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Introduction

Walter Scheidel

SCIENCE HAS LONG been making an enormous contribution to our understanding of the ancient past. Archaeology is simply unthinkable without it, and the study of various types of source material from inscriptions and coins to papyri and palimpsests has greatly benefited from scientific analysis. In recent years, the contribution of science has broadened even further as entirely new types of evidence from genetics to climate proxies have been brought to bear on historical inquiries. Thanks to this accelerating expansion, the study of history in general is now approaching a new stage of interdisciplinarity that is firmly grounded in the recognition that human and natural history are intimately and inseparably intertwined.

This book shows that the study of the ancient Roman world is no exception to this trend.[1] Climate is given pride of place (Chapter 1), a powerful influence on the development of agrarian societies that often survived on narrow margins. It remains a formidable challenge to reconstruct meaningful patterns from local data without obscuring local variation. Yet for the first time, we are now able to glimpse the contours of climate change in the long term. Roman power expanded and flourished during a period of favorable conditions—warm, stable, and moist in the right places. Given that Rome's imperial reach turned out to be a unique outlier in the history of western Eurasia, this may well be more than just a coincidence and calls for further inquiry into the interaction of institutions, geopolitics, and environmental factors that produced this outcome.

From the second century CE onwards, growing climatic instability accompanied the fitful decline of Roman power. While a warming trend in the fourth century coincided with temporary imperial recovery in the West, increased precipitation aided development in the East. Prolonged droughts may have

been implicated in population movements in the Central Asian steppe in the fourth century and in Arabia two and three centuries later. Even more ominously, the fifth and sixth centuries, a time of upheaval for the Mediterranean, experienced secular cooling coupled with a surge in volcanic activity. The historian's agenda is clear: while the temporal association between trends in macrosocial development and climatic conditions is increasingly well documented, the complexity of causal relations remains very much in need of detailed analysis. The history of climate change is also the history of human resilience, and we must ask not only how Roman society was affected by environmental forces but also how it responded to them. Moreover, other ecological factors such as pathogens or deforestation also need to be taken into account.

The study of plant remains is a complementary field of investigation (Chapter 2), closely tied up as it is with that of climatic conditions, even though the connections between them are yet to be explored in depth. Existing research has put emphasis on the spread of cultivable crops under the aegis of Roman rule. The dissemination of naked wheats that were suitable for making bread is one example; charred remains of oil pressings that point to the expansion of oleiculture are another. We can track how particular crops were at first imported, sometimes over long distances, and later incorporated into local farming regimes, and also how widely such crops came to be adopted and consumed. These observations are germane to big questions about the nature of Roman economic development. To what extent were these processes driven by imperial rule as such or were merely the by-product of ongoing long-term growth, just as farming itself had once spread from the Middle East? How "Roman" was the Roman economy, in the sense of being shaped by empire? The food supply of the Roman army is a case in point: how did plant foods found at military sites compare to those present among the local civilian population? Change over time in the sources of food and timber required by the military reveal how state-sponsored demand affected patterns of production. The influence of empire is also visible in the fact that the Roman conquest of Britain closely coincided with the introduction of grain beetles that thrived in large open granaries of the kind set up by the occupiers. Plant remains recovered at Red Sea ports shed light on the dynamics of long-distance trade that would otherwise be irrecoverable, such as the provenance of merchant ships and change over time. Evidence of plant production within urban sites is highly relevant to debates about population size: if the finding that one-sixth of Pompeii's surface area was given over to plant production is anything to go by, Roman cities may not have been as densely inhabited as some would like to think.

But above all, plant remains are a key source of information regarding diet. The discovery of dozens of different plant species at a whole range of Roman-era sites speaks to the scale and scope of economic development: that period's new-found diversity of food consumption was not necessarily restricted to elite settings but was also present in more modest or rural locales. This has

considerable ramifications for ongoing debates about Roman well-being and the distribution of gains from growth and commercial integration. The inhabitants of northwestern Europe in particular—a region that felt the transformative power of imperial rule more than many others—enjoyed greatly improved access to and diversity of foodstuffs.

Animal remains offer similar insights (Chapter 3). Patterns of meat consumption have been studied across time and space, linking it to "Romanization" and other processes. Just like crops, animal species spread under Roman rule. Increases in the size of domestic animals in Roman Italy point to productivity gains. A combination of osteometric and genetic investigations helps clarify how much this progress owed to breeding or the introduction of imported varieties. The study of animal remains has enlightened us about various kinds of transfers, from the export of Nile fish to Asia Minor to the migrations of the black rat, which eventually came to be instrumental in the transmission of bubonic plague. Skeletal pathologies, for instance those that document the use of cows alongside oxen for plowing, add to our knowledge of the efficiency of the rural economy. Feeding regimes inferred from dental micro-wear tell us if animals were sustained by pasture or fodder, and variations in heavy metal deposits in goat bones have even been used to track changes in their proximity to human settlements.

Yet however much the remains of ancient plants, livestock, and pests may have to teach us, it is the human body that takes center stage (Chapter 4). It is one thing to observe which crops or animals had spread or were present at a particular site; it is another one entirely to examine how such findings correlate with the physical well-being of people at the time. In the absence of contemporary statistics on food consumption or public health, human bones and teeth are the most important source of information about nutritional status, health, and morbidity in the Roman world. Without them, we cannot hope to observe change over time, both within a given person's life and across generations or centuries. Human skeletal remains form the biggest archive of what it was like, in the most fundamental terms, to "be Roman."

Not all lines of inquiry are equally promising. Longevity is a crucial variable in assessing overall well-being and levels of development, but it is generally poorly or not at all attested outside very narrow settings, most notably the papyrological census record of Roman Egypt. Unfortunately, aggregations of human remains in ancient cemeteries tend to be an unreliable guide to the age structure of past populations. This raises the question whether exceptional cases that have produced demographically plausible patterns are capable of vindicating paleodemographic reconstructions. After all, even a broken clock is sometimes right. But maybe we have been barking up the wrong tree: instead of bemoaning the manifold biases that have shaped (and, from a demographer's perspective, spoiled) the funerary record, these very biases are likely to reflect cultural practices and preferences that are very much worth

investigating. In the end, bones may have to tell us more about culture than about demography, a valuable reminder of osteology's ability to shed light on life in the past well beyond the physiological dimension of human existence.

Bones and teeth are of paramount importance in identifying a wide variety of ailments that can often be linked to specific infections, occupational hazards, and cultural norms. It is important to be aware of the limitations of this evidence: the inconclusive debate about the connection between certain types of porotic lesions and malaria stands as a warning against overly confident identifications of Roman pathogen loads. The most common and deadliest diseases of the ancient world, such as gastro-intestinal infections, generally remain hidden from view, and mummified bodies, which allow a wider range of investigations, are confined to just one corner of the Roman world and even there have not fully received the attention they deserve. Even so, considerable progress has been made. The bodies of infants and children hold out particular promise, as dental enamel analysis has begun to shed light on weaning and sanitation practices that would otherwise remain obscure. The early, formative years are in some ways also the ones most worth knowing about, and it should be remembered that children and adolescents would have accounted for over a third of any ancient population. If we ultimately end up with more detailed information about children than adults, this will help offset the general scarcity of information about this critical phase of the ancient life cycle.

Much the same is true for diet. Stable isotope analysis of teeth and bones provides valuable clues about the types of food people used to consume, even though in practice precision remains an elusive goal. Isotopic studies have been at their most successful in ascertaining the relative weight of terrestrial and marine food sources for different groups of people. Given that a sizeable share of the population of the Roman Empire was concentrated in coastal areas where access to seafood was at least an option and that processed marine-based foods were shipped over long distances, this metric is more useful than it might seem in illuminating dietary variations rooted in class and gender as well as geography. However, the biggest question concerns the overall importance of cereals as opposed to animal products in Roman-era diets, and there much work remains to be done.

Last but not least, stable isotope analysis helps us track migration at different stages of the life cycle. Because humans acquire oxygen and strontium isotopic signatures by consuming local food and water—in their dental enamel in childhood and in their bones throughout their lives—comparison of such profiles with local patterns allows inferences about mobility. Complications abound: short-term movement may be hard to track down, imported food and water piped in through aqueducts affect the record, and different regions may exhibit similar isotopic properties. Systematic compilation of local reference data will be the solution to at least some of these problems. Just as previous generations compiled huge editions of inscriptions or papyri, the time has

come to create comparable collections of scientific evidence that is relevant to our understanding of life in the past. This applies to isotope signatures just as it does to climate records and genetic information.

The study of body height is yet another branch of osteology (Chapter 5), embedded in a rich tradition of scholarship that seeks to relate stature to various factors such as health and economic development. In the most general terms, height tends to correlate with well-being: however, the fact that the former is the single cumulative outcome of a wide variety of inputs such as genetics, diet and disease greatly complicate causal explanation. In this field, large bodies of data and long-term comparison across space and time are once again of the essence. One key observation that has emerged from the aggregation of local samples is that the Roman period in general was associated with lower body heights than previous or subsequent centuries.[2] The question whether nutrition or pathogen loads played a greater role in this is of fundamental importance to our understanding of the Roman economy. The relationship between imperial rule and physical well-being was bound to be complex, mediated by factors such as economic development, urbanization, connectivity, and inequality that produced conflicting gains and costs in terms of nutrition, health, and thus stature. Once again, as with teeth, the pre-adult record may turn out to be of particular value. The stature evidence points to late menarche and male puberty, in keeping with conditions in current low-income countries and other historical populations. And given enough and sufficiently fine-grained data, class differences in body height—which are well attested for early modern and contemporary societies—may also become apparent. In general, the study of somatic development will greatly benefit from the proper integration of different strands of research, from information about health and diet derived from teeth and bones, about the availability of foodstuffs documented by plant and animal remains, and about geographical and ancestral provenance as documented by stable isotopes and ancient DNA.

The last one of these data sources is derived from most of the other types of ancient remains surveyed so far, from plants to humans and other animals (Chapter 6). Owing to the relatively recent nature of ancient DNA studies and especially the rapid pace of innovation in this field, it has only just begun to contribute to the study of the Roman world. Genetic analysis holds particular promise in identifying the geographical origin of people, livestock, and crops and thus in establishing patterns of human mobility and the transfer of productive resources. Possible genetic discontinuities between ancient Etruscans and more recent Tuscans and connections between Etruscans and the Eastern Mediterranean are of obvious relevance to our assessment of ancient traditions regarding their provenance and to modern models of ethnogenesis. Individual cases of migration over very large distances may catch the eye, but findings of local continuity are equally valuable. Overall, whole-genomic sequencing of larger samples is the best way forward. For antiquity, the most revealing findings made so far concern pathogens rather than humans: the

identification of the cause of the sixth-century CE "Plague of Justinian" (as well as the late medieval "Black Death") as *Yersinia pestis* must count as a milestone in the annals of historical epidemiology. The agents behind earlier pandemics such as the second-century CE "Antonine Plague" and the third-century CE "Plague of Cyprian" still await scientific discovery. Among other potent infections, malaria, which is otherwise difficult to infer from skeletal evidence, is also becoming visible, although relative to the likely scale of its spread in the ancient world the existing genetic evidence remains exiguous indeed. All the same, in light of the speed with which this line of research has developed and matured in recent years, it is hard to overestimate its potential for enriching our knowledge of the ancient world.

Analysis of surviving strands of ancient biomolecules is complemented by studies of the genetic makeup of current populations that serves as a giant archive of demographic processes in the past (Chapter 7). Measures of affinity and admixture throw light on the origins of those alive today. In this field, just as with ancient DNA, most existing research has focused on prehistory. A few studies, some of them perhaps already superseded by more recent advances, have identified patterns suggestive of migration from the Levant to North Africa and from the Aegean to Sicily and southern Provence that may be linked to Phoenician and Greek settler activity. Roman history, which lacks similarly distinctive migration events, may prove less fruitful terrain for such studies. One important question that remains to be explored is whether the massive inflow of slaves into select parts of the Italian peninsula has left traces in the genetic record. Both ancient and modern DNA will need to be marshaled to address this problem. Elsewhere, solid evidence of genetic continuity over time could serve as an important antidote to exaggerated notions of population mobility in the Mediterranean environment.

Even this rapid and superficial survey of some of the issues covered in the following chapters should leave no doubt that scientific methods provide insight at all levels of resolution of historical inquiry, from "micro" to "macro." At one end of the spectrum, the individual. Under ideal circumstances, by integrating various approaches, we are now able to tell where someone was from and at what age that person moved to where she died; at which age she was weaned and experienced serious physiological stress; whether she subsisted more on terrestrial or marine foods; and whether she died of the plague. Her somatic data could be compared to those of others at the site and matched with local remains of cultivars, weeds, livestock, and pests, as well as the usual array of inorganic archaeological remains. Never before has it been possible to examine individual Roman lives in such detail.

At the "meso" level, serial analysis of data from a particular locale over the long run and comparison with those from other sites steer us toward broader questions about the impact of empire, of political and economic integration, of urbanization and culture change at the local or regional level and beyond.

Just as the archaeoscience of inanimate objects from ceramics to metals and stone has done for a long time, climatology and bioscience hand the historian additional tools for tackling these questions.

And moving even further to the opposite end of the spectrum, we are now for the first time in a position to try our hand at defensible biohistorical narratives of the Roman Empire as a whole. Kyle Harper's new book meshes climate proxies and scientific data about pathogens with more conventional sources in elucidating the interplay of ecology and human agency over the course of centuries.[3] Much will need to be refined as the scientific evidence expands, but the contours of a truly interdisciplinary history of ancient Rome are now finally in view.

Pursuit of questions about big structures and large processes will require us to think hard about how to integrate conventional evidence with scientific findings. Integration is predicated on the compatibility of observations from different domains of inquiry, a compatibility that arises from *consilience*. Coined in the nineteenth century, this term, to quote Michael McCormick's pithy summary,

> refers to the quality of investigations that draw conclusions from forms of evidence that are epistemologically distinct. The term seems particularly apt for conclusions produced by natural-scientific investigations on one hand and by historical and archaeological studies on the other. Consilience points to areas of underlying unity of humanistic and scientific investigation—a unity arising from that of reality itself.[4]

While this perspective is designed to bridge the gaps between different disciplinary practices and academic precincts of specialized expertise and inquiry, it is worth acknowledging that the underlying premise might also reinforce existing divisions rather than leveling them. Some of our colleagues in the humanities may be skeptical of notions of a "unified reality" or harbor reservations about an encroachment of science. And indeed, the premise of consilient unity leaves little room for the more esoteric varieties of postmodern engagement with the historical record: the very concept is resolutely "modern." To the extent that it will succeed, it may mark a swing of the pendulum towards a more open and, for want of a better word, optimistic perspective on the production of knowledge and our understanding of the world. I believe we ought to welcome such a shift. It is also worth noting that recourse to insights derived from the biosciences readily accommodates historians' concerns about hegemonic discourses and the subaltern: what more immediate way of accessing the history of the "99%" than to study what is actually left of them and the organisms that both sustained and blighted their lives? Archaeobiology gives a powerful boost to history from below, shining a light on those of whom no other record exists.

Nevertheless, biohistorical interdisciplinarity poses genuine challenges. Increasingly sophisticated techniques and falling costs, most dramatically in genetics, keep boosting the contribution of science to historical inquiry. But this progress frequently entails a fair amount of creative destruction. We are faced with perpetual churn in which results made only a few years—never mind decades—ago are called into question or downright superseded by the application of improved methods. This makes for treacherous terrain for the uninitiated. Keeping up to date is an imperfect solution: five or ten years ago, it was perfectly possible for experts to be both up to date and wrong. Caution is the order of the day. Paleodemography and the extrapolation of stature from bone length have long been beset by ongoing confusion about norms and standards. More recently, we have learned that methods and procedures that once seemed state-of-the-art—from trace element analysis in the osteology of ancient nutrition to blood allele studies of modern populations and early work on ancient DNA—cannot bear the weight they had been granted. The enduring lesson is to remain circumspect and resist the ever-present temptation to oversell the latest findings. The very dynamism of scientific research is at once its most attractive feature and a challenge to historians who wish to capitalize on it.

Both the pace of change in the sciences and the professional expertise required to assess and apply its results highlight the need for collaboration across established disciplinary boundaries. Outside archaeology, transdisciplinary research (not to mention teaching) on the ancient world has been rare, and even collaborative work more generally is an exception rather than the norm. Continuing emphasis on individual competence has held back innovation in a variety of areas, from cross-cultural comparative history to Digital Humanities. A biohistorical approach is if anything even more profoundly incompatible with the existing model of training, supporting, and evaluating professional historians as some sort of latter-day master crafts(wo)men. It adds new expectations in terms of what historians ought to know and how they are to cooperate with colleagues from other fields, and draws them deeper into the complex world of grant applications that are the life-blood of their colleagues in the sciences. At the same time, it calls for scientists to partner up with historians in the development of research designs and interpreting the results: transdisciplinarity must not turn into a one-way street that casts historians in the passive role of consumers. Rather, consilient perspectives on the past allow historians to become brokers, by creating ties between discrete communities of scholars that unite them in the pursuit of a richer understanding of the past.

The present volume illustrates only some elements of an engagement with the Roman world that is informed by scientific knowledge. We focus on the human

body and on the surrounding biosphere. In so doing, the seven chapters follow an arc from the weather to plants, animals, and humans, and, for humans, from large (skeletons) to small (biomolecules), from phenotype to genotype, and from ancient to modern. For our purposes, the distinction between climatology as part of the Earth Sciences and areas of research that are rooted in biology is merely a formality. Although most climate change in the last few millennia was caused by variations in solar and volcanic activity and the earth's orbit, climate occupies a central position in biohistorical reconstructions because it primarily affected humans indirectly through its impact on flora, fauna, and the water supply.

More could be added. A true "biohistory" of ancient Rome would be broader still, extending into the scientific study of human cognition and behavior, an area that is challenging to access for students of the more distant past and remains outside the scope of this survey. One day, it may be worth pondering how Roman brains and minds were shaped by an environment of endemic slavery and organized violence (from mass conscription to the carnage of the arena), to name just a few prominent features of the historical record.[5]

This volume is meant to offer a guide to different bioscientific approaches and their contribution to the study of Roman history: how they have (or have not) enriched our understanding, and how they might do so in the future.[6] While our focus is on the ancient Roman world broadly defined, the scope of coverage varies from chapter to chapter, and for good reason. Most relevant work on ancient and especially modern DNA deals with earlier periods of human history. Rather than elucidating specific issues of Roman Studies, it gives us a sense of the potential of this research to re-shape our understanding of ancient societies in the coming years. Conversely, the study of bones and teeth presents us with an embarrassment of riches that calls for a degree of selectivity. Chapter 4 therefore concentrates on Roman Italy proper while Chapter 5 privileges stature data from Roman Britain, which has attracted some of the most careful attention. Not every part of the Roman world could be covered in equal measure: evidence from Egypt is particularly rich and would deserve a separate volume, contextualizing Roman finds in the great time depth of Nilotic civilization and making full use of the unique evidence of mummified remains.[7]

One thing is certain. No matter how comprehensive the coverage of a survey of this kind, the rapid progress of scientific research ensures that before long it will seem dated. It cannot be more than a snapshot, capturing a particular moment in the growing entanglement of ancient history and the sciences. We are pushing against the limits of conventional formats of dissemination: the next step may well have to be a continuously updated electronic publication to keep us up to date.

Notes

1. The seven chapters contain over 1,000 references. I therefore largely refrain from adding further bibliography.

2. In addition to the work cited in Chapter 5, this is documented in particular by the dissertation project of Geertje Klein Goldewijk at the University of Groningen, which draws on a larger amount of data than published studies: see Scheidel 2012: 326.

3. Harper 2017. For other times or places, see now especially White 2011; Broodbank 2013; Parker 2013; Brooke 2014; Campbell 2016.

4. McCormick 2011: 257. His article inspires much of what follows in this section.

5. AHR Roundtable 2014 calls on historians to engage with biology more generally. That forum includes contributions on behavior and emotion by Harper 2014, Roth 2014, and Scheidel 2014. See also Harper 2013.

6. Killgrove forthcoming offers a complementary perspective.

7. See Scheidel 2010 for a brief survey of the ancient disease environment.

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