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The Justinianic Plague: an interdisciplinary review

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This article is a detailed critical review of all the major scholarly publications in the rapidly expanding field of the Justinianic Plague published from 2000 through 2018. It updates the article in this journal by Dionysios Stathakopoulos from 2000, while also providing a detailed appraisal of the state of the field across all disciplines, including: literary studies, archaeology, DNA evidence, climatology, and epidemiology. We also identify the current paradigm for the Justinianic Plague as well as survey possible avenues forward for the field in the future.[1]

Keywords: Justinianic Plague; pandemics; ancient DNA; climate change; end of Antiquity

Introduction

The Justinianic Plague and the first plague pandemic that followed have enjoyed a substantial increase in scholarly and public attention over the last few decades. This article attempts to offer a useful starting point for scholars in all fields to assess the current state of the study of the Justinianic Plague in hope of increasing interdisciplinary collaboration and raising awareness of key issues while reducing circular reasoning. It builds upon the substantial increase in Justinianic Plague research since the beginning of the 21st century and updates the survey of Dionysios

1 We would like to thank Tim Newfield and the two anonymous reviewers for commenting on an earlier version of this paper. Princeton's Climate Change and History Research Initiative provided an instrumental platform for the refinement and discussion of the ideas behind this paper. This survey is comprehensive through 2018. Due to publication schedules we were able to include only brief references to a few studies from 2019. We use the term 'Justinianic Plague' in this article as a shorthand to refer to all outbreaks of plague from c. 541–750 since that remains the most commonly used term to discuss the first pandemic.

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Stathakopoulos published in this journal in 2000.[2] Studies in multiple fields and disciplines have contributed to this effort. Historians, archaeologists and natural scientists have published on the plague in different venues, enriching their respective fields, which is a welcome development but also one that makes it difficult to remain aware of parallel research.

Over the past two decades, historians have expanded the impact of the plague to include areas beyond the peripheries of the Greco-Roman ancient world and extended its chronological timespan, while the existing material in the written sources has been systematically organized through a catalogue of epidemics. Within the discipline of history, the study of the Justinianic Plague has been incorporated within the growing field of environmental history. Nevertheless, broader bibliographic surveys of premodern environmental history such as Eisenberg et al., McMahon and Sargent, and Newfield and Labuhn cover it in just a few pages. While these overviews are useful starting points for research, they are neither comprehensive nor critical due to their wider scope.[3] In the sciences, specialist studies in plague genomics have been appearing at an accelerating rate since 2010. After establishing that *Yersinia pestis* caused the plague, these studies tend to focus on identifying the plague in ancient human remains and reconstructing the pathogen's evolution and genetic composition from the Stone Age to the present. This study critically surveys the main contributions published since Stathakopoulos' article, establishes the current state of research on the topic, highlights the questions that are currently debated, and suggests ways to move forward.

Increasing interest

The recent increase in studies of the Justinianic Plague can be traced to several connected developments around the year 2000. In 2003, after significant scholarly and media attention, the Human Genome Project was completed. Two years earlier, the plague genome was identified and, five years before that, a method to identify the causative microorganism, *Y. pestis*, in the skeletal remains of its human victims was developed. Following these first breakthroughs, an influential multidisciplinary conference was held at the American Academy in Rome in late 2001.[4] The conference brought together specialists working on late antique plague in different geographical regions,

2 D. Stathakopoulos, 'The Justinianic Plague revisited', *Byzantine and Modern Greek Studies* 24 (2000) 256–76.

3 M. Eisenberg et al., 'The environmental history of the Late Antique West', *Late Antique Archaeology* (2018); L. McMahon and A. Sargent, 'Environmental history of the Late Antique Eastern Mediterranean', *Late Antique Archaeology* (2018); T. Newfield and I. Labuhn, 'Realizing consilience in studies of pre-instrumental climate and pre-laboratory disease', *The Journal of Interdisciplinary History* 48, no. 2 (2017) 218–19.

4 The conference resulted from conversations at the American Academy in Rome two years earlier. See L. Little, 'Preface', in L. Little (ed.) *Plague and the End of Antiquity: The Pandemic of 541–750* (Cambridge 2007) xii.

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from the Near East to Ireland, together with others who examined it through scientific and consilient approaches. Some of the studies in this conference would later be published in the primary book dedicated to the Justinianic Plague to date. Delays, however, meant that the book was only published in 2007, postponing the impact of the conference upon the wider scholarly community for several years.[5]

In the meantime, some conference participants continued to advance their research. A key development was the publication of Dionysios Stathakopoulos' book in 2004. This monograph examined two specific types of environmental stress upon human societies in late antiquity: famine and pestilence. The book begins with an interdisciplinary survey of food shortages and epidemics, using historical sources alongside scientific research. The second section is an annotated catalogue of famine and pestilence which remains the most comprehensive survey of the sources to date. Each of the 222 entries includes an estimated timeframe for the event, its location, and relevant primary sources and secondary research, together with Stathakopoulos' own commentary.

Although Stathakopoulos did not focus exclusively on the Justinianic Plague, he paid close attention to it. His chapter on the Justinianic Plague is the longest in the book and, of the 222 events in his catalogue, 16 concern the original outbreak of plague, and another 43 address later plague recurrences. As a result, the innovative monograph remains the best reference work on late antique plague.[6]

Despite its numerous advantages, however, the book and especially the catalogue contained several problems future researchers would replicate. First, how Stathakopoulos identified an epidemic as being a plague remained unclear. While some non-plague epidemics are reported, unknown disease outbreaks are often haphazardly identified as plagues. Stathakopoulos repeatedly accepted weak or circumstantial evidence for plague, often constructing recurrent outbreaks based upon the spatiotemporal proximity of reported epidemics.[7] Second, in almost all cases, Stathakopoulos paraphrased the primary sources and did not provide the original text. This differs from other catalogues of ancient environmental events and distanced readers from the primary sources.[8] Third, organizing so many events in a catalogue

5 For the resulting book see Little (ed.), *Plague and the End of Antiquity*.

6 For both his catalogue and his epidemiology section, D. Stathakopoulos, *Famine and Pestilence in the Late Roman and Early Byzantine Empire: A Systematic Survey of Subsistence Crises and Epidemics* (Aldershot 2004) 124–34.

7 See the discussion in Stathakopoulos, *Famine and Pestilence*, 111 which he did not follow in his catalogue. For example, some entries for the first outbreak (e.g. #114–118, pp. 290–4) are based on circumstantial evidence and only one (#114) refers to buboes, but without a specific place.

8 For other catalogues of environmental events that include the primary source text in translation, see for example: N. Ambraseys, *Earthquakes in the Mediterranean and Middle East: A Multidisciplinary Study of Seismicity up to 1900* (Cambridge 2009); E. Guidoboni, *Catalogue of Ancient Earthquakes in the Mediterranean Area up to the 10th Century* (Rome 1994); E. Guidoboni and A. Comastri, *Catalogue of Earthquakes and Tsunamis in the Mediterranean Area from the 11th to the 15th Century* (Rome 2005). The Guidoboni catalogues also include primary sources in the original languages.

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created a strong impression of a multitude of disasters ('waves') that struck Eurasia repeatedly over centuries. Moreover, at first glance, the disasters appear equivalent in magnitude and scope, whereas in reality most events were confined to specific locales.

Subsequent publications extended the range of the plague. The most important publication in this regard was Lester Little's edited volume (2007) based on the aforementioned Rome conference. While some of the contributions in the book covered the Eastern Mediterranean, Merovingian Gaul and Anglo-Saxon England, which were by then already familiar in Justinianic Plague scholarship, two chapters examined plague in European peripheries: Spain and Ireland.[9] In these two cases, as in the paper on England, the authors struggled to overcome the lack of textual sources by examining other types of evidence and basing much of their argument upon chronological correlation. The chapters raised more questions than answers, for example, as to why archaeologists in England have yet to find early medieval rat bones in their sieves, or the startling speed in which the plague apparently moved, reportedly 4.2 km/day on average.[10] These contributions joined earlier publications that identified the plague in other peripheries such as Finland and Yemen, and reinforced the existing framing of the plague as being a global pandemic.[11]

The chronological scope of the plague was similarly extended. The title of Little's edited volume, 'Plague and the End of Antiquity 541–750', matched the end of Stathakopoulos' catalogue and cemented the chronological extent of the Justinianic Plague in scholarly consensus. The year 750 offered an attractive endpoint to the Justinianic Plague. It had some foundation in the European sources and fitted well with the beginning of the Abbasid and Carolingian Empires.[12] Nevertheless, this chronological limit is not clear cut. Little's book included a chapter by Morony, who examined the Syriac sources and suggested that they could be interpreted to show that

9 M. Kulikowski, 'Plague in Spanish Late Antiquity', in Little (ed.), *Plague and the End of Antiquity,* 150–70; A. Dooley, 'The plague and its consequences in Ireland', in L. Little (ed.), *Plague and the End of Antiquity*, 215–28.

10 J. Maddicott, 'Plague in seventh-century England', in L. Little (ed.), *Plague and the End of Antiquity*, 185–90.

11 T. Seger, 'The plague of Justinian and other scourges: An analysis of the anomalies in the development of the iron age population in Finland', *Fornvännen* 77 (1982) 184–96; C-J. Robin, 'Guerre et épidémie dans les royaumes d'Arabie du Sud, d'après une inscription datée (IIe s. de l'ère chrétienne)', *Comptes rendus des séances de l'Académie des Inscriptions et Belles-Lettres* 136, no. 1 (1992) 215–34.

12 This is not to say that 750 was arbitrarily selected, but the emphasis on such a round number as an *anno mirabilis* is tempting. L. I. Conrad, 'Arabic plague chronologies and treatises: Social and historical factors in the formation of a literary genre', *Studia Islamica*, no. 54 (1981) 53, notes the last outbreak in 749; M. Dols, 'Plague in early Islamic history', *Journal of the American Oriental Society* 94, no. 3 (1974) 380–81, notes that it was severe under the Umayyads, but plague did seem to continue afterwards as well. See the more recent M. Morony, '"For whom does the writer write?": The first bubonic plague pandemic according to Syriac sources', in Little (ed.), *Plague and the End of Antiquity*, 67. Dating the end of the plague in the mid-eighth century goes back to the early twentieth century, but the precise year remains debatable. See: Stathakopoulos, 'The Justinianic plague revisited', 259, 264, 268 and passim.

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the plague continued into the mid-ninth century.[13] This post-750 extension of plague, however, has not been accepted by most subsequent scholars.

Little's book also extended the type of sources used to track and investigate the plague, bringing many of these to the attention of historians. Archaeological evidence featured prominently in several of the contributions and, although generally circumstantial, marked a significant expansion of the source base.[14] Sarris, who had attended the 2001 conference, published an article on the origins and non-literary sources of the plague in 2002. The latter part of his article was an explicit answer to Jean Durliat, who had pointed out the surprising absence of non-literary sources in a 1989 article that remains as influential as the main critical ('minimalist') paper on the Justinianic Plague.[15] Sarris' article was reprinted in Little's volume, making it more accessible to plague scholars.[16] Although Sarris only examines the first outbreak of plague in the early 540s, rather than later plague waves, it remains the main study for non-literary evidence for plague (see below).[17]

The 2001 conference also broke new ground by integrating biological data, notably DNA evidence from premodern skeletal assemblages. Michel Drancourt, a molecular biologist who had already worked on the early modern plague, presented a paper at the conference.[18] Although Drancourt did not include his paper in Little's volume, he subsequently published several articles about the evidence for *Y. pestis* in skeletal material he tied to the Justinianic Plague (see below). Little's book did include two important contributions that considered DNA evidence for the plague. Michael McCormick, who would become a leading figure in the field, published the first systematic outline of how pathogenic evidence could help scholars better understand the Justinianic Plague, drawing upon existing investigations of the Black Death. McCormick tried to instill among his fellow historians an awareness of scientific evidence's growing potential ('every passing week deepens biologists' understanding of DNA'). Using DNA evidence, historians could finally determine whether the Justinianic Plague was truly bubonic plague, a question then hotly debated, trace the spread of the disease in human remains, and use rat bones as proxies for

13 Morony, "'For whom does the writer write?'", 68–9.

14 See, for example, the contributions of H. Kennedy, 'Justinianic plague in Syria and the archaeological evidence', in Little (ed.), *Plague and the End of Antiquity*, 87–98; Maddicott, 'Plague in seventh-century England.'

15 J. Durliat, 'La peste du VIe siècle: pour un nouvel examen des sources byzantines', in C. Abadie-Reynal, C. Morrisson, and J. Lefort (eds.), *Hommes et richesses dans l'Empire byzantine* (Paris 1989) 107–19.

16 P. Sarris, 'The Justinianic plague: origins and effects', *Continuity and Change* 17,2 (2002) 169–182; P. Sarris, 'Bubonic plague in Byzantium: The evidence of non-literary sources', in Little (ed.), *Plague and the End of Antiquity*, 119–32. Little appears unaware of this, although Sarris noted it in the first footnote in his 2007 chapter. See Little, 'Preface', xiii.

17 See, for example, M. Meier, 'The "Justinianic plague": The economic consequences of the pandemic in the Eastern Roman Empire and its cultural and religious effects', *Early Medieval Europe* 24.3 (2016) 274, 280, who describes it as 'important and highly pertinent'.

18 See Little, 'Preface', xii–xiii.

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plague.[19] In another chapter, Robert Sallares used biological, but primarily epidemiological, studies in tandem with historical descriptions of the plague's extent to conclude that the pathogen responsible for the pandemic was *Y. pestis*.[20]

Little's volume also associated the plague with the end of antiquity. This was not the only book with a title about the end of antiquity and the beginning of the Middle Ages published at around the same time. Others included Chris Wickham's *Framing the Early Middle Ages* and Bryan Ward-Perkins' *The Fall of Rome*, neither of which paid much attention to the plague, clearly disagreeing with the argument that the plague ended antiquity. Although Little himself asserted that 'the time is not yet ripe for a lone author to undertake a continuous and fully integrated narrative', it was only a matter of time until both narratives were brought together.[21]

The first attempt at a synthesis was by William Rosen in his 2007 book *Justinian's Flea*.[22] Rosen wrote in sensational language for a public audience and used the plague to explain the fall of the Eastern Roman Empire. In his analysis, the plague weakened the empire so significantly that it easily fell to the Arabs a century later. Rosen was a trade press executive and his work is littered with factual errors, which led historians to disparage or ignore his book.[23] Nevertheless, scientists were more enthusiastic. Reviews of Rosen's book in two of the most prestigious journals of medicine strongly recommended it.[24] Although non-historians had published on the Justinianic Plague before, the de facto success of *Justinian's Flea* - according to Google Scholar, the book

19 M. McCormick, 'Toward a molecular history of the Justinianic pandemic', L. Little (ed.), *Plague and the End of Antiquity*, 290–312 [290]. McCormick's notion of continued discoveries in plague studies features in his recent thought as well. See his introduction of Science of the Human Past, *SoHP: Johannes Krause 2/16/17*, 2017, https://www.youtube.com/watch?v=ywlXj46SeUg at 00:00:15, 00:03:45, 00:04:25, 00:04:35.

20 R. Sallares, 'Ecology, evolution, and epidemiology of plague', in Little (ed.), *Plague and the End of Antiquity*, 231–89.

21 C. Wickham, *Framing the Early Middle Ages: Europe and the Mediterranean 400–800* (Oxford 2005); B. Ward-Perkins, *The Fall of Rome and the End of Civilization* (Oxford 2005); Little, 'Preface', xi–xii.

22 W. Rosen, *Justinian's Flea: Plague, Empire, and the Birth of Europe* (Penguin 2007). Notably, Antoniou and Sinakos' attempt to connect the scientific background for plague, demographic decline, and the end of antiquity was published in a leading Byzantine history journal, *Byzantinische Zeitschrift*. Their effort, however, was little noticed. See I. Antoniou and A. Sinakos, 'The sixth-century plague, Its repeated appearance until 746 AD and the explosion of the Rabaul Volcano', *Byzantinische Zeitschrift* 98.1 (2008) 1–4.

23 M. Kulikowski, 'Justinian's flea: Plague, empire, and the birth of Europe', *History: Reviews of New Books* 35.4 (2007) 148, described it as being 'a wasted opportunity'; A. Kaldellis, 'Plague and the end of antiquity: The pandemic of 541–750', and: 'Justinian's flea: Plague, empire, and the birth of Europe (Review)', *Journal of Late Antiquity* 1.2 (2008) 385–8, asserted that it 'is full of errors, misunderstandings, and outdated notions'; W. Treadgold, *Review of Justinian's Flea: Plague, Empire, and the Birth of Europe*, by William Rosen, *The Historian* 71.1 (2009) 172–3 claimed that the book 'is so inaccurate and poorly written as almost to give common sense a bad name'.

24 R. Dattwyler, 'Book review', *New England Journal of Medicine* 357, no. 13 (2007) 1354–5; T. Burki, 'Book: Justinian's flea: Plague, empire and the birth of Europe', *The Lancet Infectious Diseases; London* 7.12 (2007).

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has been cited in more than 100 studies as of 2018 - signaled that the debate was expanding to include more non-historians than ever before.[25]

Rosen's book was merely the tip of the iceberg. Following the 2001 conference, plague scholarship has rapidly expanded in at least three different areas: history, archaeology, and genetics. The growing number of methodologies and findings has introduced additional challenges. This development has introduced a rift between scientific and humanistic work on the plague. Scientific publications, for example, are multi-authored and increasingly technical. Since historians are not often trained to analyze scientific methods, especially statistics and 'big data', when working alone, they run the risk of reifying debatable or thin scientific evidence as established facts, resulting in circular reasoning in their own work. Meanwhile, scientists tend to ignore historical nuance, which can be difficult to understand and inaccessible, and base their work on obsolete historiography.[26]

Since many of the aforementioned fields do not engage with one another, but simply appropriate conclusions, we will examine each of these developments in turn. We will begin with traditional historical sources and non-literary sources. Afterwards, we will examine the developments in epidemiology, mass burials, genetics, and climate. We will continue by investigating demography, the prevailing paradigm, counter-narratives, and then the most recent research. In the last section we address potential future directions for plague research: earlier pandemics, analysis of the cultural effects of the plague, and the proliferation of multidisciplinary online resources. As recent interdisciplinary research suggests, the division between scientific and humanistic fields is resolvable, but will require more collaboration and co-operation between both groups to understand differing methodologies.

Traditional historical sources

The literary historical accounts of the plague narrative that serve as its foundation have been all but exhausted. Scholars have mined the famous accounts of the plague including Procopius, John of Ephesus, Evagrius, and Gregory of Tours, among others, for decades and they will probably yield few new arguments. Detailed discussions of plague passages in these sources have appeared as well, although some of the primary sources still await further nuanced discussion. For example, Bernard Bachrach has explored Gregory's discussions in significant detail, while Averil Cameron has done the same for Procopius.[27]

25 https://scholar.google.com/scholar?cites=5692900760900037153&as_sdt=800005&sciodt=0,15&hl=en

26 J. Roosen and D. R. Curtis, 'Dangers of non-critical use of historical plague data', *Emerging Infectious Diseases* 24.1 (2018) 103–10. And for the accessibility question: H. King and M. H. Green. 'On the misuses of medical history', *The Lancet* 391, no. 10128 (7 April 7 2018): 1354–5.

27 On this point, see D. Stathakopoulos, 'Death in the countryside: some thoughts on the effects of famine and epidemics', *Antiquité Tardive* 20 (2012) 107; in more detail: B. Bachrach, 'Plague, population, and economy in Merovingian Gaul', *Journal of the Australian Early Medieval Association* 3 (2007) 29–57; A. Cameron, *Procopius and the Sixth Century* (Berkeley 1985) 39–43.

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Other literary genres such as church councils, which discuss changes to burial practices, have also been linked to the plague.[28] Compared to the rich historiography on the literary sources of the plague for western Europe and Byzantium, far less scholarship has explored the plague's impact in southwest Asia, Persia or on the early Islamic Empire. If the plague devastated Eurasia, there should be more sources from other locations across southwest Asia in particular, but scholars of this region appear less interested in the plague's effects, with little research appearing over the past two decades.[29]

The comprehensive analyses of the plague written by Stathakopoulos, and earlier by Biraben and Le Goff, asserted that the plague returned up to 18 times in 'waves' from 541 until the late 740s, which might have reached as far north as Scandinavia and as far south as Yemen.[30] Nevertheless, the written evidence for most of these waves remains scant. It is not surprising, therefore, that scholars have increasingly turned to non-literary sources, especially as archaeological and DNA evidence burgeons.

Non-literary historical evidence was a serious gap in the scholarship before 2000. While most research on the plague quoted the literary sources and debated their veracity, non-literary sources enjoyed far less attention. In his 1989 article, Durliat addressed this lacuna explicitly, pointing out the lack of non-literary sources for the Justinianic Plague, establishing a challenge that scholars have sought to resolve for over a decade.[31]

The status quo changed in the early 2000s when Peter Sarris argued for the plague's impact through an analysis of epigraphic, legal, numismatic, and papyrological evidence to create a synthetic picture of the plague's significant socio-economic upheaval. Sarris responded directly to Durliat, but then expanded his analysis further.[32] Sarris used this new evidence, combined with the discussions of the plague's origins and impact, to argue that the plague was the culprit behind several ongoing contemporary state problems. By doing so, he established the plague as a central factor in the decline of the East Roman Empire independently from the written sources.[33]

Sarris did not discuss the extant relevant inscriptions, a key non-literary source in late antiquity. Two inscriptions that refer specifically to the plague have been found so far,

28 The specific causal link between canons and plague, however, does not necessarily exist, since the vocabulary for plague never appears. See M. McCormick, 'Tracking mass death during the fall of Rome's empire (I)', *Journal of Roman Archaeology* 28 (2015) 338, for one example. And see now: H. Gruber, 'Indirect Evidence for the Social Impact of the Justinianic Pandemic: Episcopal Burial and Conciliar Legislation in Visigothic Hispania', *Journal of Late Antiquity* 11 (2018), 193–215.

29 Conrad's works remain indispensable for the region, see: L. I. Conrad, 'The plague in the early Medieval Near East' (Princeton University 1981); L. I Conrad, 'Die Pest und ihr Soziales Umfeld im Nahen Osten des Frühen Mittelalters', *Der Islam* 73.1 (1996) 81–112.

30 For the waves: Stathakopoulos, *Famine and Pestilence*, 110 his list is at 113–24; for the geographic range: 116.

31 Durliat, 'La peste du VIe siècle'.

32 Sarris, 'The Justinianic plague', 173–8.

33 Sarris, 'The Justinianic plague', 169–73, 178–9.

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with several others referring to anonymous epidemics.[34] A more limited analysis of the datable Greek epitaphs in four Byzantine provinces demonstrated that the onset of the plague does coincide with a significant increase in dated epitaphs. The same study found some correlation between the number of known deaths from epitaphs and waves of plague.[35] These debates can themselves cause circular reasoning: single site excavations, such as Nessana and Gaza, tend to interpret ambiguous epitaphs dated to the early 540s as belonging to plague victims.[36]

Epidemiological questions

In an early attempt to move beyond more traditional historical sources, Michael McCormick introduced the study of rats in a seminal article, bringing a significant bibliography to the attention of plague scholars.[37] McCormick argued that it was possible to uncover new insights about trade, communications, and the plague by tracking and dating rat remains across the Mediterranean world. He acknowledged that the number of finds was small at the time, but expressed confidence that more research would improve our understanding.[38]

A closer examination of the historiography reveals that the connection between rats and plagues is assumed to be key, based upon research on the later two plague pandemics - the Second Pandemic (the Black Death), and the worldwide Third Pandemic that began during the 19th century and caused high mortality in India and, to a lesser extent, in China. The Justinianic Plague is almost exclusively compared to the Black Death, which many historians appear to think represents the 'standard' way plague behaves.

Although the rat-and-flea model is assumed for the Justinianic Plague, very little evidence exists for it during the sixth-century pandemic. Opponents point out that it is

34 Descriptions and discussions in N. Benovitz, 'The Justinianic plague: evidence from the dated Greek epitaphs of Byzantine Palestine and Arabia', *Journal of Roman Archaeology* 27 (2014) 491–2; McCormick, 'Tracking mass death (I)', 327–8; Meier, 'The "Justinianic plague"', 267–9. The building inscription from Syria is understood to refer to a bubo (πότμον βονβῶνος [sic] καὶ μάλης, which McCormick translates as 'an evil destiny of bubo and armpit'); an epitaph from Spain mentions that the person died ab inguinali plaga ('from the affliction of the groin').

35 Benovitz, 'The Justinianic plague', 495–96. The number of dead for 541, the beginning of the first outbreak, is sixteen - double the number of dead in any other year in the studied interval between 300–699.

36 For two examples: H. Colt, *Excavations at Nessana* (Princeton 1962) 168 no. 80 and 179–81 nos. 112–14; C. Glucker, *The City of Gaza in the Roman and Byzantine Periods* (Oxford 1987) 124–7 nos. 9–11. Glucker's proof of plague is a citation to Colt, who simply made the suggestion, but left the question open.

37 M. McCormick, 'Rats, communications, and plague: Toward an ecological history', *The Journal of Interdisciplinary History* 34, no. 1 (2003) 1–25; see also D. Stathakopoulos, 'Invisible protagonists: The Justinianic plague from a zoocentric point of view', in E. Anagnostakis, T. Kolias, and E. Papadopoulou (eds.), *Ζώα και περιβάλλον στο Βυζάντιο (7ος-12ος αι.) = Animals and Environment in Byzantium (7th-12th c.)*, 87–95 (Athens 2011) 87–95.

38 McCormick, 'Rats, communications, and plague', 9 knew of 65 finds of rat bones until the eighth century CE.

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based on a specific well-recorded case: the Third Pandemic in Bombay (modern Mumbai) in the early twentieth century.[39] Third Pandemic outbreaks elsewhere, for instance in Glasgow in 1900, reveal low numbers of rats and very low ratios of infected to non-infected rats.[40] A broader survey found only five cases of historical plague (pre-1800) in which primary sources mentioned rats.[41] Moreover, as Samuel Cohn repeatedly argued, the epidemiology of the devastating Second Pandemic does not fit the Third Pandemic.[42] The discrepancies between the mortality and the effects of these pandemics, present in the debates surrounding the Black Death, are largely unmentioned by historians of the Justinianic Plague.[43]

While research into the Justinianic Plague remains focused on the rat-and-flea model, scholars of the Black Death have proposed two alternative models. These could theoretically fit the Justinianic Plague, but the lack of evidence from late antiquity prevents scholars from testing them more thoroughly.

The first alternative associates the first pandemic with pneumonic plague emphasizes pneumonic plague as being the etiology for the pandemic. Its proponents stress that there is almost no textual and archaeological evidence for rats, since the rat-and-flea model would require very high numbers of commensal rats. They hypothesize that outbreaks in humans quickly became pneumonic, allowing humans to infect each other directly. Pneumonic plague is attractive for explaining historical pandemics because of its core features, namely its quick progression (death comes 1–3 days after onset of first symptoms) and its mortality rate (near 100%). Opponents of the pneumonic plague model point out that there is little historical evidence for major outbreaks of pneumonic plague. The only known large-scale examples occurred in Manchuria in the early twentieth century in unique environmental and demographic contexts. Although tens of thousands died, it was a result of rather specific conditions, living in close quarters and unsanitary conditions, which

39 K. Royer, 'The blind men and the elephant: Imperial medicine, medieval historians and the role of rats in the historiography of plague', *Medicine and Colonialism* (2014) 113–24. Royer points out that even in India the Third Pandemic varied in its epidemiology and notes that historians prefer to seek a one-size-fits-all explanation for complex and protean biological phenomena. For a recent study about the Black Death, see: K. Dean et al., 'Human ectoparasites and the spread of plague in Europe during the Second Pandemic', *Proceedings of the National Academy of Sciences* 115.6 (2018) 1304–9.

40 K. Dean, F. Krauer, and B. Schmid, 'Epidemiology of a bubonic plague outbreak in Glasgow, Scotland in 1900', *Royal Society Open Science* 6.1 (2019) 3.

41 Sallares, 'Ecology, evolution, and epidemiology of plague', 269. This work does not appear to be comprehensive and Sallares maintained his support for the rat-and-flea model.

42 S. Cohn, 'The Black Death: end of a paradigm', *The American Historical Review* 107.3 (2002) 703–38; S. Cohn, 'Epidemiology of the Black Death and successive waves of plague', *Medical History. Supplement*, no. 27 (2008) 75–77, also discusses the discrepancies between the Justinianic Plague and the Third Pandemic; see also P. Horden, 'Mediterranean plague in the age of Justinian', in M. Maas (ed.), *The Cambridge Companion to the Age of Justinian* (Cambridge 2005) 134–60; Royer, 'The blind men and the elephant'.

43 While Stathakopoulos, *Famine and Pestilence*, 112 suggests that the next two pandemics should be studied, he cited nine recent works on the Black Death, but only one (from 1936) on the Third Pandemic.

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facilitated the spread of pneumonic plague. Moreover, the high virulence of pneumonic plague would normally prevent it from disseminating quickly, since it would kill people faster than they could infect others.[44]

The second alternative accepts that plague was mostly bubonic, but instead of rats and fleas, it asserts that the hosts and vectors were respectively humans and human ectoparasites (e.g. human fleas and lice).[45] While this is an attractive explanation, since it overcomes the lack of evidence for the rat-and-flea model, it is difficult, if not impossible, to prove since it does not (and arguably cannot) provide any positive evidence. Moreover, opponents of this model point out that human fleas seem to be inefficient plague vectors.[46]

Since these possibilities are intractable for the moment, recent studies of the Black Death instead use mathematical mortality models based upon specific city outbreak data and try to match modern epidemiological knowledge with medieval temporal mortality patterns.[47] Disregarding arguments against such methodologies, a similar approach to the Justinianic Plague is impossible since there is no comparable detailed demographic dataset.

A final question about the epidemiology of the Justinianic Plague relates to its geographical origins. Prokopios mentions that the plague started in Pelusium, in the eastern Nile Delta. Most scholars accept this information, but they disagree about whether the plague arrived there from sub-Saharan Africa or Central Asia.[48] More

44 J. Kool, 'Risk of person-to-person transmission of pneumonic plague', *Clinical Infectious Diseases: An Official Publication of the Infectious Diseases Society of America* 40.8 (2005) 1166–72. For an argument against pneumonic, see E. Begier et al., 'Pneumonic plague cluster, Uganda, 2004', *Emerging Infectious Diseases* 12.3 (2006) 460–67.

45 See, for example, M. Drancourt, L. Houhamdi, and D. Raoult, 'Yersinia Pestis as a telluric, human ectoparasite-borne organism', *The Lancet Infectious Diseases* 6, no. 4 (2006) 234–41; A. Hufthammer and L. Walløe, 'Rats cannot have been intermediate hosts for Yersinia Pestis during medieval plague epidemics in Northern Europe', *Journal of Archaeological Science* 40, no. 4 (2013) 1752–59; L. Houhamdi and D. Raoult, 'Different genes govern Yersinia Pestis pathogenicity in Caenorhabditis Elegans and human lice', *Microbial Pathogenesis* 44.5 (2008) 435–37; R. Piarroux et al., 'Plague epidemics and lice, Democratic Republic of the Congo', *Emerging Infectious Diseases* 19.3 (2013) 505–6.

46 Cohn, 'Epidemiology', 95–7; B. M. S. Campbell, *The Great Transition* (Cambridge 2016) 232–3.

47 See for example K. Dean, 'Modeling plague transmission in medieval European cities' (University of Oslo, 2015), https://www.duo.uio.no/bitstream/handle/10852/45490/KDPlagueThesis.pdf?sequence=9; Dean et al., 'Human ectoparasites'.

48 Although historians were well aware that they could not resolve this question by themselves, they made arguments for both places of origin. C. Tsiamis, E. Poulakou-Rebelakouand E. Petridou, 'The Red Sea and the port of Clysma. A possible gate of Justinian's Plague', *Gesnerus* 66.2 (2009) 209–17, argued that plague reached Pelusium through the port of Clysma in the Red Sea; For an African origin, see Sarris, 'Bubonic Plague in Byzantium', 120–3. For a central Asian origin, see for example: M. Green et al., 'Yersinia Pestis and the three plague pandemics', *The Lancet Infectious Diseases; London* 14.10 (2014) 918; V. Kutyrev et al., 'Phylogeny and classification of Yersinia Pestis through the lens of strains from the plague foci of Commonwealth of Independent States', *Frontiers in Microbiology* 9 (2018) 1106.

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recent biological and DNA research appears to have settled the question in favour of a central Asian origin.[49]

At this point, it might be worth asking how these debates, which have consumed a great deal of scholarly energy, have advanced our understanding of the Justinianic Plague's effects upon the Mediterranean world. After all, neither suggest anything about the broader political, social, and cultural effects of the plague.[50] As more research on the Black Death and Third Pandemic accumulated, it became clear that even identifying the pathogen as *Y. pestis* did little to clarify some of the most basic questions about plague epidemiology or the late antique plague experience. Although rarely appearing in print, opponents of these debates tend to suggest that the attention to technical epidemiological questions moves the focus of research away from the actual effects of the plague upon the human societies that experienced it.[51]

Mass burials

A potentially more promising approach is to examine the archaeological evidence for the plague. Since Black Death plague victims have often been found in large mass graves, some scholars have argued that Justinianic- era mass graves might similarly contain plague victims. Yet, reaching any conclusion is difficult as the archaeological burial and DNA evidence is difficult to interpret. For example, the first DNA evidence thought to be relevant to the Justinianic Plague was extracted from human remains from France, which were tested because they were buried in a mass grave that appeared to have been hastily dug. Although archaeologists working on the site were reluctant to connect all the victims to the plague, a few of the remains tested positive for *Y. pestis*. Subsequent tests revealed that these results were probably contaminated. This would not preclude further tests on French sites or new finds in France with possible archaeological evidence of plague victims, although no such tests have been published on Justinianic Plague remains since 2007.[52]

49 Y. Cui et al., 'Historical variations in mutation rate in an epidemic pathogen, Yersinia Pestis', *Proceedings of the National Academy of Sciences of the United States of America* 110.2 (2013) 577–82. The conclusion has been accepted by historians, e.g. M. Green, 'Taking "pandemic" seriously: making the Black Death global,' *The Medieval Globe* 1 (2014) 36–7; N. Varlık, *Plague and Empire in the Early Modern Mediterranean World: The Ottoman Experience, 1347–1600* (Cambridge 2015) 19–20 (emphasizing the origins of rats); K. Harper, *The Fate of Rome: Climate, Disease, and the End of an Empire* (Princeton 2017), 210–14.

50 Such questions have been asked, for instance by: Horden, 'Mediterranean plague'; J. Hays, 'Historians and epidemics: Simple questions, complex answers', in Little (ed.), *Plague and the End of Antiquity*, 42ff.

51 See, for example, the hints in Horden, 'Mediterranean plague', 143ff and his stronger conclusion that the Justinianic Plague 'absorbs a great deal of our energy; it gives very little out' (p. 157).

52 For the positive DNA tests, see M. Drancourt et al., 'Yersinia Pestis Orientalis in remains of ancient plague patients', *Emerging Infectious Diseases* 13, no. 2 (2007) 332–3; and for the archaeological evidence: M. Signoli et al., 'Une sépulture de pestiférés du Haut Moyen Âge à Vienne (Isère)', *Archéologie du Midi médiéval* 27.1 (2009) 19–29. See now also Keller et al. 'Ancient Yersinia pestis genomes from

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More recently, Michael McCormick has catalogued dozens of mass graves (defined as five individuals or more) across the late antique Mediterranean world in order to understand the phenomenon of mass burial.[53] He was able to link some mass graves to the general timing of various plague outbreaks, with an increase in their frequency over time. Upon closer examination, however, the connection between the location of the mass graves and independent historical or archaeological evidence of high plague mortality is weak, if it even exists. McCormick himself acknowledged that burial practices were probably more nuanced, suggesting that mass graves might be an urban burial practice, while we might expect to find rural plague victims in single graves.[54]

Subsequent research raised other doubts about McCormick's hypothesis altogether. First, there is the need to differentiate between mass graves and multiple burials, since large graves from the Black Death were hastily dug while graves from the first pandemic period, especially in Western Europe, contained grave goods in 'standard' Merovingian style. Secondly, multiple inhumations in the same graves were a normative burial practice in locations throughout the late and post- Roman and Byzantine worlds.[55] As a whole, mass graves could be proxies for the Justinianic Plague, but more supporting evidence is required to confirm this hypothesis.

Aside from mass graves and epigraphy, archaeology has been used in a variety of ways to debate the spread, mortality, and virulence of the plague. Both Chris Wickham's and Michael McCormick's syntheses of the late antique Mediterranean have traced the slow disintegration of Roman trade networks and its fracturing into smaller regional connections. Demographic decline, due to the plague, may have played a role in this process, but neither scholar places it as a central driver. If it is mentioned, the plague is one of many changes during the transition from the ancient to the medieval world.[56]

Similarly, scholars have generally not connected most regional transformations to the plague. Syria is a case in point. While a few scholars, such as Hugh Kennedy, have dated the decline in Syrian rural and urban sites to the mid-sixth century, and causally

across Western Europe reveal early diversification during the First Pandemic (541–750)', *Proceedings of the National Academy of Sciences*, 116.25 (2019) 12363–12372.

53 McCormick, 'Tracking mass death (I)'; M. McCormick, 'Tracking mass death during the fall of Rome's empire (II): A first inventory of mass graves', *Journal of Roman Archaeology* 29 (2016) 1004–7, for the catalogue of mass graves.

54 McCormick, 'Tracking mass death (I)', 333.

55 D. Gutsmiedl-Schümann et al., 'Digging up the plague: A diachronic comparison of aDNA confirmed plague burials and associated burial customs in Germany', *Praehistorische Zeitschrift* 92.2 (2018), 408, 410, 416; E. Ivison, 'Burial and urbanism at Late Antique and early Byzantine Corinth (c. AD 400–700)', in N. Christie and S. T. Loseby (eds.), *Towns in Transition: Urban Evolution in Late Antiquity and the Early Middle Ages* (Brookfield, VT 1996), 108–10, 112–14; T. Schneider, 'Mehrfachbestattungen von Männern in der Merowingerzeit', *Zeitschrift für Archäologie des Mittelalters* 36 (2008) 1–32, for Merovingian graves in particular.

56 Wickham, *Framing the Early Middle Ages*; M. McCormick, *Origins of the European Economy: Communications and Commerce, A.D. 300–900* (Cambridge 2001).

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linked it to the plague, many others disagree.[57] Historians such as Jairus Banaji and archaeologists who have excavated numerous sites in Palestine and Syria, such as Gideon Avni and Jodi Magness, found no evidence of decline due to the plague or any other 'disaster', but rather continuous, intensified occupation.[58] Further archaeological evidence would need to be compared in different regions to identify any broad plague effect. In the current state of debate, it remains difficult to use material culture as a causal link between the plague and demographic collapse.

Identifying and reconstructing Late Antique *Yersinia pestis*

Perhaps the seminal question about the plague for most of the early twenty-first century was whether the pathogen behind the Justinianic Plague was really the *Y. pestis* bacterium. The heated debates were based upon historical, archaeological, and modern epidemiological comparative cases, but remained inconclusive until ancient DNA (aDNA) finds firmly associated *Y. pestis* with the Justinianic Plague.[59]

Over the past two decades, aDNA evidence has become a useful resource to identify premodern plague cases. This evidence is extracted from the dental pulp of teeth from skeletal remains found in archaeological excavations. Initial analyses were performed in the late 1990s and were focused on late medieval and early modern human remains, but these tests quickly expanded to include remains dated to late antiquity. Michel Drancourt and his collaborators first identified plague remnants from skeletal remains in France and subsequently claimed to have found evidence of plague in graves in Vienne and Poitiers, France.[60] Although later research indicated Drancourt's results were flawed due to insufficient anti-contamination protocols, his team pioneered the testing of mass burial sites for plague and his colleagues and students have continued to publish on sites in France and Italy.[61]

57 Kennedy, 'Justinianic Plague in Syria'.

58 G. Avni, *The Byzantine-Islamic Transition in Palestine: An Archaeological Approach* (Oxford 2014); J. Magness, *The Archaeology of the Early Islamic Settlement in Palestine* (Winona Lake, IN 2003).

59 The connection between *Y. pestis* and the historical pandemics was assumed until called into question in 1984. For a review of the debate, see L. Little, 'Plague historians in lab coats', *Past & Present* 213.1 (2011): 272ff. For a useful review of scientific research on plague, see K. Gage and M. Kosoy, 'Natural history of plague: Perspectives from more than a century of research', *Annual Review of Entomology* 50 (2005) 505–28. See below for a survey of ancient DNA, which is comprehensive through August 2018, but only discusses a few key updates afterward.

60 M. Drancourt et al., 'Genotyping, Orientalis-like Yersinia Pestis, and plague pandemics', *Emerging Infectious Diseases* 10, no. 9 (2004) 1585–92; for Vienne: Drancourt et al., 'Yersinia Pestis Orientalis'. For Poitiers, see: D. Castex and S. Kacki, 'Demographic patterns distinctive of epidemic cemeteries in archaeological samples', *Microbiology Spectrum* 4, no. 4 (2016), which is based on material culture remains and not DNA.

61 For problems: G. Vergnaud, 'Yersinia Pestis genotyping', *Emerging Infectious Diseases* 11.8 (2005) 1317–19; M. Prentice, T. Gilbert, and A. Cooper, 'Was the Black Death caused by Yersinia Pestis?', *The Lancet. Infectious Diseases* 4.2 (2004) 72; and most notably: M. T. P. Gilbert et al., 'Absence of Yersinia

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Another group of researchers based in Germany has been performing aDNA analysis at two Bavarian cemeteries: Aschheim and Altenerding, which are approximately twenty miles apart. Ingrid Wiechmann and Gisela Grupe first identified *Y. pestis* in 2005 at Aschheim and later studies confirmed its presence using more rigorous techniques.[62] Michal Feldman and colleagues have more recently confirmed the presence of the plague at Altenerding, although their study noted a number of variances when compared against the Aschheim genome data that would suggest problems in data collection at one or both of the sites.[63] A recent article by Marcel Keller and his colleagues has isolated *Y. pestis* DNA from approximately 45 individuals in central and western Europe dating to late antiquity.[64] Doris Gutsmiedl-Schümann and colleagues have noted that it remains difficult to fit the aDNA evidence with the independent archaeological evidence from these burials. Not only were existing burial traditions maintained, but some of those who tested positive for plague were in fact among the richest graves in both cemeteries. In the words of the authors, 'there are no archeological indications that these people died of the plague'.[65]

As a complicating factor, the teams working on aDNA rarely include historians and often base their work on outdated historiography. On the other hand, historians often lack the technical knowledge required to assess the robustness of the scientific data. In addition, they tend to cite and discuss the Bavarian evidence in more detail and more frequently than the French and other cases. However, the French archaeological evidence is entirely ignored even though it could provide useful comparative evidence for burial methods.

Pestis- specific DNA in human teeth from five European excavations of putative plague victims', *Microbiology* 150.2 (2004) 341–54. M. Harbeck et al., 'Yersinia Pestis DNA from skeletal remains from the 6th century AD reveals insights into Justinianic Plague', *PLOS Pathogens* 9.5 (2013); further critiqued Drancourt et al.'s 2007 paper. On more recent French work, see the special journal issue edited by: M. Drancourt and D. Raoult (eds.), *Paleomicrobiology of Humans* (Washington, D.C. 2016). For a personal discussion of these debates, see D. Raoult, 'A personal view of how paleomicrobiology aids our understanding of the role of lice in plague pandemics', *Microbiology Spectrum* 4.4 (2016). On Italy and France from the High Middle Ages: T-N-N. Tran et al., 'High throughput, multiplexed pathogen detection authenticates plague waves in medieval Venice, Italy', *PLoS ONE* 6.3 (2011); T-N-N. Tran et al., 'Brief communication: Co-detection of Bartonella Quintana and Yersinia Pestis in an 11th-15th burial site in Bondy, France', *American Journal of Physical Anthropology* 145.3 (2011): 489–94.

62 I. Wiechmann and G. Grupe, 'Detection of Yersinia pestis DNA in two early medieval skeletal finds from Aschheim (Upper Bavaria, 6th century A.D.)', *American Journal of Physical Anthropology* 126.1 (2005): 48–55; Harbeck et al., 'Yersinia Pestis DNA'; D. Wagner, 'Yersinia Pestis and the plague of Justinian 541–543 AD: A genomic analysis', *The Lancet Infectious Diseases* 14.4 (2014): 319–26.

63 M. Feldman et al., 'A high-coverage Yersinia Pestis genome from a sixth-century Justinianic Plague victim', *Molecular Biology and Evolution* 33.11 (2016): 2911–23.

64 Keller et al. 'Ancient Yersinia pestis genomes from across Western Europe', has the total numbers.

65 Gutsmiedl-Schümann et al., 'Digging up the plague'. The quote is from p. 410 and refers to the Aschheim cemetery, although the same phenomenon is discussed for Altenerding as well.

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Most aDNA studies focus their efforts on confirming the presence of *Y. pestis* and then placing it on the phylogenetic tree of *Y. pestis* - a graphic representation of the relationship between all known modern and premodern plague strains. This allows scientists to trace connections between plague outbreaks which has in turn advanced scholarship significantly. A few decades ago the plague was divided into three theoretical biovars – antiqua, mediaevalis, and orientalis – which were supposedly connected to the three pandemics.[66] Studies over the past twenty years have rejected this division, showing that the plague developed and branched off repeatedly during its history. Multiple studies since the beginning of the decade, including the most recent research, agree that the Justinianic Plague strains are not directly ancestral to later strains, which could mean that late antique plague was not established in multiple, long-lived or highly active reservoirs.[67] This issue further hinders any attempt to model the impact of the Justinianic Plague. Any extrapolation from the genetics of premodern plague strains to the mortality, virulence, and epidemiology of premodern plague is, therefore, problematic. Late antique and late medieval plague strains were capable of being rat-borne and flea-transmitted, but that need not mean they principally were.

Climate and plague

In recent decades, climatic changes have been raised as a major causal agent in the appearance and spread of premodern pandemics. In its many reservoirs, plague has been argued to have a connection with climate. Climate affects the wild sylvatic rodents that maintain plague foci. Plague ecologists, working with paleoclimatologists, have attempted on several occasions to work backward, using modern knowledge to speculate on the impact of climate upon past plague foci. While the connection had been hypothesized based on historical sources, Ulf Büntgen's research group recently synthesized evidence from multiple types of paleoclimate proxies (e.g. tree rings, lake sediments, etc.) and from earlier scholarship to demonstrate the centrality of a series of volcanic eruptions from the mid-530s through the late 540s to an overall

66 R. Devignat, 'Variétés de l'espèce Pasteurella Pestis', *Bulletin of the World Health Organization* 4.2 (1951) 247–63.

67 For the most recent phylogenetic trees, see P. de Barros Damgaard et al., '137 ancient human genomes from across the Eurasian steppes', *Nature* 557, no. 7705 (2018) fig. 9 (Extended Data); and the synthesis with several descriptions of branches on the larger tree in Kutyrev et al., 'Phylogeny and classification'. Another updated version is in pre-print: Zhou, et al., 'The user's guide to comparative genomics with EnteroBase. Three case studies: micro-clades within Salmonella enterica serovar Agama, ancient and modern populations of Yersinia pestis, and core genomic diversity of all Escherichia', *bioRxiv* (2019). For discussions, see Green et al., 'Yersinia Pestis and the three plague pandemics'; G. Sussman, 'Scientists doing history: Central Africa and the origins of the First Plague Pandemic', *Journal of World History* 26.2 (2016) 325–54.

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transformation in Northern Hemispheric climate. This period of cooling was termed the 'Late Antique Little Ice Age' and was connected to various events from the Justinianic Plague through the Arab invasions of the Near East in the 630s.[68]

Building upon the work of Büntgen's research group, Kyle Harper associated this mid-sixth-century temperature downturn with increased epidemic mortality alongside the population's greater susceptibility to disease because of agricultural crises. This implicitly follows the Second Pandemic model, in which the Black Death followed the Great Famine and perhaps caused increased mortality due to earlier shortages. Harper firmly linked the first emergence of the Justinainic Plague to volcanic activity in the year 536, which created a 'year without summer' and the perfect incubation for the plague's emergence.[69]

While these correlations are notable, the causation between climate, weather, and plague remain unclear.[70] Most studies assume a uniform change to climate across all plague affected regions and that colder, wetter weather is the best driver despite the lack of consensus on the weather's impact upon plague.[71] In contrast, others have suggested warmer weather and wetter summers or cooling after an unusually warm sequence of summers in the 520s were more conducive for spreading the plague.[72] Perhaps most importantly, micro-regions are more useful vehicles to understand climate change. Asia Minor alone, for example, has at least seven sub-regional zones, with significant climatic variability even within these zones. Climate changes have

68 U. Büntgen et al., 'Cooling and societal change during the Late Antique Little Ice Age from 536 to around 660 AD', *Nature Geoscience* 9.3 (2016) 231–6. For previous linkages between plague and climate, see N. Stenseth et al., 'Plague dynamics are driven by climate variation', *Proceedings of the National Academy of Sciences of the United States of America* 103.35 (2006) 13110–15; B. Schmid et al., 'Climate-driven introduction of the Black Death and successive plague re-introductions into Europe', *Proceedings of the National Academy of Sciences* 112.10 (2015) 3020–3025.

69 Harper, *The Fate of Rome*, 167–75, 218–20; K. Harper, 'Invisible environmental history: Infectious disease in Late Antiquity', *Late Antique Archaeology*, (2018). The catastrophist-determinist connection between the volcanic activity and the ensuing societal disruption and collapse world was discussed in a sensational form by Keys almost two decades ago. See D. Keys, *Catastrophe: An Investigation into the Origins of the Modern World* (London 1999). For a more scholarly approach, which lacked some of the data now available, see: A. Arjava, 'The mystery cloud of 536 CE in the Mediterranean sources', *Dumbarton Oaks Papers* 59 (2005) 73–94.

70 On the difficulties in establishing such a connection, see: T. Newfield, 'Mysterious and mortiferous clouds: The climate cooling and disease burden of Late Antiquity', *Late Antique Archaeology* (2018).

71 L. Xu et al., 'Wet climate and transportation routes accelerate the spread of human plague', *Proceedings of the Royal Society B: Biological Sciences* 281, no. 1780 (2014) 1–9; also, T. Snäll, R. E. Benestad, and N. C. Stenseth, 'Expected future plague levels in a wildlife host under different scenarios of climate change', *Global Change Biology* 15.2 (2009) 500–7.

72 Stenseth et al., 'Plague dynamics' for warmer springs and wetter summers; Schmid et al., 'Climate-driven introduction of the Black Death' for cooling after a warm period.

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affected each of these regions in a variety of ways across the centuries.[73] Drawing simple causal conclusions from Eurasian-wide climate changes is problematic.

Moreover, recent studies of the ongoing Third Pandemic (c. 1850-present) suggest that micro-climates are more important than continent-wide climate change in influencing the plague's spread. Lei Xu's study suggested that wetter and drier weather, and colder and hotter climates, may all help spread the plague depending on complex variable interaction within different micro-environments. Parts of northern and southern China, for example, had all types of weather, which both helped and hindered the plague's spread and mortality.[74] These findings suggest that a simple correlation between colder weather and the plague's first outbreak in 541–542 is uncertain at best, if not unfounded.[75]

Demographic effects

Scholars have attempted to quantify the late antique demographic decline plague caused, which is, perhaps, the central question driving all plague studies. If severe demographic contraction could be linked to the Justinianic Plague, it would help answer many questions regarding contemporary changes in land use and the extent of arable agriculture, urban decline, tax revenue, and reduced army size, among many other issues. Depending on its ability to cause high mortality, the late antique plague could have had cascading effects that may have persisted for centuries. Scholars differ in how they discuss mortality, with some preferring blanket statements for the entire Byzantine Empire and others differentiating between cities and rural areas or between Constantinople and other cities. Although scholars examining mortality rates all use the same data, they reach varying conclusions and rarely explain their reasoning. These attempts to estimate plague mortality and the ensuing demographic effects have not changed methodologically before or after Stathakopoulos' 2000 article.[76] Surprisingly, few critical studies have proposed holistic demographic models through extrapolations from known data.

Stathakopoulos was relatively careful in his analysis and suggested a mortality rate of about twenty percent in Constantinople during the first outbreak, but was otherwise reluctant to give numbers or percentages, although he believed it was a key event in

73 J. Haldon et al., 'The climate and environment of Byzantine Anatolia: Integrating science, history, and archaeology', *Journal of Interdisciplinary History* 45.2 (2014) 113–61; A. Izdebski, *A Rural Economy in Transition: Asia Minor from Late Antiquity into the Early Middle Ages* (Warsaw 2013).

74 L. Xu et al., 'Nonlinear effect of climate on plague during the Third Pandemic in China', *Proceedings of the National Academy of Sciences* 108.25 (2011) 10214–19; Xu et al., 'Wet climate and transportation routes'.

75 On this, and for a broader nuanced discussion about the connection between plague and climate, see Newfield, 'Mysterious and mortiferous clouds: The climate cooling and disease burden of Late Antiquity.'

76 Stathakopoulos, 'The Justinianic Plague revisited', 262ff.

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the demographic development of the Byzantine state.[77] Horden suggested that the mortality was around twenty to thirty percent of the Mediterranean population, while Antoniou and Sinakos accept that a third of the capital's population died and between a sixth and a tenth of the overall population.[78] Notably, these numbers seem to increase significantly in papers scientists write. Already in 2005, in his study on the epidemiology of pneumonic plague, Kool asserted that almost one hundred million people died.[79] David Wagner similarly estimated that one hundred million people died and a mortality rate of between fifteen and forty percent for the entire empire in subsequent outbreaks.[80] Harper, the most significant recent contributor to the debate (see below), suggested an initial fifty percent population reduction in the Eastern Roman Empire (of a thirty million total population) followed by subsequent ten percent mortality every fifteen years thereafter.[81]

Existing paradigm

The rapid research progress in different fields of the Justinianic Plague has until recently hindered efforts to synthesize the current state of the field into a narrative. Stephen Mitchell's survey of the later Roman Empire argued in favour of significant mortality from the initial outbreak in the 540s through the reign of Heraclius (610–41). Mitchell's synthesis compiled examples from all the relevant sources – literary, epigraphic, archaeological, and demographic – into a narrative that cautiously, but demonstrably, favoured a pessimistic outcome for the empire. Mitchell concentrated on the archaeological evidence across the Mediterranean, in which he saw rapid signs of decline in almost every region.[82] While he was careful to note the ongoing debate

77 Stathakopoulos, *Famine and Pestilence*, 139–41; repeated in D. Stathakopoulos, 'Population, demography, and disease,' in E. Jeffreys, J. Haldon and R. Cormack (eds.), *The Oxford Handbook of Byzantine Studies* (Oxford 2008) 310. An estimate found separately in C. Zuckerman, *Du village à l'empire: autour du registre fiscal d'Aphroditô (525/526)* (Paris 2004), 189–212 but who noted the population seems to have rebounded within a decade.

78 Horden, 'Mediterranean plague', 149; Antoniou and Sinakos, 'The sixth-century plague.'

79 Kool, 'Risk of person-to-person transmission', 1166. The number is not cited in Kool's source for the paragraph.

80 Wagner, 'Yersinia Pestis and the Plague of Justinian.' Their estimate is based upon Procopius' *Secret History*, which they admit 'is disputed'.

81 Harper, *The Fate of Rome*, 244.

82 S. Mitchell, *A History of the Later Roman Empire, AD 284–641*, 2nd edn (Chichester 2015), 410–13, 479–91. Notably, Mitchell divides sites between pre-and post-550 dating to suggest that a demographic decline is a direct result of the plague. However, the imprecision in dating material culture through archaeological evidence, alongside the other potential causes for demographic decline in the mid-sixth century, cast doubt on these conclusions. J-P. Devoery, 'Catastrophe, crise et changement social: à propos des paradigmes d'interprétation du développement médiéval (500–1100)', in L. Buchet, C. Rigeade and I. Séguy (eds.), *Actes des 9e Journées Anthropologiques de Valbonne* (Valbonne 2009) argues for an increase in uncultivated land starting already in the third century in the west, which might have accelerated due to further declines in the sixth century.

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over the plague's impact, his maximalist narrative promoted the plague as being one of the causes of the 'end' of the Eastern Roman Empire.

The most recent synthesis of these diverse areas of research is Kyle Harper's *Fate of Rome,* published in 2017. Harper expanded Peter Sarris and Michael McCormick's academic maximalist paradigm, which remains the normative position of the field, with a popular writing style aimed at a wider audience.[83] He connected all the pieces of evidence - literary, non-literary, archaeology, rat remains, aDNA, and natural climate archives - to synthesize the narrative of the end of Rome. Using wonderfully evocative language, Harper argued for three devastating pandemics: the Antonine Plague, the Cyprian Plague, and the Justinianic Plague. Together with an oddly defined Late Antique Little Ice Age, these disease events are deterministically cast as eroding the empire's population and leading to the end of the ancient world. His book is the first synthesis to grapple with the transformation of the entire late antique world through the lens of disease and climate.[84]

Counter arguments

Most critiques of plague research focus upon the direction of historiographical debate rather than on plague evidence. Peregrine Horden, for example, discussed the plague evidence, only to suggest that the entire debate focused on the wrong questions. According to Horden, the plague simply confirms the presence of existing trade networks – for which archaeological and material culture remains are far more plentiful – and the debate about plague itself reveals little more about the sixth-century world.[85]

After Durliat's 1989 article, few revisionists have engaged with the substantial arguments plague maximalists have compiled over the past few decades.[86] A debate about the plague's effects does not exist in practice. The disagreement with the existing maximalist plague paradigm is confined to an abstract argument based on principle, rather than evidence and its interpretation. Mark Whittow, for example, dismissed the plague's effects in a few short pages, while Chris Wickham's overview of medieval history noted the incongruity between the dynamic economic situation in the sixth-century Eastern Mediterranean and the plague's supposed massive impact. Both scholars disagree on the extent of the plague's consequences, but neither countered more recent analyses, notably Sarris' arguments, nor proposed an alternative.[87] Most revisionist scholarship on the plague remains limited to a brief rejection of the

83 For the originals: McCormick, 'Rats, communications, and plague'; McCormick, 'Tracking mass death (I)'; Sarris, 'The Justinianic Plague.'

84 Harper, *The Fate of Rome*.

85 Horden, 'Mediterranean plague'.

86 Durliat, 'La peste du VIe siècle'.

87 M. Whittow, *The Making of Byzantium, 600–1025* (Berkeley 1996), 66–68; C. Wickham, *Medieval Europe* (New Haven 2016), 43–4; Sarris, 'The Justinianic Plague.'

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mortality claims and the socio-cultural effects of plague, but rarely, if ever, engages with the material its proponents have offered.

Cracks have, however, begun appearing at the seams of the plague narrative at the regional level. Clive Foss's detailed survey of Syrian cities found little evidence for major effects of the plague, arguing that the plague 'was not such a widespread disaster as it has been portrayed and that it was not the agent of fundamental change.'[88] Bachrach meanwhile argued that in Gaul the plague did not have a significant long-term demographic effect either.[89]

Most recently, we have laid out a substantial critique of the maximalist interpretation, which has, for the first time, engaged with its proponents across all the disciplinary evidence. We argue that the evidence of the plague's mortality is tenuous and does not indicate massive demographic collapse and the end of antiquity. Instead, its effects remained limited beyond the local and short-term.[90]

Recent developments

Due to the trends of the last twenty years, the Justinianic Plague is firmly entrenched in scholarly and public conversations as an explanation for the transformation from the ancient to the medieval world. Three recent avenues of scholarship could be incorporated into future research.

1. Earlier plague pandemics?

Scholars generally believe that the first outbreak of the Justinianic Plague was more lethal than subsequent outbreaks because it was unexpected and unknown. Mid-sixth-century people had no previous cultural or immunological experience with *Y. pestis*. Nevertheless, other historians have argued persuasively that plague had persisted in the southeastern Mediterranean region earlier, as the evidence of Rufus of Ephesus suggests.[91] At the same time, evolutionary biologists have demonstrated clearly that *Y. pestis* was widely dispersed in western Eurasia more than a thousand years before the onset of the Justinianic Plague. If true, this could mean that plague was endemic or enzootic in the western Eurasian world.

Lars Walløe has argued that another ancient plague pandemic caused the end of the Mycenaean world and severe disruptions across the eastern Mediterranean from c. 1200–900 BCE. Scholars have proposed many different explanations for the collapse of the

88 C. Foss, 'Syria in transition, A. D. 550–750: An archaeological approach', *Dumbarton Oaks Papers* 51 (1997) 260.

89 Bachrach, 'Plague, population, and economy.' This is not an uncommon position: J-P. Devroey, *Économie rurale et société dans l'Europe franque: VIe - IXe siècles. T. 1: Fondements matériels, échanges et lien social* (Paris 2003); Devroey, 'Catastrophe, Crise et Changement Social', 146, 148–9.

90 L. Mordechai and M. Eisenberg, 'Rejecting catastrophe: The case of the Justinianic Plague', *Past & Present* 244 (2019) 3–50.

91 See a brief discussion in Sallares, 'Ecology, evolution, and epidemiology of plague', 251.

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Mycenaean world, and Walløe supplemented the existing list with plague based on an epidemic mentioned in the Old Testament (1 Samuel 5 and 6), re-imagining the Mycenaean collapse as being a parallel version of the first and second pandemics.[92]

Evidence for prehistoric plague cases have likewise been found in ancient DNA. Simon Rasmussen and his team asserted that *Yersinia pestis* was endemic across Eurasia after finding remains with plague DNA from 5,000 years ago. However, they noted that this Bronze Age *Y. pestis* was not capable of causing the bubonic type of plague, which was a later genetic development.[93] Recent research by Maria Spyrou's team revised these conclusions and asserted that bubonic-plague-causing strains had appeared, at least in some regions, as early as c. 4,000 years ago.[94]

The gap between these Bronze Age finds and the Justinianic Plague was recently bridged in another aDNA article, which surveyed 137 ancient human genomes from the Eurasian steppes. Of the two cases of plague they found, the authors dated one set from the Tian Shan mountains in Central Asia to c. 200 CE. Although relatively far spatially, this brings the pre-Justinianic Plague DNA finds well into temporal proximity with the earliest known literary evidence for plague in Rufus of Ephesus. The exact connection between this find and the Justinianic Plague remains unknown, and future research is likely to further illuminate the pre-Justinianic Plague disease environment.

2. *Plague-driven cultural change*

Scholars have proposed a variety of connections between the plague and cultural change in late antiquity. Many of the transformations, which can be dated to the mid-sixth century, correlate chronologically with the first outbreaks of the plague. Mischa Meier's research has focused on the transformations of Justinian's reign, which can be divided between early and late phases, with the plague squarely in between. Meier has argued that the plague contributed to cultural changes such as greater liturgification, the sacralization of the emperor, the increased worship of the Virgin Mary, and the emergence of iconolatry.[95] He concluded that plague facilitated the solidification of these changes during the mid-sixth century.

92 L. Walløe, 'Was the disruption of the Mycenaean world caused by repeated epidemics of Bubonic Plague?', *Opusula Atheniensia* 24 (1999) 121–6; C. Cunha and B. Cunha, 'Impact of plague on human history', *Infectious Disease Clinics of North America* 20, no. 2 (2006) 253, agree that the biblical epidemic (which they date to 1320 BCE) was plague. The biblical connection dates back to the nineteenth century, see W. McNeill, *Plagues and Peoples* (Garden City, NY 1976), 112–13.

93 S. Rasmussen et al., 'Early divergent strains of Yersinia Pestis in Eurasia 5,000 years ago', *Cell* 163, no. 3 (2015) 571–82. A. A. Valtueña et al., 'The Stone Age plague and its persistence in Eurasia', *Current Biology* 27.23 (2017) 3683–3691.e8, followed up with more research into early plague cases (naming it the Stone Age plague).

94 M. Spyrou et al., 'Analysis of 3800-year-old Yersinia Pestis genomes suggests a Bronze Age origin for Bubonic Plague', *Nature Communications* 9.1 (2018) 2234.

95 M. Meier, *Das andere Zeitalter Justinians: Kontingenzerfahrung und Kontingenzbewältigung im 6. Jahrhundert n. Chr* (Göttingen 2003); then summarized in Meier, 'The "Justinianic Plague"'; also see the case studies on various sources in M. Meier, 'Von Prokop zu Gregor von Tours: Kultur- und

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Similarly, some scholars have cast the plague as being key to religious changes in Western Europe. Karl Ubl has linked increased legislation against incest to the plague, asserting that bishops at the Council of Tours (567 CE) had to ensure proper sexual behaviour to assuage divine wrath.[96] Nonetheless, such plague-based explanations are less common in the West, since the various post-Roman barbarian kingdoms had already begun to diverge from their late Roman predecessors by the mid-fifth century, before plague set in. If anything, the post-plague west witnessed an increase in Christian diversity, rather than a solidification of specific norms such as liturgification.[97] Moreover, even late antique eastern scholars have argued for the long-term transformation of various religious and cultural aspects, which cannot be clearly dated to the plague.[98] The initial outbreak of the plague might have catalyzed pre-existing changes, but Justinian himself, both before and after the early 540s, had already begun to transform the empire he inherited. Subsequent research might further illuminate the connection, or lack thereof, between plague and socio-cultural change in different regions of the late antique world.

3. *Online discussions and resources*

The internet has facilitated plague research through faster communication and by making key resources more accessible. Various online databases, forums, and lists on the plague and broader medical history have proliferated over the past few decades. The most active resource is MEDMED, a mailing list organized by Monica Green which connects over 800 subscribers to information about medicine in the medieval period.[99] While the mailing list's interests are broad, plague appears frequently in notifications and commentaries on newly published studies alongside discussions of plague related questions.

A related online resource, Michelle Ziegler's Contagions blog, similarly reports on new plague articles and relevant information.[100] Her website also contains links to a series of introductory articles that offer background to the plague's epidemiology, spread, and mortality. The Black Death Network, organized by a number of

mentalitätengeschichtlich relevante Folgen der "Pest" im 6. Jahrhundert', in F. Steger and K. P. Jankrift, *Gesundheit - Krankheit: Kulturtransfer medizinischen Wissens von der Spätantike bis in die Frühe Neuzeit* (Köln 2004), 19–40; and M. Meier, 'Natural disasters in the chronographia of John Malalas: Reflections on their function - an initial sketch', *Medieval History Journal* 10.1–2 (2007) 237–66; or M. Meier, 'Prokop, Agathias, Die Pest und Das, Ende' der Antiken Historiographie', *Historische Zeitschrift* 278, no. 1 (2014) 281–310.

96 K. Ubl, *Inzestverbot und Gesetzgebung: die Konstruktion eines Verbrechens (300–1100)* (Berlin 2008) 163.

97 See, for example, P. Brown, *The Rise of Western Christendom: Triumph and Diversity, A.D. 200–1000*, 10th anniversary rev. edn (Chichester 2013).

98 On Mary, see for example, S. Shoemaker, *Mary in Early Christian Faith and Devotion* (New Haven 2016).

99 https://lists.asu.edu/cgi-bin/wa?A0=MEDMED-L.

100 https://contagions.wordpress.com.

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academics, likewise posts significant new information on the plague, although generally focused on the Black Death with some comparative perspectives included.[101]

A key reference work for some of the plague datasets is Harvard's Digital Atlas of Roman and Medieval Civilizations (DARMC) database.[102] DARMC is run by Michael McCormick, and consists of a series of datasets, including several relevant to the Justinianic Plague. The 'Summary Geodatabase of Epidemics, 312–749 AD' dataset, for example, contains Stathakopoulos' record of epidemics across the Mediterranean alongside other outbreaks of disease with geolocations and limited commentary.[103] Other datasets that may be of interest to the study of the Justinianic Plague include 'Rats 1–1500 [AD] to Archaeology of Rats 1–1500' and 'Roman Climate Historical Evidence'.

Finally, the internet also serves as a repository for video resources for plague-related presentations. This is particularly useful for non-specialist audiences as the talks are both easier to follow than the technical scientific articles and emphasize their main findings. There is no central repository for these lectures, but they can be accessed through academic institutions. For instance, an entire session entitled 'Plague in Diachronic and Interdisciplinary Perspective', was held at the European Association of Archaeologists in Vilnius, Lithuania in September 2016, and is now online and accessible through the website of the European Association of Archaeologists.[104] Another set of interdisciplinary lectures can be found at the website of the Max Planck-Harvard Research Center for the Archaeoscience of the Ancient Mediterranean (MHAAM).[105] Many of these lectures can also be found on YouTube. All of these resources make premodern plague more accessible to scholars and enhance both the speed and the scope of the discussion, facilitating further research.

Concluding remarks

This article has attempted to aggregate the most important developments in the study of the Justinianic Plague over the past two decades. As we have shown, a large number of scholars in diverse disciplines have tackled the plague as an inherently interdisciplinary field of study. As a result, the geographical and chronological scopes of the plague have been expanded substantially, reference works in the form of catalogues of plague occurrences have been published, and scientific studies have revealed novel insights.

101 https://bldeathnet.hypotheses.org/.

102 https://darmc.harvard.edu.

103 Note that the dataset names can be slightly different to those in the digital application.

104 https://www.e-a-a.org/Conferences/Filmed_EAA_Conference_Sessions/Vilnius_2016/Plague/EAA/Navigation_conferences/2016_videos/Plague.aspx.

105 https://sohp.fas.harvard.edu/inaugural-lectures-max-planck-harvard-research-center-archaeoscience-ancient-mediterranean-mhaam. See also the series of lectures on plague in Harvard's Initiative for the Science of the Human Past (webpage: https://sohp.fas.harvard.edu/video-presentations).

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From a broader perspective, the trend in most recent scholarship is a movement away from moderate outcomes for the plague's impact, such as significant population loss, but with mixed long-term results, toward maximalist paradigms that envisage a demographic decline that persisted for centuries. Cautious views that equivocated on the plague's effects have been replaced by studies that collect all available evidence to argue for extreme outcomes. While Stathakopoulos himself has always remained cautious of exaggerating the plague's demographic impact, his accessible dataset has facilitated maximalist interpretations of the plague.[106]

It is interesting to note that most historians of the Justinianic Plague tend to work on plague for a few years before moving on to different topics; few are plague specialists. Only Dionysios Stathakopoulos and Michael McCormick have continuously published on the Justinianic Plague. This might be explained by the dearth of potential sources, which may cause scholars to feel that they have exhausted the available material. Similarly, few historians have collaborated with others in studying the Justinianic Plague. This limits the extent to which historians are exposed to new material and methodologies, and deepens the rift between scientific and humanistic work on the topic. Finally, most historians of the Justinianic Plague work only on it and do not expand to other plague pandemics (e.g. the Black Death), non-plague epidemics, or other natural disasters. This phenomenon has contributed to the insularity of the Justinianic Plague as a field of studies and limits the engagement of its scholars with relevant research from neighboring fields and disciplines.

Moving forward, plague studies will likely continue to accelerate as scientific research continues to progress, aDNA testing becomes more common, and more positive plague remains come to light. Moreover, continued archaeological excavations could provide new evidence for continuity or change during the emergence of the plague in late antiquity, which could potentially illuminate aspects of the yet-intractable demographic questions, especially at a regional level. There is much for all of us to learn from each other.

106 Stathakopoulos, *Famine and Pestilence*; Stathakopoulos, 'The Justinianic Plague revisited', remains cautious although he would move towards the maximalist interpretation over the next few years; for example, Stathakopoulos, 'Invisible protagonists'.

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