflecting in 1480. The territory comprised a thin strip along the Andes, mostly at very high altitude. Amidst a chaos of indigenous idioms, the Incas managed to impose their language, an important unifying tool.

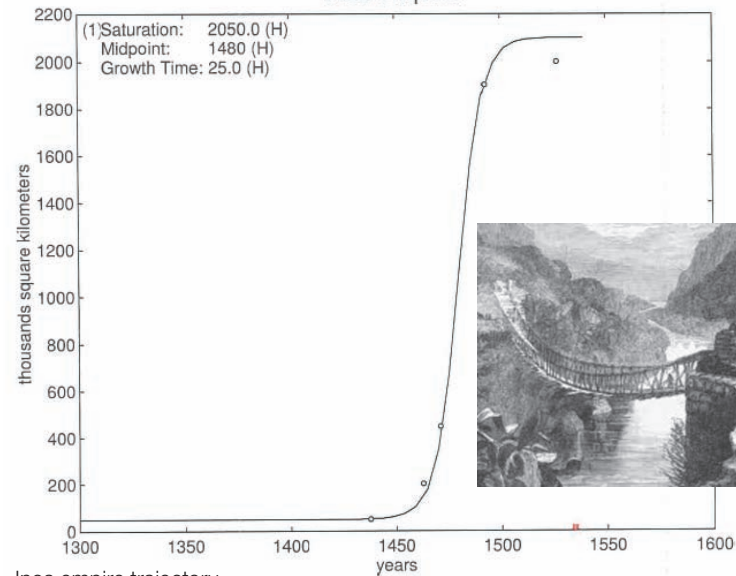
When Conquistador Francisco Pizarro arrived with his few hundred soldiers, the empire's logistic had already reached saturation and was ready to collapse. The usual internal struggles had already begun, well represented by the fact two Incas were fighting for the throne. Atahualpa reportedly ordered that his brother be killed, and he himself was finally killed by Pizarro in 1533. While army discipline excelled, with driving accompaniment of banners and drums, as theorized by Sun-Tzu in 500 BCE in his treatise *On the Art of War*, the ferociously centralized organization was paralyzed. Moreover, the Inca army had poor weapons, as metal was in short supply, and that only bronze. The empire crumbled after resisting here and there in a sort of guerrilla style.



Inca telepresence

Agile and highly-trained runners, the chasquis delivered messages, royal delicacies, and other objects throughout the Inca Empire. They used the vast Inca system of purpose-built roads and rope bridges in the Andes of Peru and Ecuador as well as routes extending into what are now Colombia, Bolivia, Argentina, and Chile. A chasqui carried a trumpet made of conch shell, a quipu to store information, and a qipi rucksack to hold objects for delivery. Working in relay, a chasqui would run from one station or tambo to the next where a rested chasqui waited to carry the message onward. The chasqui system delivered messages from Cuzco to Quito within a week.

Inca empire.



Inca empire trajectory.

Above: Inca bridges, like this one over the Apurimac River sketched by 19th-century American traveler Ephraim George Squiers, survived for centuries after the fall of the empire.

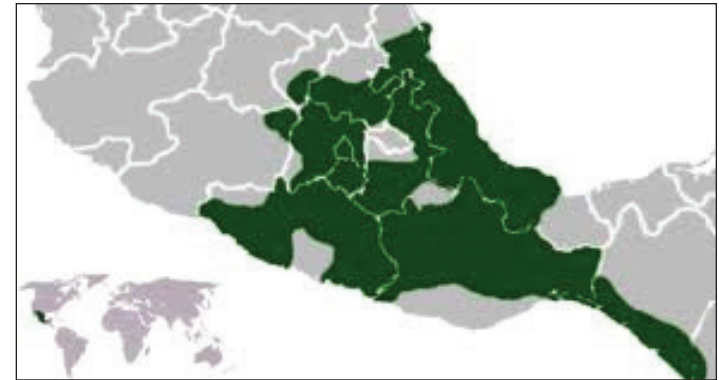
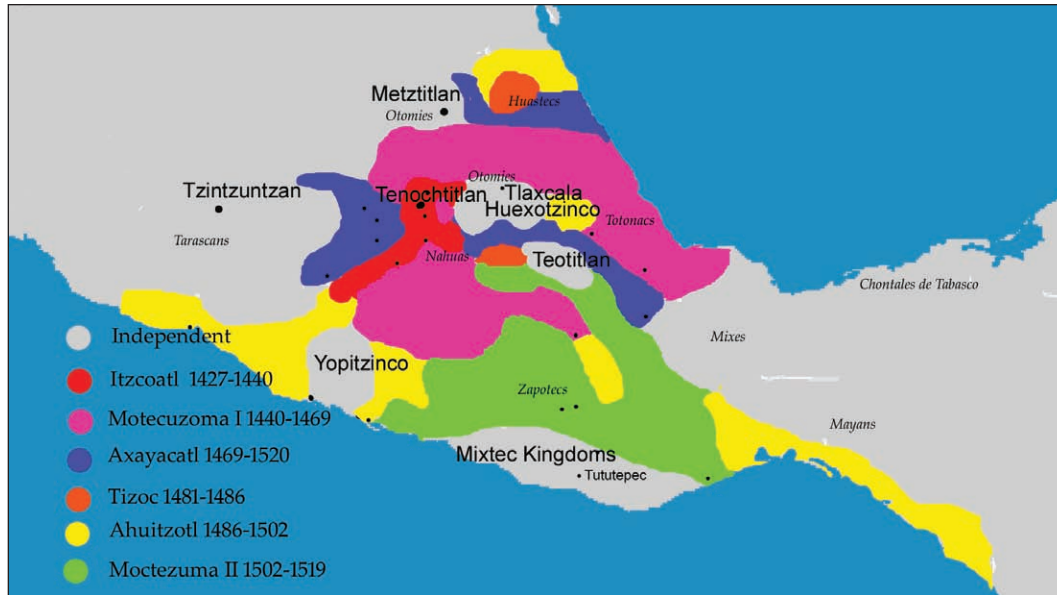


Drawing of the Spaniards executing the last Inca King, Tupac Amaru, in 1572 by Felipe Guaman Poma de Ayala, beginning of the 17th century.



Exterior wall of the Inca fortress of Sacsayhuaman. Photo by Christophe Meneboeuf, 2005.

AZTEC EMPIRE



FROM THE 13TH CENTURY, the Valley of Mexico hosted the core of Aztec culture, the city of Tenochtitlan built on raised islets in Lake Texcoco. The empire built an excellent network of roads used by messengers who carried skins with hieroglyph messages or would communicate memorized messages. Although the Aztecs had messengers running at the same speed as the Inca chasquis, the Aztec messengers ran mostly at night because of the heat.

The Aztec state was based on taxes or tributes paid by the subjugated people who could keep their rulers and administrators provided they remained tranquil, a concept often applied also by the Romans. Unsurprisingly given this arrangement, the Aztecs also maintained an efficient network of spies. Aztec cruelty astonished arriving Europeans, for example, rituals in which hundreds of men were brutally killed and finally eaten. A benevolent interpretation of some anthropologists is that the Aztec diet lacked two important amino acids, lysine and tryptophan, that they obtained from various types

of beans and meat when available. They also had amaranth, whose seeds rich in these two amino acids were consumed following complex rituals presumably underlining its importance.

A more political interpretation is that the Aztecs had to familiarize their population with cruelty, useful in conquering and maintaining empires. The Romans were also extremely cruel and kept the tendency alive with violent spectacles in their arenas. The famously dispassionate historian Edward Gibbon described the spectacles as blood-curdling, and they still capture the Hollywood imagination. Curiously, to most modern eyes the surviving Aztec monuments still exude violence whereas Roman monuments project serene eternal beauty. Montezuma's own subjects stoned him to death, a little prematurely by our calculation of how long the Aztecs might have ruled.

The military attitudes of the core Aztec population became manifest in 1400 with the onset of systematic, gradual conquest of surrounding states extending over 95 years with an inflection year of 1491, a year before Columbus. The dimensions of



Post-Conquest Nahua painting of priests holding a human heart up to the sun, c. 1560.

Aztec Empire



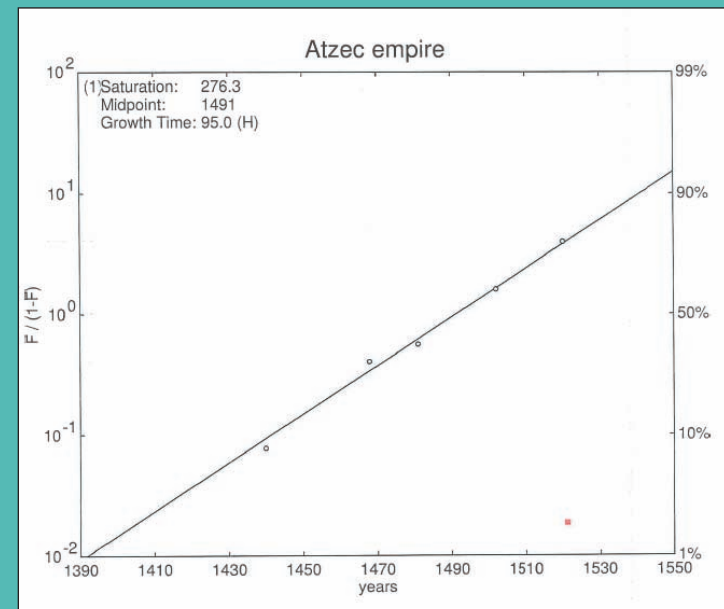
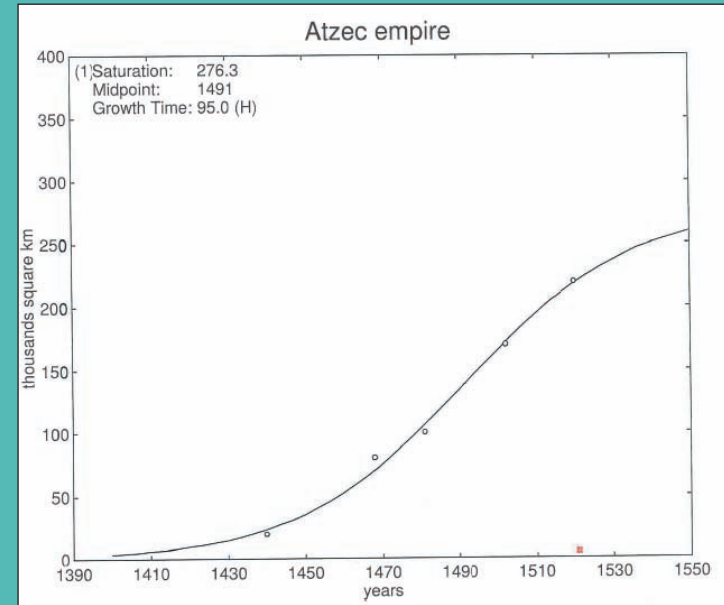
Artist's depiction of the city of Tenochtitlan, capital of the Aztec empire, before its conquest and destruction by the Spaniards. Picture courtesy of MEChA, www.CalStateLA.edu.

the empire finally saturated at about 275,000 square kilometers, a relatively small empire.

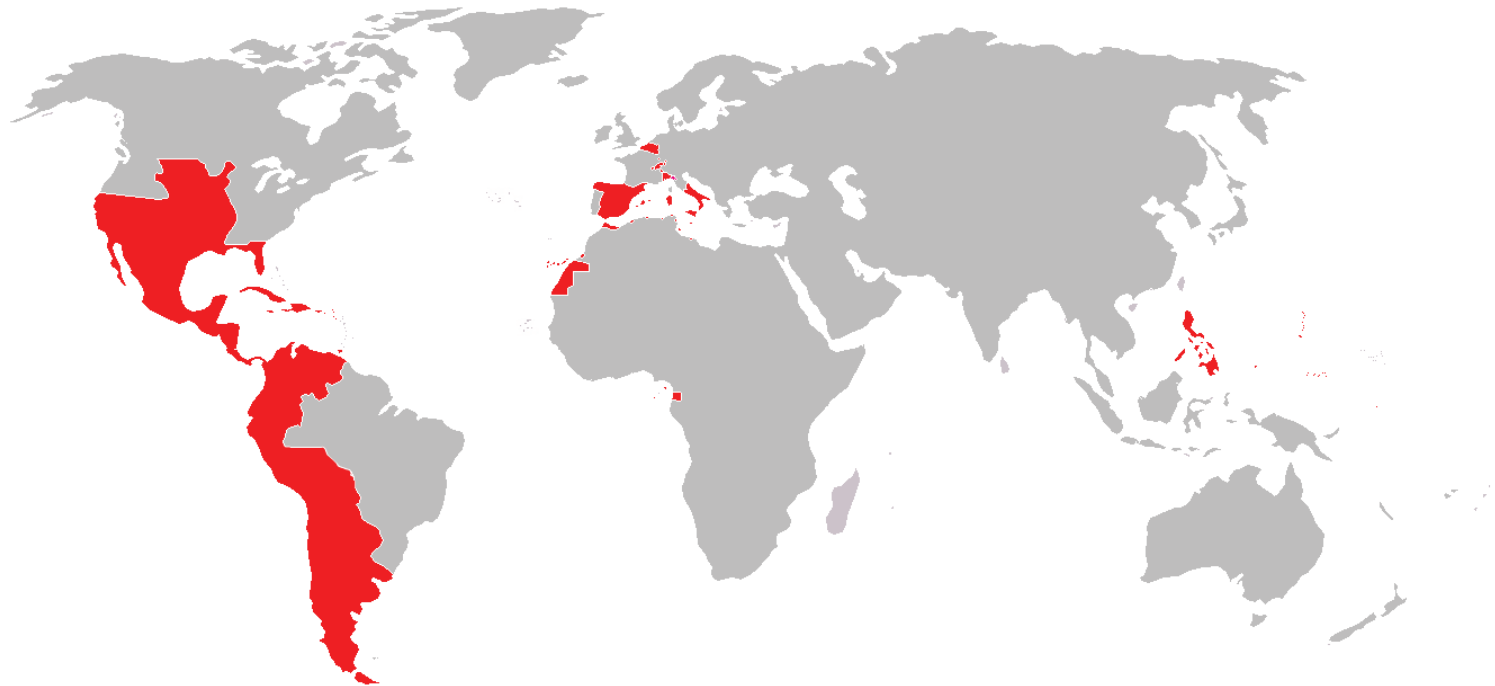
When the Spaniards landed in 1519, Montezuma was informed the next day of the size and shape of the fleet in full details. Curiously, the Spaniards arrived when the empire neared saturation and was ready to crumble, as happened with the Inca empire.



The Storming of the Teocalli, Emanuel Leutze (1848). Cortez and his armored band fight their way back into Tenochtitlan, June 1520, based on the description of William Prescott in *The History of the Conquest of Mexico*.



SPANISH EMPIRE



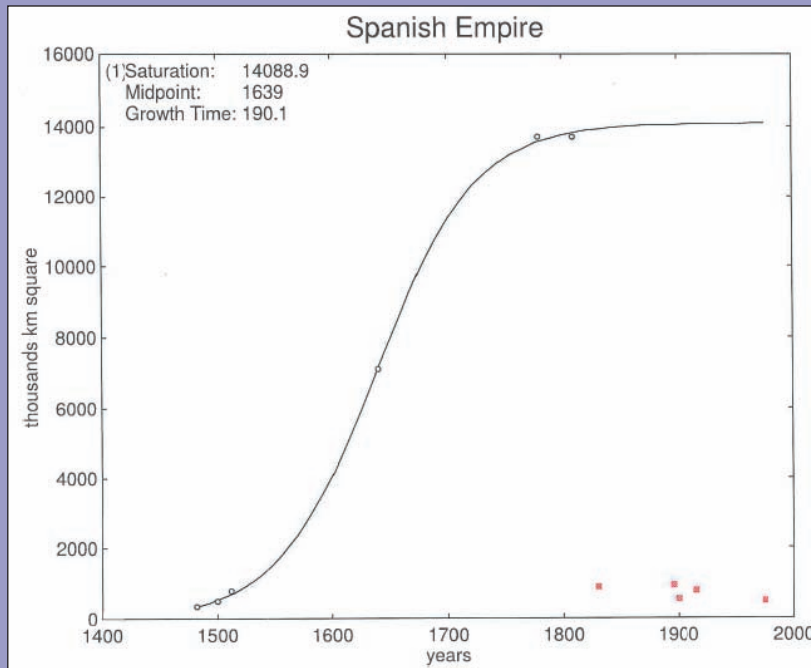
SPAIN GENERATED an exceptionally large structure covering 14 million square kilometers over a couple of centuries by a series of occasional conquests, principally in the Americas.

The Spanish empire included not only American land from Patagonia to California but the Philippines and various islands and other lands around the world, including in Africa. Because the speed of naval connections did not suffice for direct administration from Madrid, local governments were established. Consequently, this political structure stretches our definition of empire. As in the later cases of Portugal and England, it might be better to call it a commonwealth.

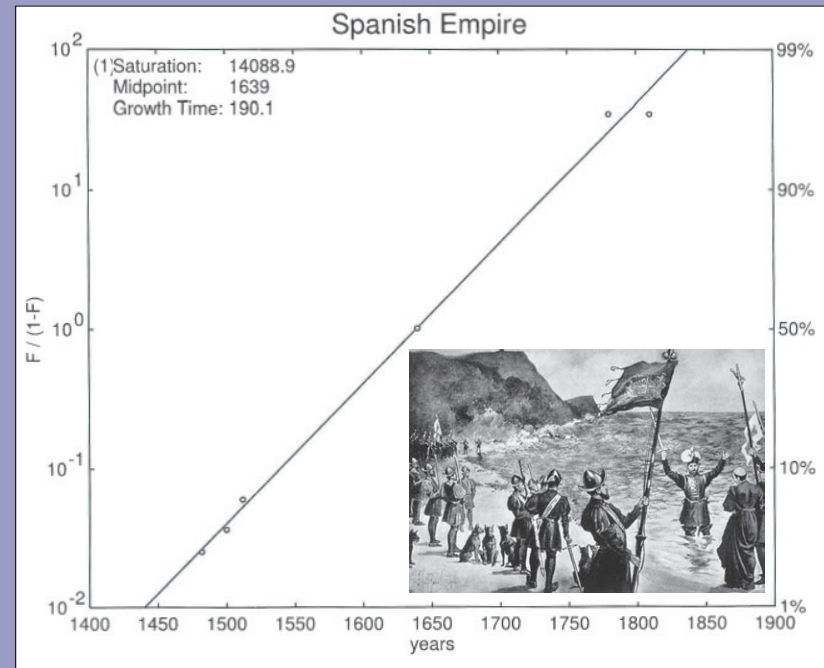
In the case of Spain, in the language of historians, the marriage of the Reyes Catolicos (Ferdinand II of Aragon and Isabella I of Castile) created a

confederation of reigns, each with its own administration, but both formally ruled by a common monarchy. Due to this particular structure, occupation somehow differed from a colonization. Aiming to recreate something in the image of Spain, the aristocracy in power tried to build something civilized, efficient, and aesthetic. This strategy did not impede the destruction of cultures that did not fit the Christian ideals of the time and their cultural artifacts, including books. Spanish laws prohibited slavery and allowed cohabitation and thus biological mixing with the local populations. In the long run, the mixing is helping preserve Spanish genes, in the mestizos, genes now being lost in Spain due to low fertility levels.

Seen in a long time frame, the Spanish empire appears as the rebound of the reconquest or *reconquista* from the Moorish occupation that ended in



Spanish empire trajectory.



Spanish empire Fisher-Pry transform.

1492 with the establishment of a unified Spanish monarchy. The continuation of the spirit of expansion can be inferred from the financing of the expeditions of Christopher Columbus and other adventurers. In fact, Columbus was a safe bet, as he had spent some time in Iceland, where the existence of America had been known for centuries and probably neglected because of the excessive distance from Europe. The inflection point of 1639 came 50 years after the Spanish Armada sailed to invade England.

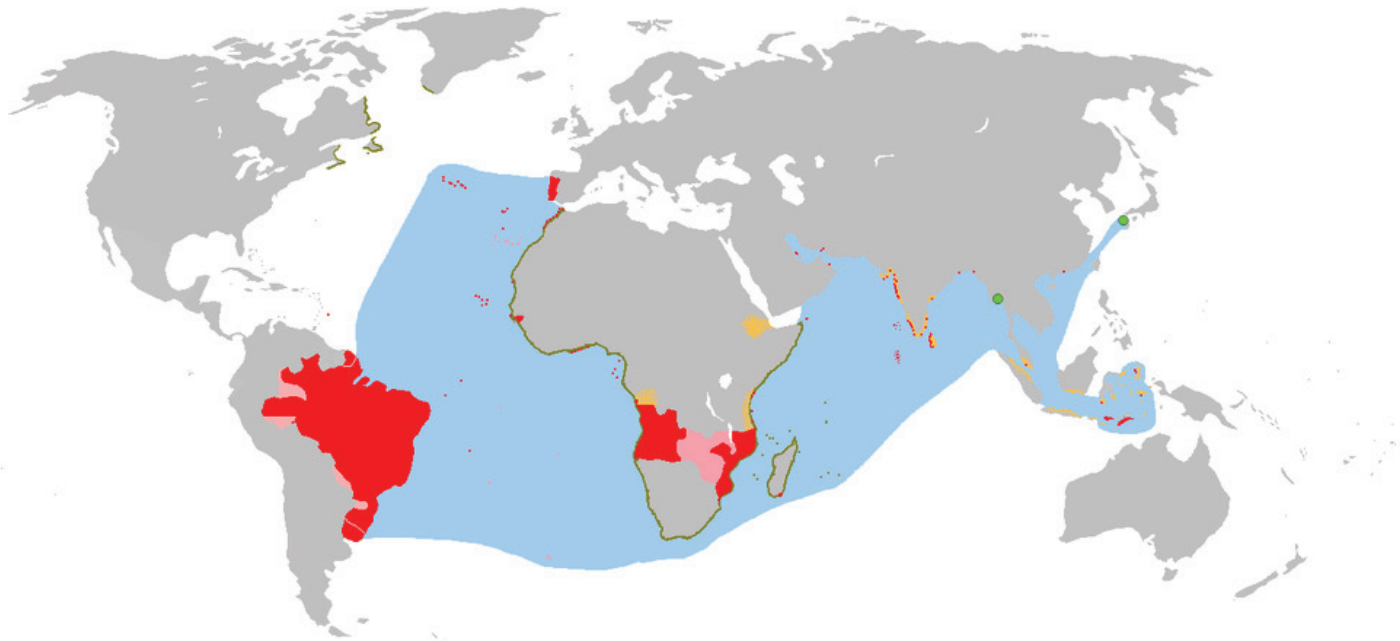
Three hundred years after the Moorish expulsion, the empire was ready to crumble, and did so rapidly when Napoleon's intrusion in European affairs upset the political situation. The confederated colonies had to defend themselves and realized they could also be fully independent. In just a few years the confederation disappeared as such and Spain was reduced to its European territories, a process with many parallels to Portugal and, a century later, to Britain.



Painted by Diego Velazquez in 1634-35, *The Surrender of Breda*, or *The Lances*, celebrates a victory of Philip IV's armies picturing the transfer of the city key that occurred after capitulation of the Netherlands to Spain in 1625 (Museo del Prado, Madrid).

Above: Spanish conquistador Vasco Núñez de Balboa (1475–1519) crossed the Isthmus of Panama in 1513 to become the first European to lead an expedition to reach the Pacific Ocean from the New World.

PORTUGUESE EMPIRE



SINCE THE OUTSET of the reconquista of Iberia, the Portuguese had been active seafarers. In the mid-15th century they developed a high-tech ship, the caravel, superior to all vessels of the time for oceanic navigation because it sailed closer to the wind. Using this new maritime technology, Portuguese navigators could sail anywhere in a profitable amount of time, circumnavigate Africa and establish trade posts in Asia.

The exploration associated with the establishment of bases, sometimes just commercial posts and, when the opportunity presented, with the conquest of territories. Due to the European technical and military superiority, these conquests were relatively easy and sometimes huge, as in the case of Brazil.

Mathematically, Portugal aimed for an empire as large as their more populous Spanish neighbors, and for a couple of hundred years stayed the

course. However, in spite of their navigational skill, sailing speed did not comply with the 14-day travel rule necessary to establish a centrally administered Portuguese empire that extended to South America.

In 1808, Napoleon Bonaparte invaded Portugal, and Prince Regent Dom João ordered transfer of the royal court to Brazil. In 1815 the exiled Lusitians elevated Brazil to the status of Kingdom, the Portuguese state officially becoming the United Kingdom of Portugal, Brazil and the Algarves, and they transferred the capital from Lisbon to Rio de Janeiro, the only example of a European country being ruled from one of its colonies. When Napoleon completed his career, the Portuguese government returned to Lisbon, a grave political mistake. Brazil was still too far away for direct rule but had tasted the glory of empire. The royal family's return to Portugal led to a growing desire for independence among Brazilians, and in 1822 Brazil proclaimed indepen-

Portuguese Empire



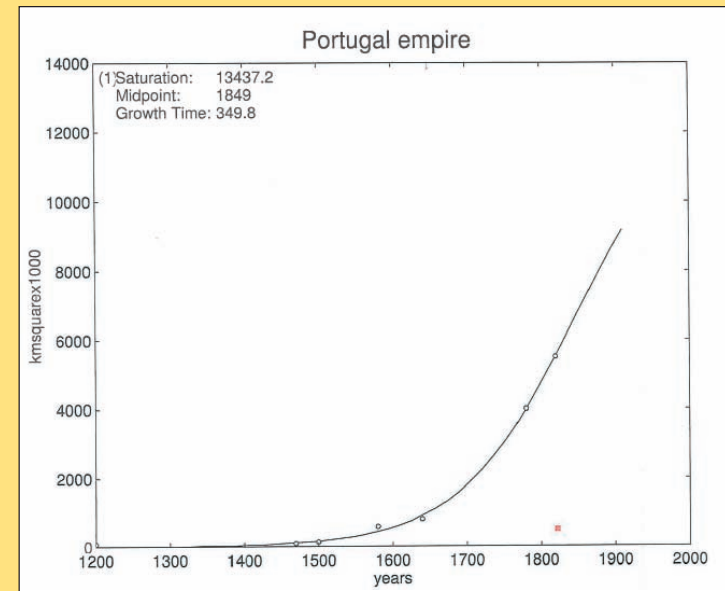
Above: *The Battle of Diu*, 1509 (16th century, Anonymous) fought in the Arabian Sea near the port of Diu, India, and won by the Portuguese over a joint fleet of Mamluks and Arabs boosted growth of the Portuguese Empire and marks the beginning of European colonialism in Asia.



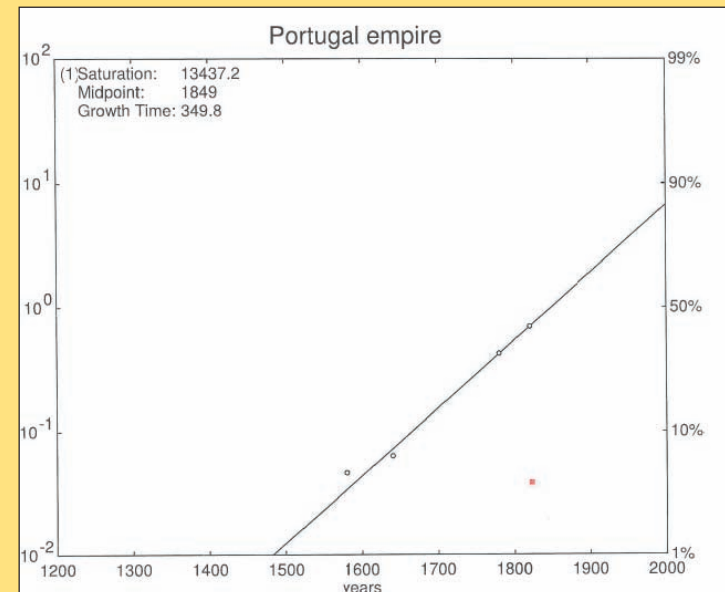
Monument to Prince Henry the Navigator and the Portuguese Age of Discovery, Lisbon. Henry holds a model of a caravel, which enabled the Portuguese to explore and dominate distant oceans during the 15th and 16th centuries.

dence and crowned its own emperor.

The 19th century European colonial outburst brought in other territories, especially in southern Africa, finally in the 1880s two weeks by motor vessel from Lisbon. Viewed as one continuous process, Portugal's empire failed prematurely. Alternately, one might view the history as having two pulses, the larger cut short about 1820, and the second peaking about 1900. Mobility makes and breaks empire.

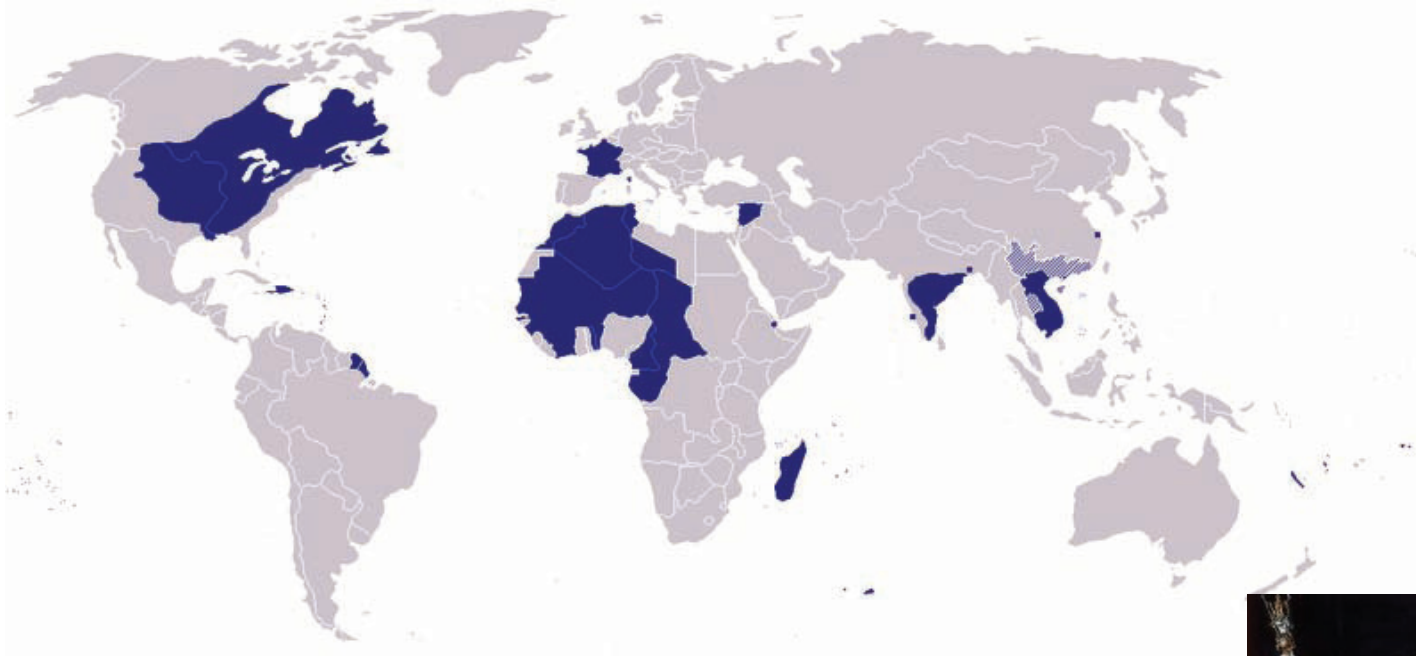


Portuguese empire trajectory.



Portuguese empire Fisher-Pry transform.

FRENCH EMPIRE



A CHARACTERISTIC OF THE COLONIES of France was the large number of French citizens who migrated into them, especially in North Africa. These populations created big problems when finally they were expelled when the colonial territories gained independence after World War II. Altogether the French colonial adventure did not provide the gains France could expect. Our guess is that emulation and testosterone were the prime movers.

For France the largest part of the colonial empire was in Africa, north and west, acquired over about 60 years with a midpoint of 1890. The area grew with an orderliness one might associate with Prussia rather than France. In terms of maximum territory, in 1945 the empire was huge, 11 million square kilometers, comparable to the British Commonwealth.

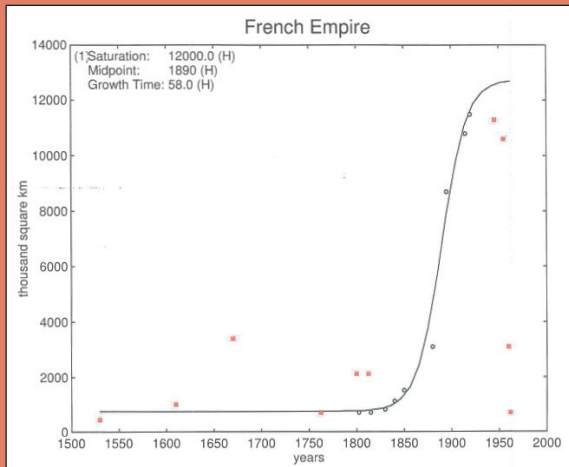
Most of the empire, especially inland, was beyond 14 days travel, even

with steam ships, and consequently local administrations operated in the style of the British Commonwealth, but with more assimilation in the spirit of the French revolution. Local chiefs administered the territories, with hierarchical organization ending in a Minister of Colonies with finally tenuous influence on the local chieftains. Many areas remained poor and rebellious. As in many cases, the empire collapsed abruptly: What took about 60 years to build crumbled in about a decade.

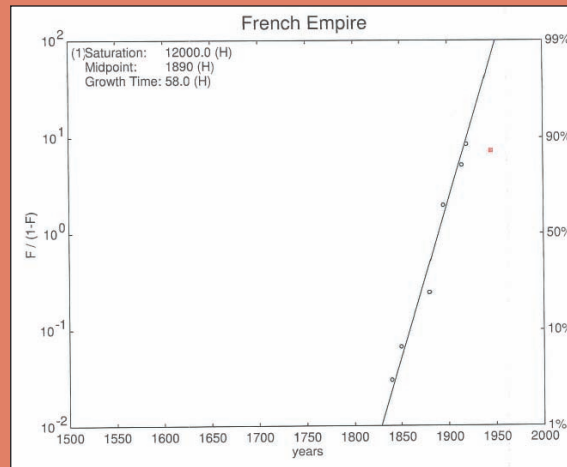


Napoleon I of France on his Imperial Throne in his coronation costume painted in 1806 by Jean Auguste Dominique Ingres (Musée de l'Armée, Hôtel des Invalides, Paris).

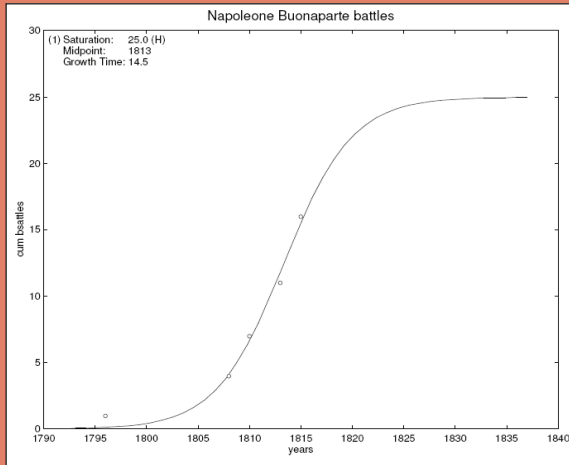
French Empire



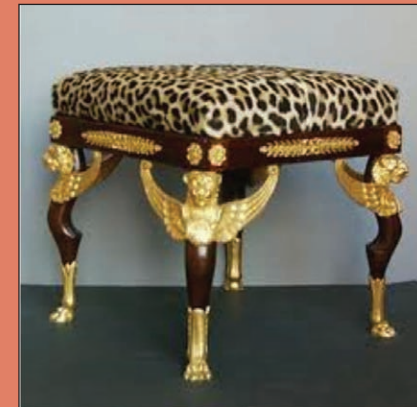
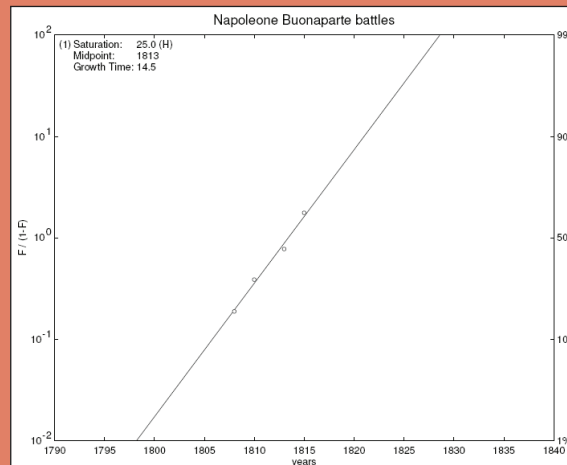
French empire trajectory.



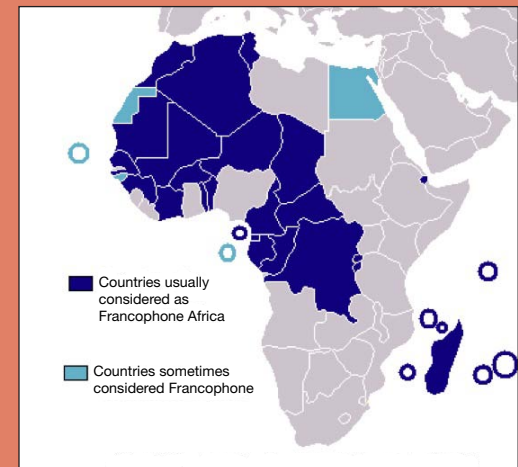
French empire Fisher-Pry transform.



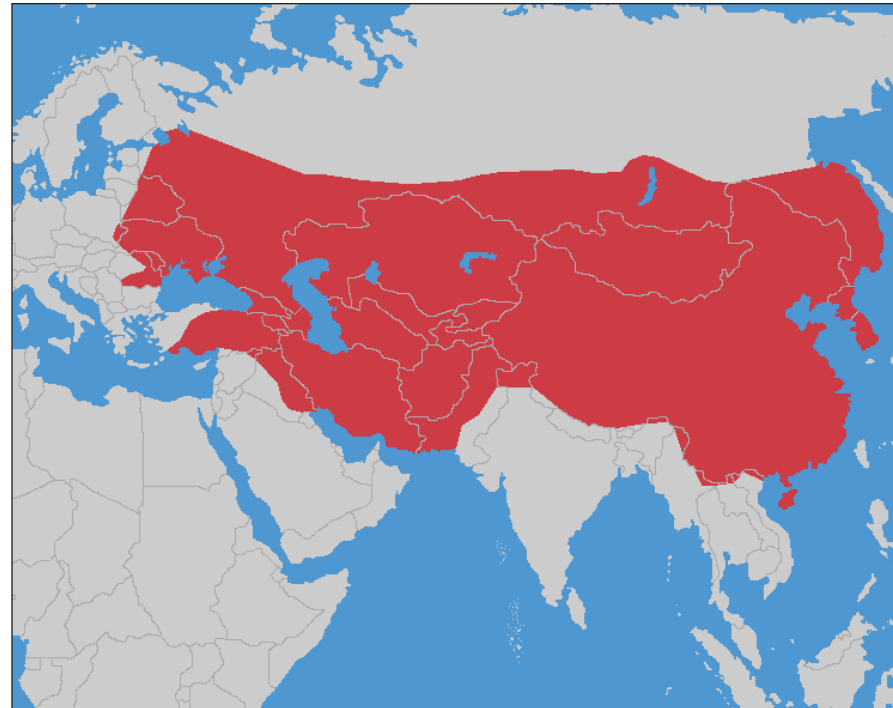
Napoleon's career, cumulative battles. In the top charts we see that about 1800 Napoleon initiated but could not sustain a French empire. When we look at Napoleon's career as a general, we see he performed according to script. The battles of his campaigns form a good logistic curve. His testosterone was not exhausted in 1815 at the time of his exile to St. Helena, but all he could dictate was his memoirs.



A French Second Empire gilt bronze and mahogany stool with Somali leopard fur cushion, circa 1850-1860, from the firm Jacob-Desmalter.



MONGOL-HUAN EMPIRE



Mongol-Huan empire, 1279.



The Genghis Khan monument near Ulan Bator, capital of Mongolia.

WHEN GENGHIS KHAN (1162? –1227) started his conquest around 1200, every soldier had a reserve of 23 horses. Nobody could resist the strength of the superb mounted army and the ability of the commander. The basic diktat was to destroy, and large swaths of Eurasia were definitively destroyed, all citizens killed, and cities burned. This may be interpreted as Genghis' super-testosterone drive leading to super-aggressiveness to the point of cruelty. Genghis reportedly had a harem of 2,000 girls, and his Y gene can be found in millions of males in the areas he conquered.

Genghis' uninterrupted series of victories finally ended at a battle in the valley of Armageddon against the Mameluks, the Turkish professional slave soldiers. The first logistic of the Mongols and their Chinese branch, the Huan (or Yuan) saturates in about 30 years at the mammoth size of 16 million

square kilometers, four times the area of the Roman empire. The problem was to sustain the single rule. Such an empire spanned too much distance to cover in 14 days even with the finest horses. Consequently, it split into four smaller divisions, each the size of the Roman empire. Inevitably they started to fight among themselves, and fragmented further.

When Genghis conquered Beijing, he found it interesting for a capital. Curiously, Beijing increased in size to 5 km x 10 km at a time when no other city had ever exceeded the dimension a person could walk in one hour, 5 kilometers. In fact Beijing formed a rectangle composed of two square cities, adjacent but separated by a sort of external wall with guards and few doors. Han Chinese inhabited one city and Mongols the other, each group keeping its languages and customs. This pattern would often define the Chinese em-

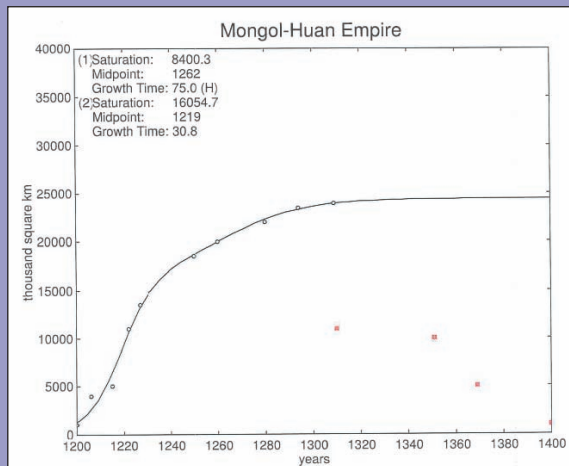
pire, composed of subject groups that conserved various degrees of autonomy.

Genghis' grandson Kublai Khan (1215–1294) built a magnificent palace complex for himself, the Forbidden City, in Beijing. Containing elements of Arabic, western Asian, and Chinese architectural styles, it also contained a vast area of Mongolian nomadic tents and a playing field for Mongolian horsemanship. Kublai earned his place as formal initiator of the Mongol-Huan dynasty by building special relays for high officials as well as ordinary relays and hostels. During the reign of Kublai, the communication system consisted of some 1,400 postal stations, which used 50,000 horses, 8,400 oxen, 6,700 mules, 4,000 carts, and 6,000 boats. The Yam, a system of relay stations maintained by the Mongol army, extended from Eastern Europe to the Pacific, separated by an average day's journey on horse. In parts of Manchuria and southern Siberia, the Mongols used dogsled relays for the Yam. The Mongol riders regularly covered 200 kilometers a day, faster than the fastest record set by the Pony Express in the American West some 600 years later.

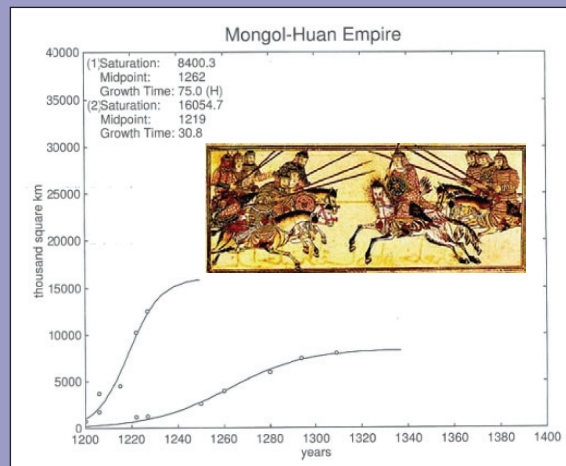
A crucial structure within the empire was the efficient postal system that

in a couple of weeks could reach any locale with precisely set timing written on the envelopes. Any delay led to investigation into the causes, and the culprit was fined up to one year of salary. Chinese wisdom, efficiency, and cruelty worked.

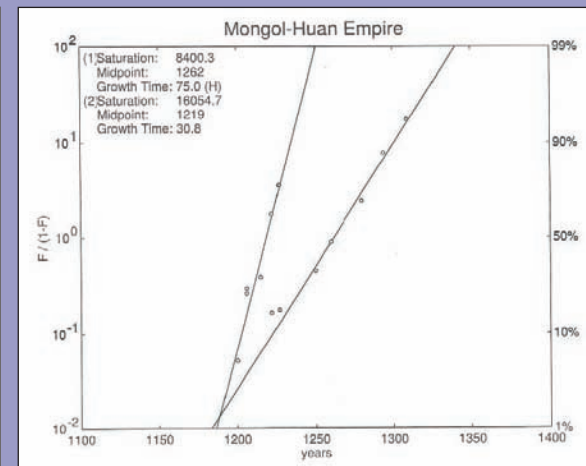
The official date of the fall of the dynasty is 1368. Later Huan emperors could not stop the slide into powerlessness. On the one hand, the Beijing Khans lost legitimacy among the Mongols still in Mongolia, who thought they had become too Chinese; on the other hand, the Chinese never accepted the Huan as a legitimate dynasty, but regarded them as bandits, or at best an occupying army who failed to learn Chinese and integrate themselves into Chinese culture. Officials attributed the downfall to nature, as the Yellow River changed course and flooded irrigation canals and so brought on massive famine in the 1340s. However, we would say the context was ripe for the testosterone peasant, monk, and bandit Chu Huan-Chang, who led a rebel army that took Beijing in 1368 and declared himself the founder of a new dynasty: the Ming (1369–1644).



Mongol-Huan empire trajectory.



Analytically, the Mongol-Huan empire reveals itself as a pair of superposed pulses, the first initiated about 1200 and lasting about 30 years and the second initiated about 1230 and lasting about 75 years. Mongol-Huan I, identified with Genghis, overrode East Europe and West Asia, while Mongol-Huan II, identified with Kublai, remained East Asian. Together, they form the shortest lived of the major Chinese dynasties. As the charts show, less than a century separates the surge about 1220 from the first collapse about 1310.



MANCHU-QING-PRC EMPIRE



The Kangxi Emperor (1654–1722), the fourth emperor of the Manchu-Qing Dynasty, was the first Manchu born on Chinese soil south of Beijing. Ascending the throne at the age of seven, he ruled for 61 years, the longest reign in Chinese history. He suppressed internal revolts, blocked Tsarist Russia on the Amur River, and expanded his empire in the northwest.

CHINESE EMPIRES have tended to cover the entire continent or region, so forces to topple them have come from internal revolution with a couple of exceptions. Genghis Khan came from outside, carried by the immense vigor of the newly united Mongol tribes. He was finally entangled in the complex and very evolved structures created by the Hans, such that the empire he established actually had a double body as we have seen, with a double logistic growth and a double capital, evocative of the famous double head of European imperial eagles.

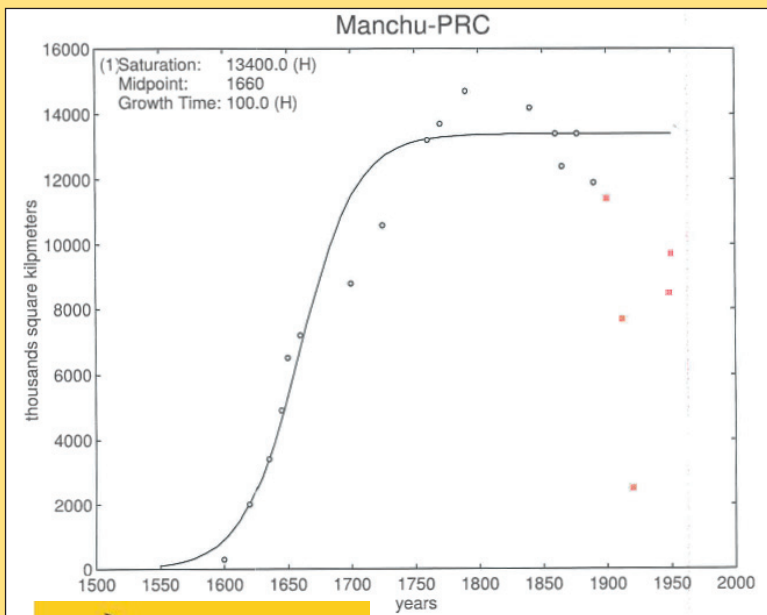
The Manchus were a population living in northern China near the Great Wall, and thus linked biologically and culturally to the Mongols of Genghis. At the beginning of the 1700s, the Ming dynasty, centered on the Han populations, had been brilliant for centuries, but was succumbing to the internal instabilities characteristic of empires sometime after they have reached saturation. Peasants revolted and fiefdoms quarreled, problems that the central government had to settle. When the pressure of authority starts to wane, newcomers try their wits.

Manchu-Qing-PRC Empire

A Manchu leader Nurhaci, originally a vassal of the Ming, in 1582 initiated an intertribal campaign to reunify the Jurchen tribes that finally involved him in the internal squabbles of the empire. Mostly victorious, he kept expanding into the Ming realm with the essential contribution of the Mongol cavalry as his ally. Nurhaci was actually defeated in 1626 by a Ming army equipped with modern Portuguese cannons, and died. His son was defeated in 1627 by the same Ming general, but the son had learned the lesson, and his reorganized army had no truly valid competitors. Seen from a distance, a weakening authority was substituted by a vigorous new one. The immensity and complexity of the imperial organization had to be taken wholesale and

the numerical superiority of the Hans accepted. In a sense the Qing were a refreshed version of the Ming. It took the Manchus 100 years to restore the full empire of more than 13 million square kilometers, manageable only with the superb infrastructure they inherited.

We follow Taagepera in referring to the empire as the Manchu-PRC because in the chart the collapse around 1920 appears as an aberration. The present area of the People's Republic of China remains about 9.6 million square kilometers, so the empire may "feel" too small. Inclusion of Mongolia and some of the Russian Far East would restore it to full dimensions.



Manchu-Qing-PRC empire trajectory.



Traditional flag of the Qing Dynasty.

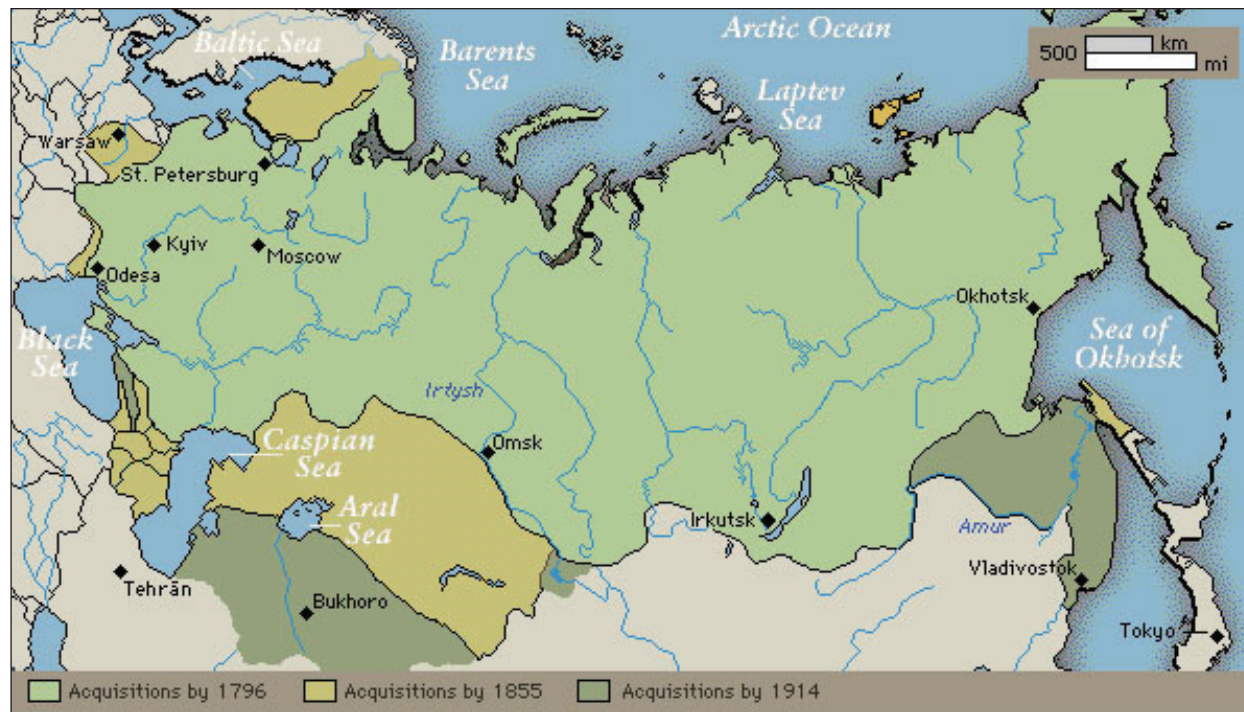


Above: Qing Dynasty cavalryman with lance, quiver, and musket, by Giuseppe Castiglione (Milan 1688 – Peking 1766) painter at the court of the Emperor Qianlong.



Statue of the youthful Mao Zedong at Changsha, capital of Hunan. Mao ruled the PRC between 1949 and 1976.

RUSSIAN EMPIRE



THE VAST AND FERTILE PLAINS of today's Russia have hosted a series of populations, agricultural and nomadic or invaders like the Mongols. A self-consistent history begins with the Czars, who provided political continuity from the middle of the 15th century, systematically expanding the territories under their rule, in tune with the definition of a vital empire. The growth of these territories has been gradual, with a time constant of 220 years, but the final size was huge, 17 million square kilometers. Most of the land, however, depended only nominally on the central ruler, as the 14-day feedback control was absent because of the immense distances lacking appropriate infrastructure.

Russia is now a power in search of a role. It is too large to join Europe and too small to play an imperial role. Furthermore, a low birthrate saps Rus-

sia, like Europe, by diverting the energy of the system toward maintenance of an increasingly large percentage of nonproductive persons.

After the Russo-Japanese war of the early 20th century, the Czar then made the right decision. He ordered acceleration of the construction of the trans-Siberian military railway that would finally link Moscow to Vladivostok in just 14 days of travel time, not only to carry orders from the center like the Persian horsemen so admired by Herodotus, but also to transport military forces. Incidentally, the cost of the railway that penetrated the Siberian wilderness approximated that borne by Russia in military support during World War I.

The stimulus to comply came from the emergence of Japan as a military power. At the end of 19th century, having absorbed western technology,

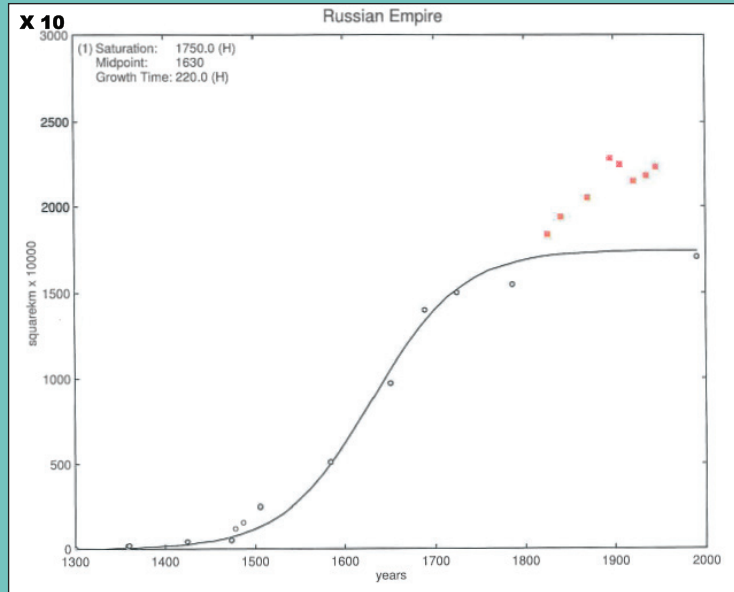
Russian Empire

Japan started rattling the sabre and menacing Russia's eastern territories by conquering big chunks of nearby Korea and China. The Czarist army reacted as well as possible but the Japanese kept gaining territories, in particular Port Arthur, considered strategic because it operated year-round. Russia sent the large Baltic fleet in the Japan seas to tame the newcomer, but the fleet was mostly sunk in the Tsushima battle by this new entry in the world political and military scene.

The Czars started as rulers of the Moscow area and proudly declared Moscow as the third Rome and the seat of the Russian Orthodox Church. Indeed, after Ivan III's marriage in 1472 to Sophia Palaiogina, the niece of the last Byzantine emperor, the Moscow court adopted Byzantine terms, rituals,



Trans-Siberian railroad.



Russian empire trajectory.



Ivan the Terrible built Saint Basil's Cathedral in Moscow between 1555 and 1561 to commemorate the capture of Kazan and Astrakhan, early in the logistic of the growth of the Russian empire.

titles, and emblems, including the double-headed eagle, which survives on the Russian coat of arms. Muscovy's conquests grew unabated, according to the logistic that marks the destiny of an empire. In 1800 the logistic of Russian territory had reached its natural saturation, but the Czars, now emperors, still had much energy and aggressiveness. The expansion continued with such vigor that even the sale of Alaska to the United States in 1867 made no dent in the bubbling overgrowth of the Russian territory. One has to wait for Gorbachev for the downloading of the extras. Gorbachev trimmed Russian size precisely to the saturation value of the imperial logistic as defined by the 300 years of Czarist conquest.

BRITISH EMPIRE



ACCORDING TO OUR DEFINITIONS, Britain did not run an empire but was dominant in an association of countries or regions linked to Britain in a sort of league appropriately named the British Commonwealth. The communication gap was acutely felt, and the remedy was put into action as soon as technology provided it. From 1850 the telegraph connected more and more members, and finally in 1902 a single network of telegraph cables, the so-called All Red Line, linked the entire Commonwealth. The integration came too late. The two world wars, beginning in 1914 and ending in 1945, brought on the final breakup of the Commonwealth and the substitution of the USA as the predominant world power.

The British empire had all the characteristics of a solid construction.

Like the Roman empire, it grew slowly, had a robust administration, and patriotic drive. However, it had a basic flaw: it grew to a size ten times that of the Roman empire, with territories in various parts of the world and speeds of transportation not much faster than those of Rome. Britain put in place a number of rules to preserve its dominant position notwithstanding the time lags in the chain of command. Nonetheless, the administration had to split geographically and risk the dangers implicit in appointment of Viceroys and other forms of aggregation much weaker than a centralized command.

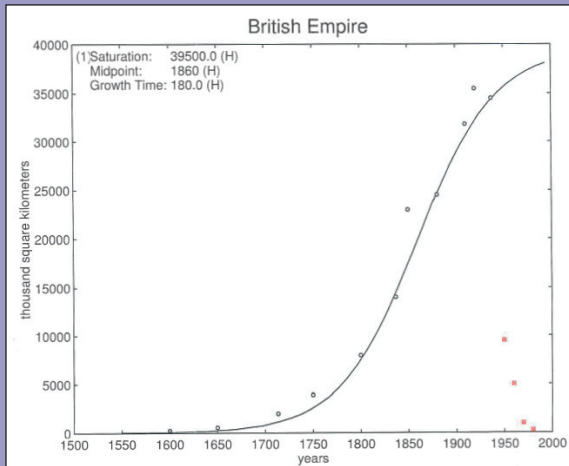
The naval fleet formed the backbone of British power, and the analysis of its evolution casts light on the internal pulse of the empire. A treasure trove of data in the Admiralty was unearthed by the research of an American

historian, George Modelski (alone and with Thompson). He prepared a list of the British battleships from 1480 on, the so-called men of war, by birth and death so that we know the constitution of the fleet at any time. The number goes up and down presumably owing to the extreme cost, but for long-term analysis one can use the cumulative number per year or cumulative cost. The result is a line that can be interpreted as a sum of seven logistic equations (see

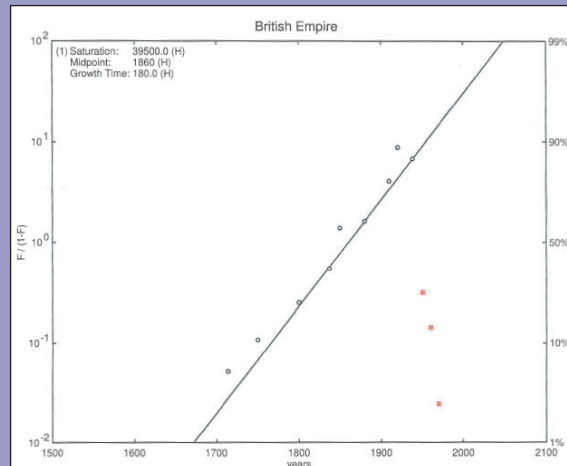
the chart of British warships, below).

The search for a general outline of the history of the British fleet succeeded when the saturation levels of the various curves, i.e., the total number of ship-years in the curve, were put on the center date, the inflection point, of each curve. A logistic fitting of the seven center points loaded with the respective ship-years provides a single logistic that covers the 500 years (from

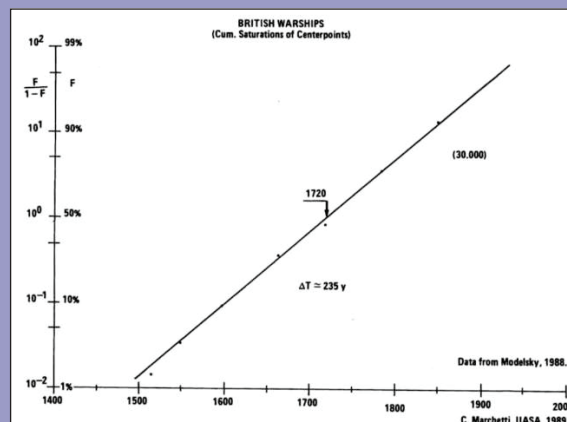
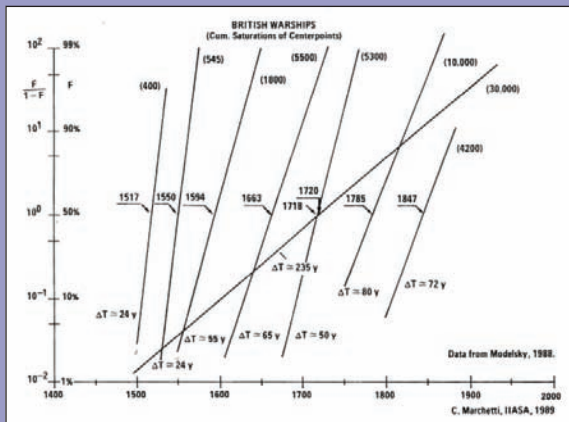
1% of the process to 99%) and fits snugly. The midpoint of the British Navy from this perspective was about 1720, when the Royal Marines beheaded Blackbeard, the most infamous pirate of the Caribbean. More remarkably, the logistic saturates around 1940–1950, a good date for defining the end of British naval dominance and the empire based on this dominance. This point could have been calculated 100 years before and betrays the undercover automatic mechanisms of human affairs. It also underlines the potential the mechanisms provide for long-term forecasting when appropriate observations are recorded.



British empire trajectory.

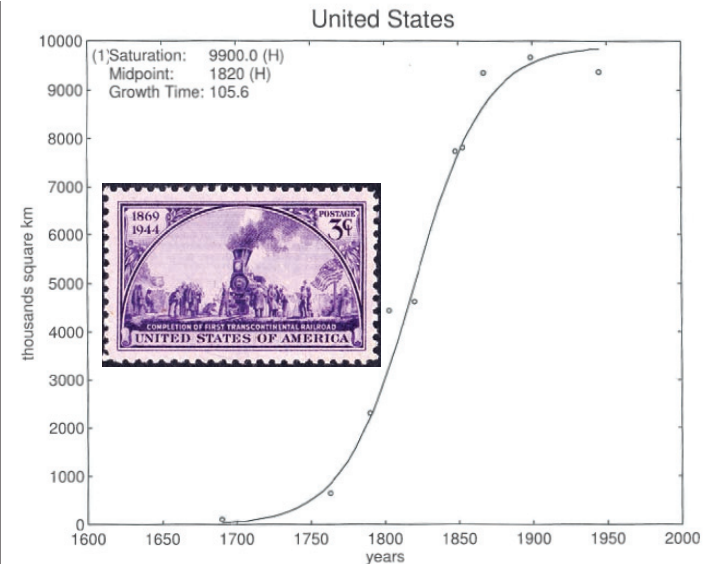


British empire Fisher-Pry transform.



Britain successfully deployed its navy in the Mediterranean for the first time in the Battle of Cape Passaro, off Sicily, 11 August 1718, defeating a Spanish fleet (painting by Richard Paton [1717–1791], National Maritime Museum, Greenwich).

USA EMPIRE



USA empire trajectory. Inset: Historians often link formation of the U.S. with railroads, which joined the coasts in 1869. According to Droege (1912, 1916), the inclusive speed of a freight train at the time of World War I averaged 12 miles per hour and a passenger train 20 mph. Thus, freight took about 10 days to cross the U.S. and a passenger a week. In 1860 the horses of the Pony Express also delivered mail between the Atlantic and Pacific in 10 days.

WHEN THE EUROPEANS arrived in North America, it was already settled by an indigenous population, not dense but numerous enough to fill the territory and ready to defend it. From the very beginning, penetration of the USA empire involved entry into hostile territory. A key idea for occupying a hostile region with a limited force was the fort, the equivalent of the medieval castle, with a military garrison inside and a fortified wall of defense. The idea succeeded in keeping the Indians in check and protecting the penetration of European populations. When the United States started vigorously expanding outside North America in the 1940s, this basic idea remained the same. The forts became military bases with similar functions. For reasons unrelated to military conquest, certain territories that

came under the control of the USA, for example, the Philippines, were eventually given their independence, although they permitted establishment of USA bases on their territory or nearby.

We first look at the USA in our now familiar way, growing as an S-curve within North America, and the fit is beautiful, with a midpoint of 1820, growth time of 105 years, and saturation around 10,000 square kilometers, sustainable with the intercontinental railroads that diffused throughout the territory.

Instead of taking territory as proxy of USA global imperial expansion, we use here the number of military bases, or forts, publicly reported by the U.S. Department of Defense. The overall S-curve in the left panel is most ac-

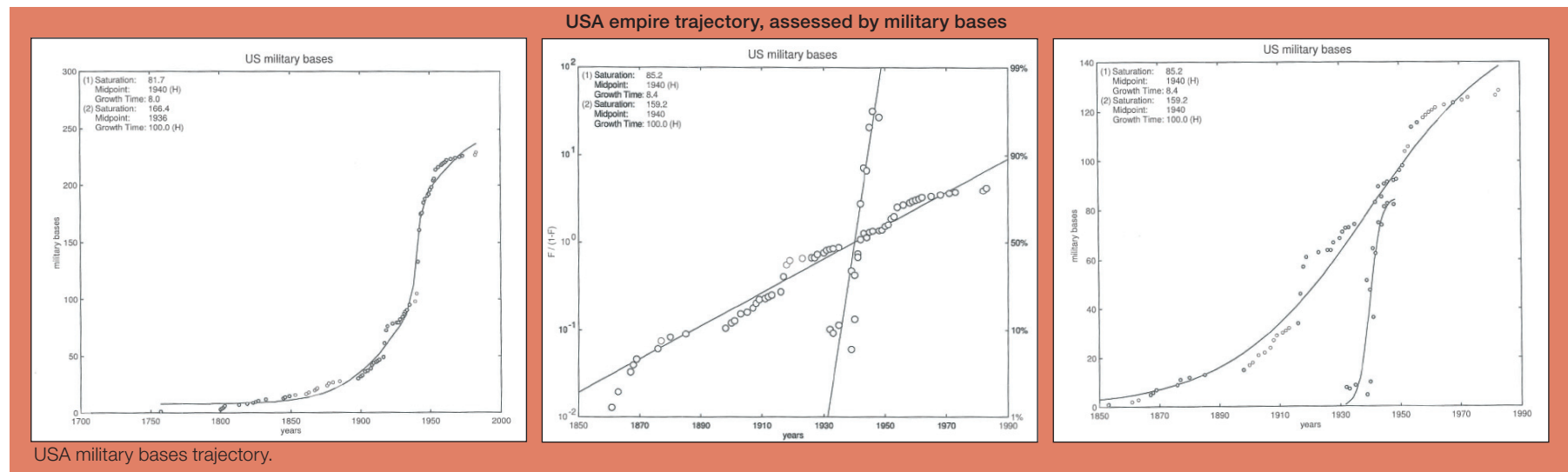
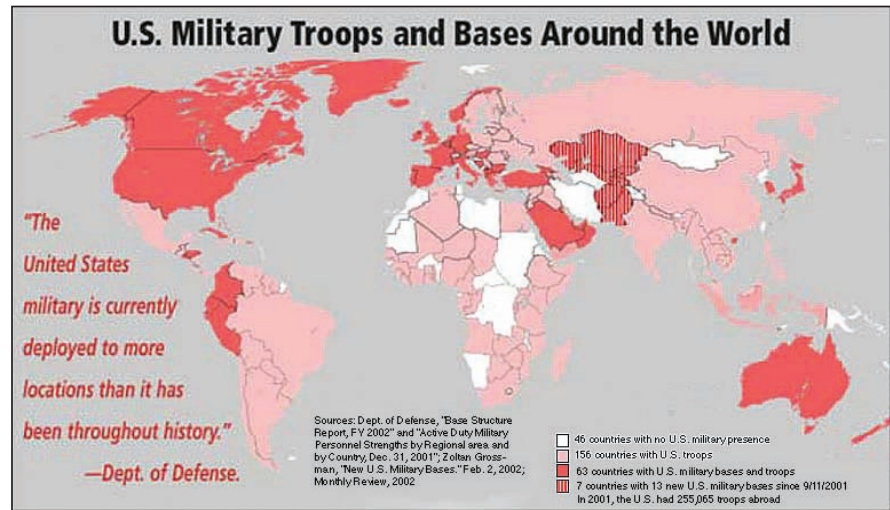
curately viewed as the sum of two logistics shown in the right panels in both basic fashion and linear transform. The first logistic has a time constant of 140 years and involves 150 bases, while the second is an 8-year flash involving 85 bases. Both have the year 1940 as midpoint.

The explosion in the number of bases starting from 1930 clearly indicates that the USA was taking seriously the task of becoming world political power number 1, and it fought World War II with no holds barred, just as a future dominating power should. The flex in 1940 signals maximum power drive, not incidentally coincident for the two logistics.

Top powers always dream of becoming number 1. According to a theory of long cycles in world history, associated with the Russian economist Nikolai Kondratiev and described by Modelski (alone and with Thompson), basically every 50–55 years contenders struggle, more or less directly and violently, for the crown. Britain, number 1 at the beginning of World War I, was already declining, but still number 1 at the end of that war. Although Britain favored the USA as successor, USA readiness was not 100%, and the war ended without a clear candidate for the succession. We interpret the intricate events taking place between the two world wars as a long truce to gain energy for the decisive run at the conclusion of World War II. As Winston Churchill and some others have done, the entire period 1914–1945 could be more precisely described as a single 30-year war.



During World War II American factories manufactured B-24 bombers around-the-clock. American sociologist Hornell Hart explored whether airpower would bring world government.



EUROPEAN (UNION) EMPIRE



AFTER WORLD WAR II, a strong movement for unification of the European states that for centuries had fought among themselves, almost to the point of destroying each other, started in a primitive format reminiscent of the German customs union or Zollverein that prefigured the unification of Germany. A core block of states, Belgium, France, Italy, Luxembourg, the Netherlands, and West Germany initially created by treaty a steel and coal community to which progressively other states could be added. This original core grew in functional scope and numbers and now comprises 27 member states and an area of about 5 million square kilometers, roughly

the size of the Roman empire, and a population of a half billion people, less than either China or India, but more than the USA.

More than 50 years after the signing of the original treaty, Europe cannot be compared to a state or any form of empire, given the fragmentation within its power system. But the population of half a billion, in many ways interconnected, fits the mechanisms of an empire. Progress has been made in unifying finance and realizing free trade, especially through the introduction of the Euro, but the armed forces, powerful or at least expensive if viewed synoptically, remain fragmented. The European military costs around 200 billion

European (Union) Empire

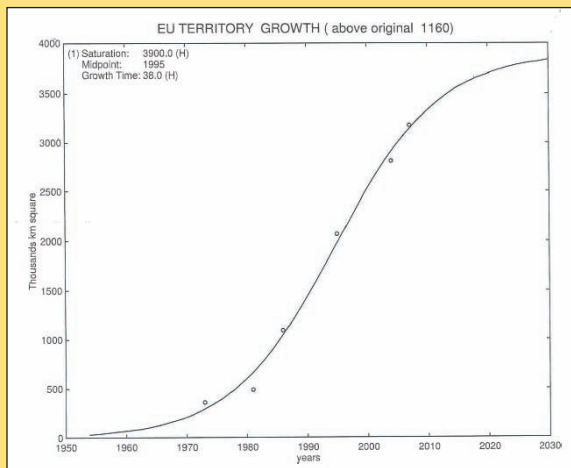
Euros per year, second only to that of the USA, 450 billion, but notwithstanding the many collaboration agreements, the various national armies are still very much on the scene.

With the partial exception of the Balkans, the European Union involves no conquest in the military sense, just seduction, to join. Thus, the rate of agglomeration of the various countries may follow any rule. We tested the logistics of empires in terms of territorial expansion on the European community, and the final figures show it works. Moreover, once the last small fragments

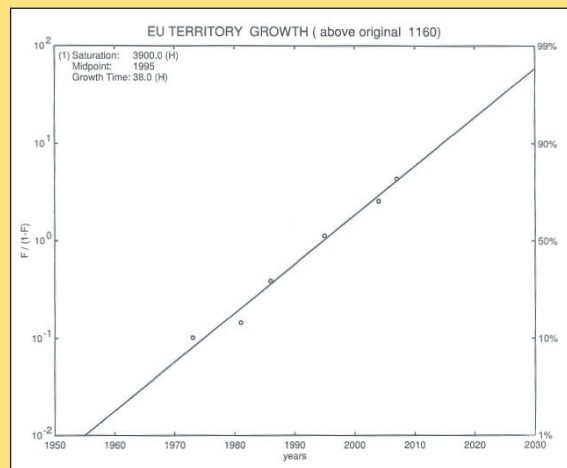
of the Balkans and Norway have joined, the saturation point will be near. We repeated the exercise using population instead of land area, and the result is practically the same.

Importantly, the fit for saturation excludes Turkey. The goodness of fit may mean that Turkey with its large territory and large population may not have the chance to enter Europe, a notable result as the entry of Turkey is a much-debated problem with many ifs. The result, however, is not a proof; on various occasions empires and their testosterone leaders overshot the

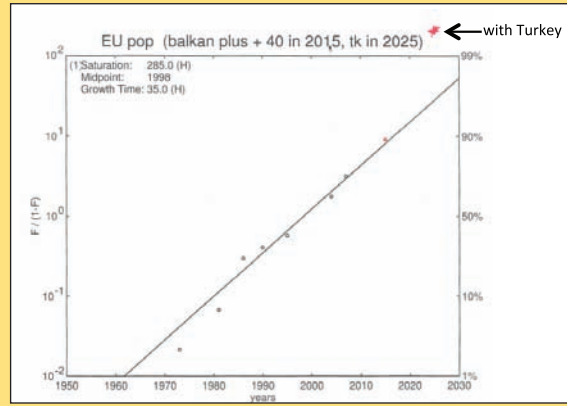
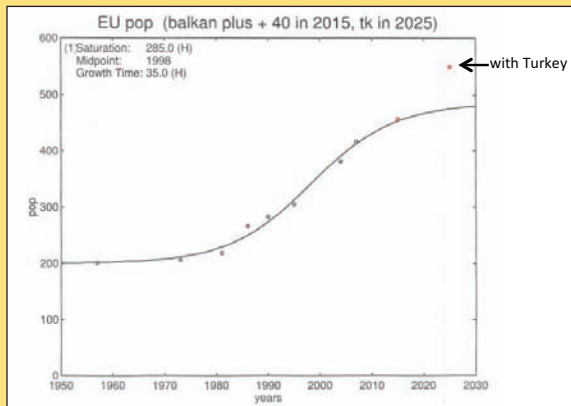
calculated saturation level, although usually with a more or less rapid adjustment for the deviation. Earlier we showed the example of the Soviet Union that, through the greed of the communist party, incorporated a number of states beyond the saturation line of Czarist logistics. When Gorbachev reset the game, several states were released, and the land area of Russia once again became exactly that of the saturation level at the time of the Czars.



European (Union) empire trajectory.



European (Union) empire Fisher-Pry transform.



The flag of the European Union created in 1955: "Against the blue sky of the Western world, the stars represent the peoples of Europe in a circle, a symbol of unity. Their number shall be invariably set at twelve, the symbol of completeness and perfection."

CONCLUSIONS

LET US NOW reflect on the succession of empires. Within a culture, such as Islam, volleys of empire occur. Figure 1 shows five of the sharp, successful thrusts for empire. The instinct persists.

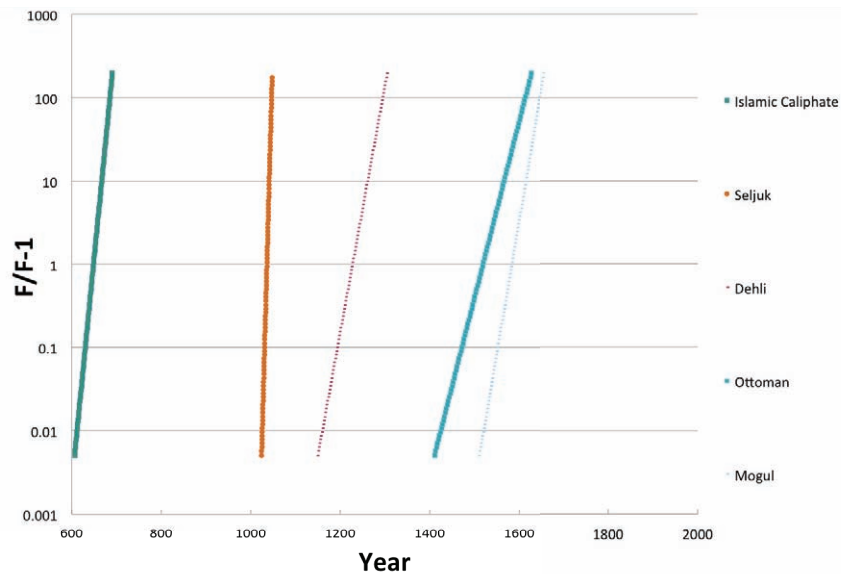


Figure 1. Normalized growth of five Islamic empires.

The instinct for empire in fact is global and cross-cultural. Figure 2 displays all the pulses we analyzed except the European Union. Recall that Taagepera collected data on 80 empires and Wikipedia lists 150.

Finally, one can reduce all empires studied to just three variables, the time the empire took to grow, the midpoint of the growth process, and the area or niche the empire aimed to fill. Table 1 supports several of our summary conclusions, such as the speed of empire creation. The majority of empires studied reached 90% of their extent within less than 100 years.

Samuel Arbesman found an exponential distribution for the fall of 41 empires (Figure 3), meaning that while a few last a long time, most do not (The Life-Spans of Empires, *Historical Methods: A Journal of Quantitative and Interdisciplinary History* 44(3): 127–129, 2011 DOI 10.1080/01615440.2011.577733).

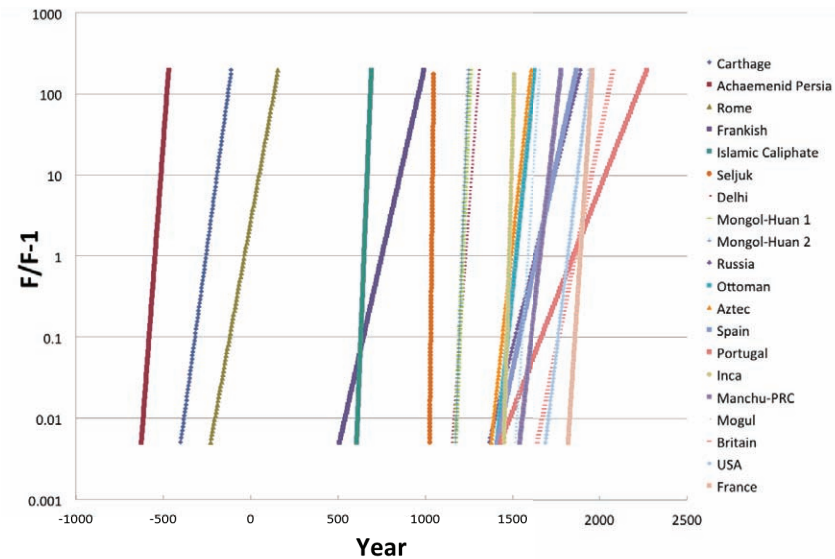


Figure 2. Normalized growth curves of 20 empires.

ABOVE ALL, our tour of 20 empires gives us confidence in a firm anthropological basis of empires. Over almost 3,000 years, monthly reassertion of social hierarchy has driven and limited empires. If we looked at Assyrians, Egyptians, Japanese, and Germans, we expect they would fit too. Basically, progesterone and testosterone make history, including empires.

At the level of the individual, testosterone is part of the life cycle of the male. It controls dominance and consequently is very important in the fight for reproduction, that is, survival of the individual genes. The will to power is independent of ideology. Testosteronic individuals (who may also be women) tend toward positions of power and drive the society to territorial expansion. If successful, the process continues, even for centuries, until the size of the territory conquered implies 14 days of travel from the capital to the frontier. At this point the expansion stops, and testosteronic aggression turns inside for the share of territory and power. This inward turn is the beginning of the end of an empire.

We may regard an imperial impulse initially as a cooperative effort starting from an efficient organization and an impulse of aggression. Most of

Table 1. Empires summary.

Empire	Growth time (yr)	Saturation (1000 km ²)	Midpoint (yr)
Achaemenid Persia	65	5150	-546
Carthage	120	260	-255
Rome	160	4300	-35
Islamic Caliphate	35	10,097	649
Frankish	200	1350	750
Seljuk	10	2050	1036
Mongol-Huan 1	31	16,055	1219
Delhi	64	2553	1225
Mongol-Huan 2	75	24,455	1262
Inca	25	2050	1480
Aztec	95	276	1491
Ottoman	90	4200	1520
Mogol	60	4100	1580
Russia	220	17,500	1630
Spain	190	14,089	1639
Manchu-PRC	100	13,400	1660
USA	106	9900	1820
Portugal	350	13,437	1849
Britain	180	38,500	1860
France	58	12,000	1890
European Union	38	3900	1995

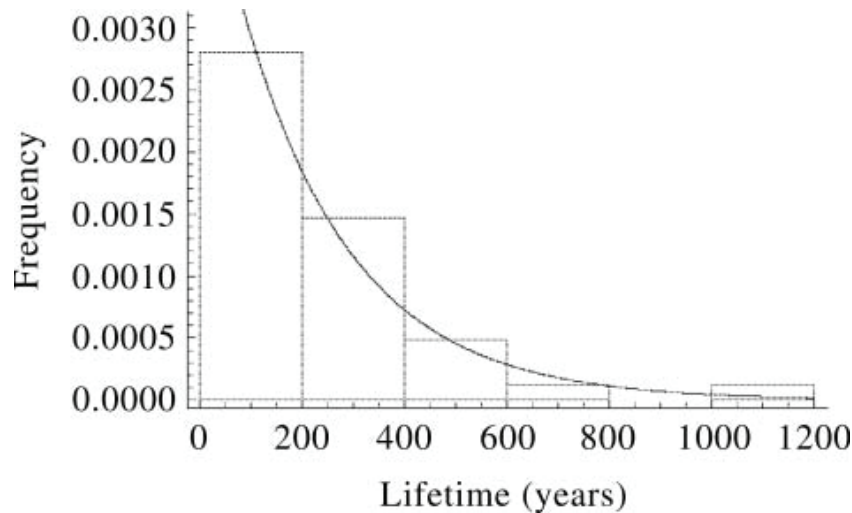


Figure 3. Lifetime distribution of 41 empires, Expected mean imperial lifetime ~220 years. Best-fit line for exponential distribution is overlaid on lifetime distribution of 41 empires (from Taagepera). Bin height is frequency of empires in each bin, divided by bin width, to arrive at a probability density. Source: Arbesman, 2011.

the time neighbors contain it, but occasionally it continues expanding, and expansion stops when a distance is reached from the capital corresponding to 14 days travel with the best means available. As we have seen, the chasqui runners of the Inca had more or less the mean speed of Roman horses, so at maturity the two empires had a similar linear dimension.

Reassured by the consistency of basic instincts, we are willing to speculate about the future.

Conclusions

- Testosterone and progesterone make empires
- Speed of transport determines size of empires
- Control of an empire requires a potential monthly visit of the ruler (importance of lunar cycle)
- Will to power is independent of ideology
- Empires can grow very fast
- Empires grow with a target size
- Empires are hard and costly to maintain
- Collapse usually comes fast
- Main reasons for collapse appear internal
- The next empire may be a true world empire

By the rules of the Kondratiev cycles, a new number 1 challenger should have appeared in 1914 + 54 years, or in 1968, and in fact Russia presented itself as a pretender for the throne. The presence of tens of thousands of atomic weapons on each side discouraged direct confrontation, but a bitter war that actually produced millions of casualties was fought by proxy. Assuming that the Kondratiev cycle remains valid, the next competition should take place around 1968 + 54 years, or in 2022. This date is a general reference position; a stronger conviction about timing requires specific indicators.

One such indicator may come from the fact that world power number 1 often ends by going broke. Being number 1 cures pride and brings benefits of various kinds, but ultimately it is extremely expensive. The previous number 1, Great Britain, toward the end used much of the taxes raised to service its debt. The USA may find itself in a similar position in the next 20 years. An-

other sign is reinvigorated interest and loud grumbling of nations on, or near, the bases of the number 1 power. If bases start being evacuated, the end is usually in sight. Also the formation of a possible new number 1 starts evolving when the possibility of a changeover is perceived.

Europe is a rich political entity with great technological and industrial skills that could be material in the next resetting of the world power system. However, Europe's weak demography makes the long-term outlook hazy. Russia and Japan suffer similarly from few testosterone youth.

Meanwhile, both China and India are rethinking their military power. The occupation of Tibet and the construction of a military railway into Tibet indicate foresight. Throwing dice, we see China more powerful, but its demography is also very leaky, and India would more likely receive USA support. However, the inevitable solution for the successor to the USA empire might be a global solution, with the rule of a supranational organization, the Holy Roman Empire serving as a conceptual archetype. However, the political system is slow and does not appear to focus in that direction, the troubled unification of Europe being a sad example. Thus, we may eventually witness a confrontation between China or India, on one side, and the USA allied with Britain (as in the two world wars), on the other. The USA empire resembles the British in exercising power not by direct administration, but through a

network of military points of strength, the military bases, to show its presence in important parts of the world. This can be seen as an evolution of the practice used in taking possession of the USA by peppering the continent with forts and garrisons.

Nevertheless, because airplanes can go anywhere in one day, the global empire is now technically possible. The USA empire tries to be, having started in the 1940s when the airplane was sufficiently mature to provide a fast and reliable transportation means. Radio and telephone alone could not fulfill the task.

In fact, multinational companies can be considered de facto global empires, in some cases more powerful than small and even middle-sized countries. Thanks to their global reach, they can escape political control, a serious problem awaiting solution. For the moment, the political system tries to solve the fiscal aspects and some of the environmental. A fully functional UN with an independent army that exercises global power seems beyond reach, still a dream or a nightmare, depending on point of view. Conquering the world piece by piece the old way remains technically impossible, as certain show-piece local wars have well demonstrated.

Whatever empire dominates the next phase of world history, its leaders will meet monthly.



A heraldic lion depicted for the Nordic Battlegroup's coat of arms.

ACKNOWLEDGMENTS

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Back cover: The Bayeux Tapestry (top and bottom bands) chronicles the adventures of an Earl of Wessex and a Duke of Normandy who meet in battle at Hastings on 14 October 1066 as Harold, King of England, and William the Conqueror. Logistic curves, central band, are another way to depict the rise and fall of empires. For more graphical detail, see page 48.



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Program for the Human Environment
<http://phe.rockefeller.edu>

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antropos@unifi.it <http://www.pontecorboli.it>