

Ibn Battuta's World



Introduction

The term “pandemic” (from the Greek roots *pan-*, meaning “all,” and *demos*, meaning “people”) has no more apt use than when applied to the catastrophic mortality events experienced in late medieval Afro-Eurasia. We now call this episode in history “the Black Death,” but that term was never used in the Middle Ages. The more common terms for the extraordinarily devastating outbreaks of the mid-14th century were “the Great Mortality” or “the Great Plague.” Most written accounts of this massively lethal outbreak of plague come from European sources or from the western Islamic world. But the disaster seems to have been experienced by many other peoples of Afro-Eurasia as well.

A contemporary witness, a historian and poet named al-Safadi (d. 1363), who saw the plague strike Damascus (in modern-day Syria), captured the sense not only of the geographic expanse of the catastrophe, but also its historic significance. The Great Plague of 1347/1348 rivalled even the plagues that defined the early years of Islam in the 7th and 8th centuries:

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Across the *umma* [the Islamic world],
the plague tarried,
striking all creatures and countries,
bringing hardship and sorrow,
anguish and heartbreak.
No one had ever heard or seen
a thing like that—what
plague crosses lands from every direc-
tion?
From the land where the sun rises
to the land where the sun sets?

This plague makes
the Plague of ‘Amwās [ca. 638 CE]
and the Plague of Ashraf [716-717 CE]
look like pinpricks.
This plague makes the Girls’ Plague
[706 CE]
seem like child’s play.¹

“What plague crosses lands from every direc-
tion?” That, indeed, is the central question
we still need to ask about the Black Death.
The expansive geography of plague’s effect
described here has been validated by both
historical and scientific analysis. Plague’s
massive proliferation across many parts of
Eurasia and Africa in the late 1340s makes it
an important element not simply of western
history but of global history. Even today, it
still ranks as the worst known pandemic in
human history in terms of the mortality it
caused. Numbers vary, but estimates range
up to 60% in some regions.

However, whereas western Eurasian ac-
counts imagined that the pandemic had
arrived from “the East” very swiftly—as if
it were blown by winds—modern analy-
ses suggest that plague’s migration across
Eurasia and into North Africa was a slower
affair. Yes, there were some rapid episodes
when plague spread ferociously through hu-
man populations, from one city to another.
But there were also periods when plague’s
movements escaped human detection. After
all, it was (and remains) a rodent disease,
not one that circulates normally through
humans. It is likely that the plague’s dissem-
ination across major parts of Eurasia and at
least some parts of Africa was a punctuated

Key Terms:

Pandemic

Black Death

Great Mortality

Yersinia pestis

Second Plague
Pandemic

Paleogenetics

Pneumonic plague

Ibn Battuta

Mongol Empire

Kara-Djigach
Cemetery

1. Ibn Hajar al-‘Asqalani, *Merits of the Plague*, trans. Joel Blecher and Mairaj U. Syed (Penguin, 2023), 213.

process: periods of war or intensive environmental disruptions could move plague long distances, and be followed by longer periods of focalization, that is, when plague embedded itself in new landscapes as well as groups of insects and rodent hosts.

Overall, the process of spreading across Eurasia and North Africa seems to have taken a century and a half. During that time, the climate of the entire earth also shifted—at times erratically but in the general direction of becoming colder—starting with the warm Medieval Climate Anomaly and ending with the onset of the Little Ice Age. Throughout all of this, the single-celled bacterium, *Yersinia pestis*, found new animal hosts and ecological niches in which to thrive. What we have come to call the Black Death was therefore the *crescendo* in the mid to late 1340s of ecological, climatic, and cultural forces that had been building for decades. This pattern continued after the mid-14th century, too, with epidemic waves of plague occurring in many regions right through the 18th and even 19th centuries. This is why we talk now not of an isolated epidemic in the 14th century, but a centuries-long Second Plague Pandemic, so called to distinguish it from the First Plague Pandemic (also called the Justinianic Plague).

Although the Great Mortality of the late 1340s wasn't unique, it was the most devastating epidemic wave, recognized as such both by contemporaries and by subsequent commentators. The drastically changing world of the 1320s through 1340s was the world the Moroccan traveler Ibn Battuta (d. 1368/1369) inhabited.

I. A standard account of the Black Death

The stories we have told about the Black Death have deep roots, many of them going back to the accounts of eyewitnesses who survived the pandemic. But here's the challenge for us in the present day: None of those 14th-century eyewitnesses had microscopes or could conceive of microorganisms as the causative



A hectic burial scene at the cemetery of Tournai (modern Belgium). The only contemporary image of a Black Death scene made during the time of the outbreak.

agents of disease. There was no World Health Organization to gather data on disease trends or mortality rates; there were barely any nation-state governments that took on public health responsibilities. There were no telephones, let alone an internet, to allow rapid transmission of epidemiological data. In short, on almost every level, eyewitnesses in the 14th century could not have had any

knowledge of either the bacteriological or the climatic forces that were shaping their world. But, this does not mean that their accounts have no value. Rather, it means that when we evaluate their observations alongside new findings from the sciences and historical records, we need to recognize the inherent limitations of what people could understand at the time.

Below is what we might consider a familiar, “standard account” of the Black Death. It comes from a biography of the Pope Clement VI (r. 1342-1352), who was reigning when the Great Mortality struck Western Europe. The papal court was based in Avignon (in southern France) at the time, and we know from a variety of sources that the region, Occitania, was hit very hard by the disease.



Pope Clement VI, cameo in Notre-Dame de Paris.

At the same time [1347] there was in the kingdom of France, and especially in the region of Occitania [southern France], a very intense dearth [of grain], and with it pestilential famines, so much so that sometimes (it is horrendous to hear) it was discovered that, in the face of excessive hunger, mothers tore their children to shreds and ate them, not to mention raw herbs and unclean animals and other unusual foods ... And this was the beginning of the greatest mortality which soon followed.

In the year of Our Lord 1348 there began such a mortality generally in the whole world that the like has scarcely been heard of elsewhere. For the living could hardly suffice to bury the dead,

or they were loath to attempt this. For almost everyone was seized with so much fear that as soon as an ulcer or a bump appeared, as in most cases in the groin or the armpit, everyone was dismissed by their attendants, even their relatives. For the father left the son and the son left the father on the litter. No wonder. For when some person was detained in the house with such an illness and finally died, it was very often found that all the others were infected and died in the same way, even dogs, cats, roosters and hens, with all the other animals living there, which is terrible to hear. Because of this, those who were healthy fled in terror. And thus many died because of carelessness, who might have escaped elsewhere. Many, too, who were seized with this infirmity, doubtless believed to die immediately, were carried without discretion to the pit for burial. And thus many were buried alive.

And to this evil is added another thing. For a certain rumor arose that there were certain evildoers, and Jews in particular, who poured potions into the waters and springs, by which action the aforesaid plague was thus aggravated. Because of this, many Christians as well as Jews, innocent and blameless, were burned and slaughtered, and in other ways ill-treated in person, when in truth this [the plague] will not happen except by reason of the [planetary] constellation or divine vengeance.

And this pestilence continued beyond the aforesaid year, and indeed through two subsequent ones, spreading itself in different parts where it had not been. And during this storm the said Pope did an act of great charity at Avignon. For in order to visit and feed the poor, he appointed certain physicians and others to assist them in their necessities during life, and when they passed away, they also attended to the necessities of burial. And because for that time the ordinary cemeteries were not sufficient to receive the bodies of the dead, he bought a large field, in which he caused a cemetery to be consecrated, where generally everyone could be buried, in which infinite persons have since been buried. And the name given to it, which lasts to this day, was the *Campus Floridus* (Flowery Field).²

Consider how this account describes the plague: where it came from, how it affected people, and how they responded. It is a horrific vision. And, save for the accusations of water-poisoning, Europe was not unique in suffering it. All regions of the Mediterranean world, and beyond, were suffering from this awful pandemic.

II. Reframing local stories as global ones: A tale of two cities

The papal court at Avignon was the source of many of the narratives that have since become foundational in standard accounts of the Black Death. For instance, Louis Heyligen, a musician at the papal court, wrote a letter from Avignon to his home community in Bruges (in modern Belgium) on April 27, 1348. In his letter, he recounted the devastations the Black Death had already caused in the few



Illustrations from a 15th-century copy of Guy de Chauliac's surgical manual. On the left, an anatomical demonstration on a skeleton. On the right, a surgeon incising an inguinal bubo while the patient displays a second, axillary bubo under his arm.

months since its arrival, linking them with apocalyptic events in India.³ He also reported the important fact that the pope had authorized that autopsies be done on some of the dead to try to ascertain the cause of the disease.

The account of Guy de Chauliac (1325-1368), a physician and surgeon at the papal court, included therapies for plague that he had devised (partly by using them on himself

when he fell ill) during both the Black Death and the *pestis secunda*, the second major wave of plague that struck much of Europe in the late 1350s and 1360s. Guy in particular focuses our attention on two elements of the Black Death story: the clinical aspects of the pandemic, on the one hand, and the question of its origin and geographical scope on the other. Epidemiologically, Guy observed that

2. *Vitae paparum avenionensium hoc est historia pontificum romanorum qui in gallia sederunt ab anno christi mccciv usque ad annum mcccxciv*, ed. Stephanus Baluzius, vol. 1 (Librarie Letouzey et Ané, 1914), 250–52. Translated by the author.

3. Rosemary Horrox, ed. and trans., *The Black Death* (University of Manchester Press, 1994), 41–43.

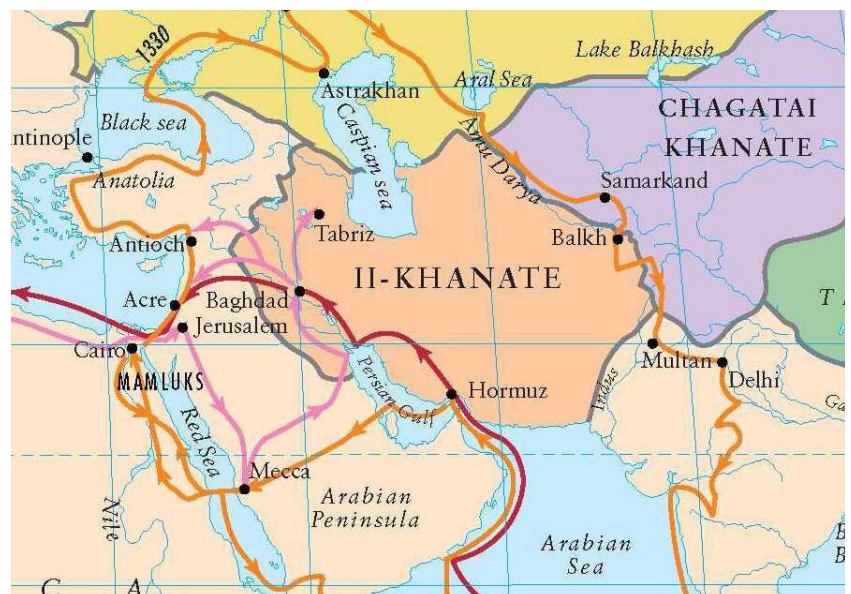
the 1348 outbreak in Avignon came in two distinct waves. The first, lasting two months, brought on spitting of blood and killed people within three days. The second wave, lasting for five months, was characterized by axillary or inguinal buboes (under the arms or in the upper thigh, respectively) and killed in about five days. In terms of the pandemic's origin and geographic scope, he wrote:

I call it great because it engaged all the world, or nearly. For it began in the East, and shooting out into the world, passed through our region toward the west. It was so extensive that it left scarcely the fourth part of the population alive. And it was unprecedented, since, although we read [about various ancient and early medieval epidemics], none of these was as great as this one. For they affected only one area; this one, the whole world; they were curable in one fashion or another; this one, in none.⁴

Whereas the papal biographer said nothing about a geographic region from which the pandemic arose (he only mentioned accusations against malevolent human agents on the one hand, and celestial or divine influences on the other), other accounts pinpointed a geographic region out of which the mortality arose. Louis Heyligen mentioned India, whereas Guy de Chauliac more vaguely invoked “the east.” If we put our finger on a globe and followed it eastward, we find other plague stories that can help us to construct an actual global story of the late medieval pandemic: its origins, its routes across Eurasia, the places where it tarried, the places it destroyed. We will explore those other stories later. Here, one will suffice. It comes from an Iraqi historian, al-Ahri, who was writing around the same time as Guy de Chauliac. His history of Azerbaijan, that is, the region just south of the Caucasus Mountains in western Asia, painted an even darker image of the years 1347 and 1348.

Al-Ahri recorded two incidents in Tabriz, a city in the mountainous terrain south of the Caucasus ridge that divides Russia from the modern countries of Georgia, Armenia, Azerbaijan, and Iran (hereafter referred to by the historical term Greater Armenia). Just a few years before 1347, Tabriz had been one of the liveliest hubs of semi-global commerce in the Mongol Empire. Ibn Battuta—who would pass through North Africa, the Middle East, Central Asia, India, China, and

Map showing location of Tabriz in the 14th century.



4. Guy de Chauliac, *Ars chirurgialis Guidonis Cauliaci medici* (1546), in *Sourcebook in Medieval Science*, trans. Michael R. McVaugh, ed. Edward Grant (Harvard University Press, 1974), 773 (no. 107).

and even (during a brief visit to al-Andalus) a corner of Europe—himself had passed through Tabriz briefly in 1326, the first year of his travels. 20 years later, it was a scene of devastation:

747 AH/1346–47 CE: “Malik Ashraf [r. 1343-1357] came to Tabriz and extorted money from the people and filled the treasury. And in that year a serious plague had broken out in Azerbaijan. Three things were abundant: oppression, dearth and the plague.”

748 AH/1347–48 CE: “Malik Ashraf came again to Tabriz and let loose a hundred thousand hungry wolves on Azerbaijan and Arran. They did what they liked and the population grew desperate. They all quitted their native country, some going to Gilan, some to Shirvan and the Qipchaq Steppe and some to Georgia. They were scattered over Byzantium, Syria and Baghdad.”⁵

Al-Ahri was no physician and we get none of the clinical detail of Guy’s account. Rather, we get a clear sense of the absolute devastation and desperation that characterized a scarred landscape: “Three things were abundant: oppression, dearth and the plague.” Al-Ahri implied that the complete desertion of the region by its populace was due to the vicious release of “a hundred thousand hungry wolves” by the region’s own ruler, Malik Ashraf. But setting aside the obviously exaggerated number, why would a ruler do that? Oddly, he never asked the question, so it’s hard to say. But it is worth noting that al-Ahri did not describe the plague as a new affliction. Instead, he seemed to treat it as a hardship that was already widespread in his world, like famine. So even if the outbreak was dramatic to him, perhaps it was not surprising.

III. Bringing biology into play

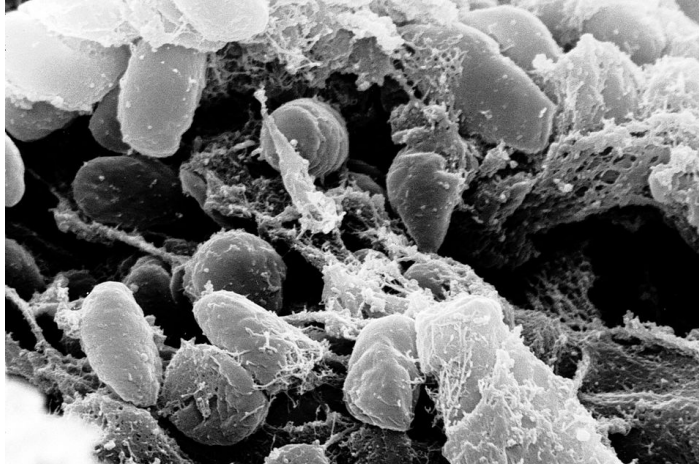
It is often assumed that plague spread because of new trade connections that were being created across Eurasia by the emerging Mongol Empire, the largest land empire in human history—under the so-called *Pax Mongolica* (Mongol Peace). Yet invoking the vague concept of “the Silk Road” is counterintuitive. If transcontinental commerce were the simple precondition of pandemics, then why was there a 600-year gap between the Justinianic Plague (6th to 8th centuries) and the devastation of the Black Death in the 14th century? After all, those were the centuries when the commercial connections we associate with “the Silk Road” were established. The causes of the Black Death we will examine in this module are instead grounded on the unique, contingent circumstances of the Mongol world that the Moroccan traveler, Ibn Battuta, moved through.

A new field of science, paleogenetics, allows us to confirm that the disease circulating in the late Middle Ages is the same disease we can now find distributed in many parts of the modern world: that is, the bacterium, *Yersinia pestis*. By retrieving molecular fragments of the organism, this work is starting to allow us to reconstruct the routes that plague took across Afro-Eurasia in the later medieval centuries. We will examine *how* we can know so much about plague’s history in Lesson 3. But here, we need to learn more about what modern science tells us about plague’s basic characteristics: how it persists and replicates, where it finds

⁵ Abu Bakr al- Qutbi al-Ahri, *Ta’rikh-i Shaikh Uwais (A History of Shaikh Uwais): An Important Source for the History of Ādharbāijān in the Fourteenth Century*, trans. J. B. Van Loon (Mouton & Co., 1954), 73 and 74.

its hosts, and how (in rare circumstances) it manages to devastate human populations.

Yersinia pestis, the bacterium that causes plague, can only be seen with a microscope, not by the naked eye. First identified scientifically in 1894, the bacterium *Yersinia pestis* is described by scientists as “a gram-negative, non-motile, coccobacillus bacterium.” Like all bacteria, it is a single-celled organism that replicates by simply dividing. “Non-motile” means that it has no mechanism to move itself around, not even a little tail (*flagellum*) to propel itself. So it relies entirely on mobile insect vectors (carriers) and animal hosts to move it around; within its mammalian victims, it commandeers the body’s own immune system to spread and replicate.



An electron microscope image of Yersinia pestis bacteria in the flea gut.

Nobody in the Middle Ages knew anything about *Yersinia pestis*. Nor is there any reason to think that anybody suspected the possible role of fleas or rodents in the transmission of the disease. That basic fact is the reason why any *historical* investigation of the late medieval plague pandemic must approach the topic both through primary sources that let us see what medieval people themselves saw *and* through scientific

methods to reconstruct what they could not have seen.

As we will learn in Lesson 3, the strains of *Yersinia pestis* involved in the Second Plague Pandemic emerged from long-term reservoirs in populations of marmots in one very specific ecological niche: the high-elevation terrain of the Tian Shan mountains that separate modern Kyrgyzstan from western China. We’ll learn more about how those strains might have been nudged out of their accustomed niches and started spilling over into rodents and eventually human populations. We call this transmission event the Big Bang. And from it, most of the modern diversity of *Yersinia pestis* throughout the world emerged.

However, rather than moving permanently into humans and being transmitted from human to human (as, for example, the viral diseases of smallpox or COVID are), plague never settled permanently in human bodies. The “blood-spitting” manifestation that Guy de Chauliac described (and that other contemporary witnesses reported) can be understood as pneumonic plague, when a victim has inhaled the bacterium directly into their lungs. This produces a particularly severe and rapid infection, killing the patient within two days of the onset of symptoms and possibly infecting others with whom that individual had close contact. Plague may have also been transmitted within human communities by means of human fleas or human lice, both of which could have amplified transmission in high population areas and contributed to the seemingly astronomical mortality figures we have from some areas.

In short, everything we are learning about plague tells us that our medieval witnesses are to be believed: they *were* facing a crisis of inexplicable severity and speed. But they, of course, were only seeing the tip of a much vaster epidemiological iceberg. To cause the level of mortality across the dispersed landscapes where plague was reported, there had to be a “plague infrastructure” of bacteria, insect vectors, and intermediate animal hosts already in place.

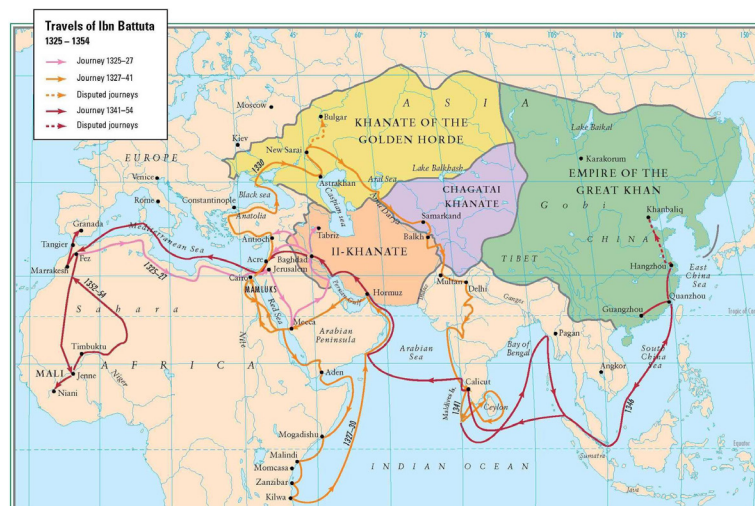
IV. The Mongol unification of Asia: the context of empire

As we will see in Lesson 2, Ibn Battuta didn’t have that much to say about plague in his long account of his travels through Asia, Africa, and (briefly) Europe. He was a layman with respect to medicine, and offered no clinical details about the disease and relatively little information on its epidemiological impacts. Nevertheless, as the most widely traveled contemporary of the Black Death, Ibn Battuta presented us with important snapshots of this world. He took us deep into the Mongol Empire and allowed us to see some of the larger cultural and environmental forces that created the biological circumstances of the pandemic.

What Ibn Battuta *did not* see was the microbial world literally under his feet. Yet that is where plague flourished and spread. When he first entered parts of the Mongol world, Ibn Battuta was not yet halfway through his 24 year journey. He had left home in 1325 planning simply to complete the Hajj, the journey to the holy city of Mecca (in modern-day Saudi Arabia) which is considered a pious goal of Muslims. In this middle period of his travels (1327-1332), he passed through the lands of the Ilkhanate, the Golden Horde and the Chaghadaid Khanate, the western, northern, and central sections, respectively, of the now-divided Mongol realm (See Map). Ibn Battuta’s route, as far as we can reconstruct it, took him directly across the path that plague must have moved along to pass into the West from the region of central Asia where the late medieval pandemic emerged. And yet, at that point in his journey, he never mentioned it.

That should not surprise us. As we have already noted, plague is not a human disease; it is a rodent disease. And why should rodents have interested Ibn Battuta?

Yersinia pestis has been traced back about 5,000 years in human bodies, but it has probably existed for about 10,000, and it is assumed that it has spent most of its existence passing back and forth between various rodent hosts—or even persisting quietly in the soil. *Yersinia pestis* has evolved many branches over the course of this



Map of Ibn Battuta's Travels.

long period; most of them have died out, as the bacterium is so lethal it kills its hosts and thus its mechanism of further transference.

During the initial years of Ibn Battuta's journey, there's no reason to think that he encountered active outbreaks of plague. Aside from his brief sojourn to Tabriz, Ibn Battuta did not pass through Greater Armenia, a region to the west of the Caspian Sea where (as we will see later) plague may have focalized after the outbreaks in Baghdad and Syria in 1258-1260. At the beginning of his travels, he did pass through Cairo, which may have suffered a plague outbreak in the 1290s. But the city had recovered before Ibn Battuta's arrival in 1326. The possibility that plague could have been quietly incubating in several new reservoirs during this period has only been realized recently.

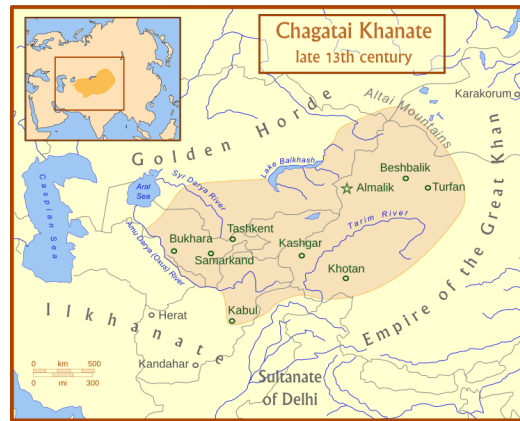
Ibn Battuta's journey led him through all four of the khanates (regional empires) that the Mongol Empire had split into after 1260. The united empire had formed after its founder, Chinggis Khan (r. 1206-1227), led troops out of Mongolia into areas that now form northern China. Westward expansion followed in the 1220s, reaching as far as eastern Europe. Chinggis Khan's conquests were extended by his sons, so that by 1260 the Mongol Empire extended from Korea to Hungary and from Anatolia, Iraq, Tibet, and Vietnam to Siberia. This was the largest land empire in history. Even with the separation into the four khanates around 1260, political, cultural, and trade connections kept the entire region permanently tied together.

Ibn Battuta's travels were in fact premised on the cultural infrastructure that the Mongols provided. The Mongol empire enabled rapid communications (its postal system remains famous to this day), it encouraged trade and protected merchants, and it enabled the spread of major faith systems because of basic policies of religious tolerance. The period of violent conquests largely ended by 1261. By this point, however, plague had likely already been distributed to several areas of the empire. That is because plague was probably spread not by "trade" generically but by particular practices of military provisioning of grain and agricultural development that could allow a highly lethal, flea-borne disease to travel unseen across wide distances.

We don't yet have enough "smoking guns" to document the precise chains of transmission that moved new strains of *Yersinia pestis* across Eurasia and into Africa. No archaeological samples of plague-infested fleas, for example, have yet been retrieved to allow us to pinpoint the species involved; to date, only one plague-infested rat has ever been found. We don't yet have any ancient *Yersinia pestis* DNA from the Middle East or North Africa, or East Asia, from the late medieval centuries. But we can draw some inferences about circumstances—or scenarios—that may explain plague's spread across the Mongol Empire and the genesis of the most severe pandemic in human history. As the most widely traveled writer from this exact period, Ibn Battuta will serve as our guide.

A case study of plague's impact: The Kara-Djigach Cemetery

To help you get a more tangible sense of the devastation that plague could cause, you and your professor will examine the case of the Kara-Djigach Cemetery in Kyrgyzstan (Central Asia) in class. In the 13th and 14th centuries, this was part of the Chaghadaid Khanate, one of the four realms that succeeded Chinggis Khan's united Mongol Empire. Even though it was excavated nearly 150 years ago (before *Yersinia pestis* was actually discovered in 1894), the site remained just an archaeological curiosity. Before 1951, it had never even been mentioned in general plague literature. Recently, however, *Yersinia pestis* has been confirmed at the site. As a result, interest in Kara-Djigach has grown.



Map of the Chaghadaid Khanate in the late 13th century.



Sampling of headstones from the Kara-Djigach archeological site.

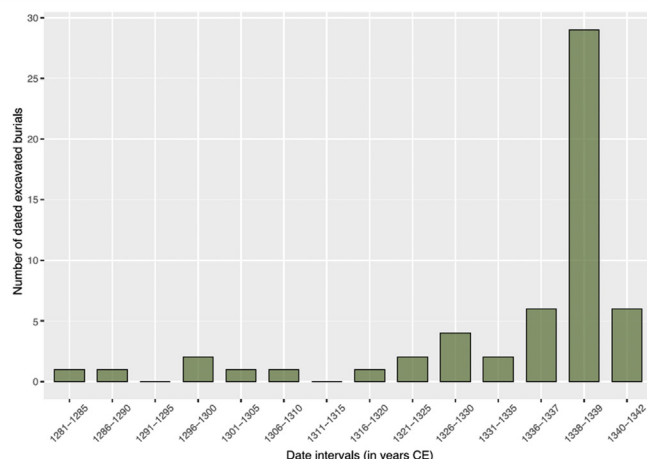


Chart showing the chronological distribution of dated Kara-Djigach burials, excavated in 1886.

Unlike other sites we'll be looking at in later lessons, we have no documentary accounts to tell us about the circumstances of this outbreak. All we have is the testimony of the headstones and the few human remains that have been retrieved. With this information we can get a quantitative sense of just how devastating the epidemic of 1338-1339 was. However, other questions about the site remain unanswered. Initially, the responses to discovering *Yersinia pestis* at the Kara-Djigach Cemetery site dating to 1338-1339 encouraged researchers to conclude that this was the origin point for the entire Black Death outbreak. But other evidence urges us to be cautious about accepting such conclusions... we will return to this point later in our studies.

Further Reading

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Image Citations

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Initial 'C', a scene representing cemetery, miniature in Omne Bonum, London, England, 1360-1375, British Library, MS Royal 6 E VI, vol. 1, f. 267vb.

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The burial of the victims of the plague in Tournai, from "The Chronicles of Gilles Li Muisis," abbot of the monastery of St. Martin of the Righteous, Bibliothèque royale de Belgique, MS 13076-77, f. 24v.

Page 4:

Pope Clement VI Cameo, Notre-Dame de Paris, PHGCOM, CC BY-SA 4.0, <https://commons.wikimedia.org/wiki/File:PopeClementVICameo.jpg>

Page 5:

Illustrations from a 15th-century copy of Guy de Chauliac's surgical manual, photographed by Monica H. Green, Bristol Central Library, MS 10, ff. 25r and 43v.

Page 6:

Travels of Ibn Battuta, 1325-1354, ORIAS, University of California Berkeley, Fair Use, <https://orias.berkeley.edu/resources-teachers/travels-ibn-battuta>

Page 8:

Scanning electron microphotograph depicting a mass of *Yersinia pestis* bacteria (the cause of bubbonic plague) in the foregut of the flea vector, Rocky Mountain Laboratories, NIAID, NIH, Public Domain, https://commons.wikimedia.org/wiki/File:Yersinia_pestis.jpg

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Travels of Ibn Battuta, 1325-1354, ORIAS, University of California Berkeley, Fair Use, <https://orias.berkeley.edu/resources-teachers/travels-ibn-battuta>

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Map of the Chagatai Khanate at the end of the 13th century, MapMaster, CC BY-SA 3.0, https://commons.wikimedia.org/wiki/File:Chagatai_Khanate_map_en.svg
Extended Data Fig. 1: Available tombstone pictures from Kara-Djigach, Spyrou, M.A., Musralina, L., Gneccchi Ruscone, G.A. et al, "The source of the Black Death in fourteenth-century central Eurasia," Nature 606, 718–724 (2022), CC BY-SA 4.0, <https://doi.org/10.1038/s41586-022-04800-3>

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Figure 1c: Chronological distribution of dated Kara-Djigach burials, excavated in 1886, Spyrou, M.A., Musralina, L., Gneccchi Ruscone, G.A. et al, "The source of the Black Death in fourteenth-century central Eurasia," Nature 606, 718–724 (2022). <https://doi.org/10.1038/s41586-022-04800-3>