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978-1-009-22868-8 — Archaeology and the Genetic Revolution in European Prehistory
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Excerpt
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1 Introduction and Background

A Brief History of Research

Right now, archaeology is experiencing its third science revolution (Kristiansen 2014b), which like the previous two is reshaping our entire archaeological discourse (Sørensen 2017a and 2017b; Ribeiro 2019). Common to all three revolutions – the Darwinian revolution introducing to archaeology principles of stratification, deep time, and evolution (1850–60); the environmental revolution and the carbon-14 (C-14) revolution introducing absolute dating (1950–60); and now the strontium/DNA revolution introducing to archaeology prehistoric population genomics and migrations (2010–20) – is the transformation of previous relative knowledge intoabsolute knowledge.[1] In doing so, they freed intellectual resources to be spent on explaining change rather than describing and debating it (Figure 1). Thus, prior to the C-14 revolution, most archaeological resources were poured into the classification and relative dating of prehistoric cultures. Beyond the safe dates of written sources, one had to project back in time the supposed length of time periods based on stratigraphy and typology. As we now know, all prehistoric periods earlier than the Bronze Age turned out to be much older than anticipated. Once the C-14 revolution unfolded and thousands of dates established safe chronologies, intellectual resources could instead be spent on explaining change, leading on to New Archaeology and what followed. Thus, these science revolutions were also intellectual revolutions propelling archaeological theory and interpretation forward.

In order to better understand and evaluate the present situation, it can be useful to trace the history of interdisciplinarity in archaeology through an analysis of the three science revolutions, and their transformative potential, and also the commonalities between all three revolutions, their theoretical and methodological implementation, and their impact on archaeology.

The Birth of Archaeology and the First Science Revolution

Archaeology as a discipline was born out of interdisciplinary collaboration. It happened during the crucial decade of 1850 to 1860, when the new natural sciences of geology, biology, and zoology achieved breakthroughs precisely through interdisciplinary collaboration with archaeology. In turn, archaeology achieved its status as an independent discipline through interdisciplinary

[1] This does not imply that there is no debate possible about interpretation or improvement of methodologies. A good historical example is the calibration curve of C-14; similarly, one can also discuss the way aDNA data is analyzed and presented using different statistical methods. However, the baseline is that certain types of questions can be answered with a high degree of probability and that genetic base data is correct, if correctly sequenced.

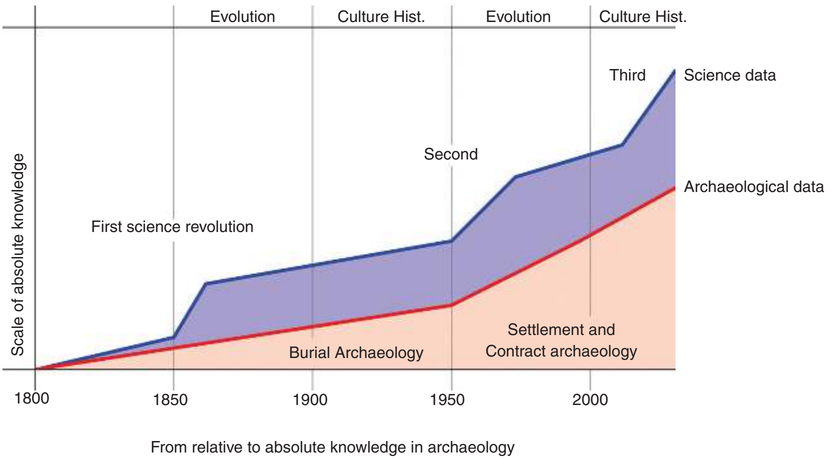

Figure 1 Model of the impact of the three science revolutions in archaeology through their transformation of relative knowledge to absolute knowledge

collaboration with zoology and geology. It happened through the combined application of systematic excavation, observation, and documentation in the three disciplines (Kristiansen 2002; Grayson 1983).

Excavation and classification were thus the new methodological principles in archaeology borrowed from geology, zoology, and biology (the work of Charles Darwin and Carl Linné), which propelled it into an independent discipline. Classification and typology were further developed by Oscar Montelius to become the new methodological tools of archaeology; and in anthropology, the concept of evolution inspired a new perception of the social evolution of human culture in the works of Lewis H. Morgan (*Ancient Society* [1877]) and E. B. Tylor (*Primitive Culture* [1871]).

The decade of 1850 to 1860 thus revolutionized the classical biblical perceptions of the antiquity of Man and laid the foundations not only for the modern worldview, but also for its science-based foundations in geology, zoology, and archaeology. We can hardly imagine the revolutionary impact of these discoveries during their time. They became an essential part of the birth of modernity and a new perception of history and science (Toulmin and Goodfield 1965; Grayson 1983; Schnapp 1996; Schnapp and Kristiansen 1999).

The Second Science Revolution: The Birth of Environmental Science and Absolute Time

Two apparently unrelated scientific breakthroughs during the 1940s and 1950s transformed archaeology into a modern science-based discipline, which fostered a massive theoretical and interpretative development during the 1960s onward in the form of "New Archaeology." The two breakthroughs were (1) the development of modern pollen analysis and environmental archaeology; and (2) the development of C-14 absolute dating, which completely changed the dating of prehistory before written sources.

The implications of the C-14 method for absolute archaeological dating were revolutionary, especially for periods before written sources. It turned out that the Neolithic and Chalcolithic periods in particular were several thousand years older than had been suggested by extrapolating from the known to the unknown – from the safe dates of the Bronze Age and back in time. However, most of this extrapolation turned out to be wrong. This meant that the whole chronological framework for prehistory before the Bronze Age collapsed and – along with it – its interpretative framework, based on the diffusion of farming and early metallurgy from the Near East. Colin Renfrew was among the first to use this to propose a new interpretative framework, where autonomous development became a dominant explanatory framework for much of European prehistory. New theoretical models were applied to support this new framework, under the banner of processual or New Archaeology, summarized by Renfrew in his book *Before Civilisation: The Radiocarbon Revolution and Prehistoric Europe* (Renfrew 1973). Processual archaeology employed a comparative approach, where ethnographic models in particular were mobilized to show that human societies worldwide were characterized by parallel and independent social evolution and innovation, in works by Elman Service (1962 and 1975) and Marshall Sahlins (1972). However, archaeological infrastructures also developed rapidly during this period, as well as the methodological and theoretical framework, by gradually including historical and contemporary archaeology as well (Kristiansen 2008, figure 1.3).

Thus, during the 1940s and 1950s, natural sciences took a giant step forward with the development of high-resolution pollen analysis and of C-14 dating, followed by a series of new analytical techniques, which created a whole new framework for archaeological theory and practice. In conjunction with the increasing emphasis on settlement archaeology and the role of contract archaeology in modern society (Cleere 1984, 1989), the consequences turned out to be dramatic in the period after 1960. It led to a restructuring not only of theory and practice, but also of the whole organizational framework of archaeology and of its role in society. New science departments for pollen analysis, paleobotany, and C-14 dating were created at many universities and national museums around the world. Natural science – or rather archaeoscience –was from now on implemented in teaching, fieldwork, and research as a matter of routine.

The Third Science Revolution: The Births of Archaeogenetics and Big Data

The third science revolution has been unfolding since 2010, but its beginnings were much earlier. Ammerman and Cavalli-Sforza (1984) were among the first to take advantage of the initial genetic breakthrough of mitochondrial DNA in the early 1980s, in an attempt to use modern genetic data to infer prehistoric migrations (discussed in Reich 2018, introduction). Soon it became possible to extract mitochondrial DNA from ancient samples, although this only contains a fraction of the genetic evidence, linked to the female lineage. A first wave of optimism was soon replaced by pessimism, as it turned out that contamination from present-day human DNA had become a nearly unsolvable problem. It was only after the publication of the first full human genome in 2004 and the development of short-read sequencing technologies that ancient DNA (aDNA) genome research became a reality, with the first prehistoric genomes published in 2010 by the Copenhagen team (Rasmussen et al. 2010) and the Max Planck team (Green et al. 2010). Since then, we have seen a steeply rising curve of new data, as well as new results that have changed the perception of prehistory globally (summarized in popular books by Reich [2018] and Krause [2019]). This has been followed by an extensive popular dissemination of results, sometimes in a more sensational form than wished for.

Another side of the third science revolution is its powerful use of big data. Once archaeological data entered the digitized world, it could be analyzed and correlated with other types of data, such as the geodata forming the backbone of GIS (McCoy 2017) or environmental and genetic data (Racimo et al. 2020a and 2020b; Roberts et al. 2018). All published genetic data is stored in a global database. This means that all new aDNA analyses can be compared to previous analyses, as well as to modern reference data. Old data can in this way be reanalyzed with new methods, all of which is part of the rapid advance and strength of archaeogenetics.

So far, most archaeological big data is stored in national databases and is therefore of limited use. Thus, the full potential of archaeological big data has yet to be realized (Huggett 2020; Perry and Taylor 2018). However, lists of C-14 dates have been made publicly available in the journal *Radiocarbon* since 1959 and can thus be employed in more advanced research crosscutting national borders. Such research has already had a profound effect upon our understanding of prehistoric demography (Hinz et al. 2012; Shennan et al. 2013; Blanko-Gonzales et al. 2018; Roberts et al. 2019).

The third science revolution is now slowly entering the implementation phase, as its results become more widely acknowledged, in tandem with a rapidly increasing number of prehistoric genomes, which allow the unfolding of much more detailed human and social histories. To better understand where we are in the process between breakthrough and implementation, I shall illuminate such processes more generally.

The Process of Scientific Breakthroughs

Historically, it can be demonstrated that major advances in archaeological interpretation are based on the results of interdisciplinary collaboration and breakthroughs. Perhaps it is the mere challenge produced by interdisciplinary research that holds the key to its innovative power, by forcing us to perceive the past in new, unexpected ways, in combination with the transformation from relative to absolute knowledge that each science revolution brought about, and which has continuously freed intellectual resources to be spent on interpretation and explanation rather than documentation.

What more can we learn from the history of interdisciplinarity to better understand the ongoing third science revolution? Based on observations from the three science revolutions in archaeology, we can define a three-step process in the formation and implementation of science revolutions: (1) An upstart phase or prologue when new methods and new knowledge are being formulated and tested, yet without a clear perception of their scientific potential. This is realized in (2) the breakthrough phase, when suddenly a leading researcher or research group demonstrates the full potential of the new methods. This is then followed by (3) an implementation phase, where methods become standardized and widely applied. I shall next describe the commonalities of these three phases.

Prologue

This is the phase from the detection of a new scientific field or principle to its full application. It normally lasts around twenty-five years. Twenty-five years passed from the detection of pollen to its application as a science of human impact on the environment, and another ten years before enough pollen types had been identified to allow full environmental reconstruction. Twenty-five years passed between the first detection and analysis of human DNA and its full genomic application in aDNA. Likewise, twenty-five years passed from the detection of stratified geological layers to their combination with archaeological and zoological documentation and classification.

Breakthrough

This is when one or more leading research groups are able to demonstrate the full potential of the new scientific principles, by recombining them into a new methodological package, as happened during the first science revolution, or when a scientific method can be applied in a new field, as happened when C-14 determination and pollen analysis were applied to archaeological data, or when new powerful computers in combination with new methods of sorting contamination led to the breakthrough of next-generation sequencing of ancient DNA. Along the way from breakthrough to implementation, one can often observe an intermediate phase of doubt and critique, where critical methodological adjustments are made (Figure 2). For the C-14 method, it is represented by the phase leading to calibration, and right now strontium isotopic research is going through a similar phase as to how to establish reliable baselines. It might be proposed that aDNA went through an analogous process during the early 2000s, when disillusion due to contamination problems nearly killed the field, before leading up to next-generation sequencing.

Implementation

This is when the new results and their methods become widely accepted and routinized. This is also when their interpretative and theoretical implications are fully understood and applied, sometimes leading to the formation of new disciplines. During the first science revolution, archaeology, geology, and zoology reached their final form as scientific disciplines, just as zoological and archaeological museums and research departments were established all over the world. Now, the traditional field of zoology is part of archaeological laboratories, while genetics has taken over basic research in biological evolution. Likewise, pollen botanical analysis became part of a new biological subdiscipline, today partly superseded by environmental DNA, and commercial

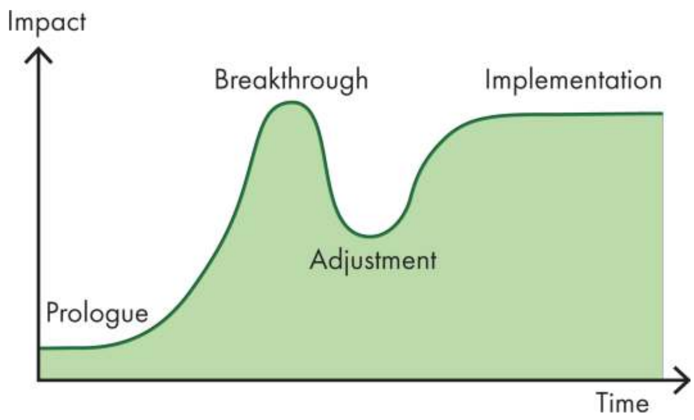

Figure 2 Model of the process of scientific breakthroughs

C-14 laboratories were established from the late 1950s onward. The third science revolution is so far contained within the confines of basic university research, with publications in high-profile journals, but is supported by widespread publicity in the press. While we witness an expansion of aDNA laboratories around the world, the scientific leaders are still a handful of university-based research institutions. The field has not yet entered the implementation phase.

However, we may also observe another historical regularity following the three science revolutions, which I shall term culture-historical counterrevolutions.

Revolutions and Counterrevolutions

Counterrevolutions can be defined as a discursive reaction from practitioners of humanities and cultural history against science-based interpretations, or rather about the role of science, which in their view should be supporting archaeological interpretation rather than playing an equal, collaborative role – if it has a role at all. It is well described and discussed by Martinon-Torres and Killick (2015). Early postprocessualists especially were hostile toward science and wanted to abolish science and quantification, as they "dehumanized" history, in the words of Shanks and Tilley (1987a, 77). However, the trend was partly reversed by the example of the Çatalhöyük project led by Ian Hodder, synthesized in Hodder (1992). Now, we witness a similar critical debate over the role of big data and quantitative modeling versus contextual studies (Huggett 2020; Ribeiro 2019).

These debates, or counterrevolutions, have accompanied archaeology from the very beginning, leading to repeated swings of the pendulum at intervals of thirty to fifty years (Figure 3). Since the beginnings of the discipline, there has existed a debate over the relationship between archaeology and science, which has led to a number of ontological turns that I termed "Rationalism" and "Romanticism" (Kristiansen 1996, figure 4, 2008, figures 2 and 7). Should archaeology be a historical discipline whose interpretations were anchored in a humanistic discourse of the particular, or a science-based discipline whose interpretations were anchored in a scientific discourse of historical regularities? For every discursive turn, however, the repertoire of archaeology expanded, and even if the dominant interpretations were sometimes one-sided, new methods – from excavation techniques to science-based analyses – steadily expanded the archaeological field of knowledge and thus paved the way for the next revolution. Each revolution in turn responded to the previous one: The culture-historical turn after 1900 was a reaction against the dominantly grand schemes of typology and social evolution, leading to a new focus on local culture histories and the identification of ethnic groups with material cultures as represented by the

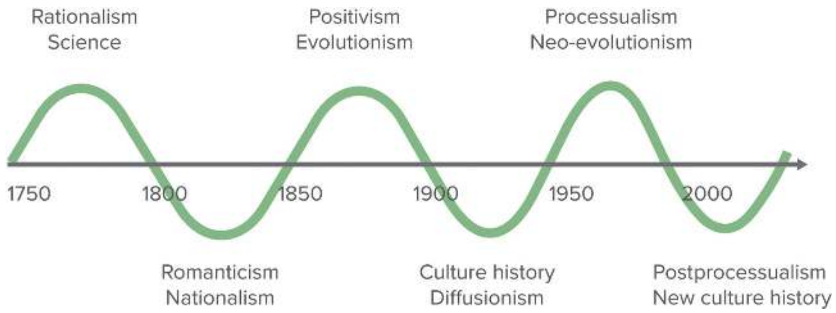

Figure 3 Graph showing repeated swings of the historical pendulum between the two dominant discourses: the science-based, and the humanistic-based, corresponding broadly to the “Two Cultures” in the terminology of C. P. Snow

Kossinna school in European archaeology, the related “Kulturkreislehre” of the Vienna school in ethnography, and the Boas school in the USA. New Archaeology was the predictable counterrevolution against this interpretative scheme, supported by the second science revolution, which in turn spurred a “reactionary” (in the words of Ian Hodder [1982a]) culture-historical counter-revolution that became postprocessualism, which was linked to the postmodern turn in humanities and social sciences. And now the historical pendulum is swinging again with the third science revolution (Kristiansen 2014b).

Throughout all of these revolutions and counterrevolutions, archaeology expanded its repertoire of methods and theories. Therefore, archaeology embraces more diversity than probably any other discipline, both in terms of time depth – from the Paleolithic to the present – and in terms of materials, methods, and theories. Progress in interpretation and new knowledge likewise come from many directions (Lucas 2015 and 2017; Sørensen 2018) – from revisiting old material in museum stores or more likely today from compiling such material in new accessible databases with the potential of big data analysis. It comes from revisiting old philosophical and theoretical positions in the humanities, social sciences, and philosophy, which are constantly updated, from hermeneutics to social evolution (Gardner, Lake and Sommer 2013). And it comes from new breakthroughs in science, such as strontium isotopic tracing of mobility and next-generation sequencing of aDNA, which has suddenly allowed genomic analyses of prehistoric individuals. It revitalized old collections of human remains in museums, just as new methods of lead isotopic analysis revitalized collections of bronzes or lipid analysis revitalized pots and potsherds. More than 150 years of systematic collecting pays off when new observations and new scientific methods can be applied to old materials. Therefore excavators, museum curators, scientists, and theoretical archaeologists are all unified in maintaining this complex web of stored information that is the infrastructure of archaeology, and whose knowledge potential has always demanded interdisciplinarity. Throughout its history, archaeology has been dominated by one or the other interpretative perspective – science or humanities – and in the best of worlds by their collaboration, most often when the historical pendulum was in a middle position on its way from one to the other discourse – the position where we are right now (Figure 3).

Archaeology is thus a creative, borrowing discipline, which has throughout its history successfully applied many methods and theories from a variety of disciplines, from social anthropology, history, and philosophy to various branches of science from geology, zoology, and physics to genetics. Therefore, archaeology is interdisciplinary, or it is nothing.

Archaeology and Genetics: An Ongoing Debate about Interpretation

The Current Debate

As would be expected, a revolution does not unfold without critique, even opposition, as well as debate about how to understand and interpret its results. These debates, however, besides being necessary, are also informative about the dynamics of adapting to a new scientific reality. Here, I shall concentrate on methodological and theoretical aspects and leave the debate about ideology to the next section.

I take inspiration from three thoughtful contributions in order to contextualize the debate. At the recent 9th ISBA Conference on Biomolecular Archaeology in Toulouse (June 2021), the keynote talk by Tamsin O’Connell discussed what is real and unreal in current debates on interdisciplinarity. To unravel the process, she returned to David Clarke’s classic paper “Archaeology: The Loss of Innocence” (Clarke 1973). Here, he focuses on the big transitions in archaeology, and he outlines the historical process from being “conscious,” to becoming “self-conscious,” before reaching the phase of “critical self-consciousness.” Tamsin O’Connell then suggested that the current transition of the third science revolution can be described by applying this framework. She concluded that, from the perspective of biomolecular archaeology, we were still in the phase of being “self-conscious.” It implies that the ability to take critique on board is still considered threatening to the newly won consciousness of biomolecular archaeology. The conclusion was that too much is at stake to reach a more mature level of “critical self-consciousness” at the present moment. Why is that? In order to understand this phenomenon, we need to focus on the meaning and demands of being interdisciplinary. Then it becomes more comprehensible.

In a recent paper, Liv Nilsson Stutz suggests that, in order to create a more productive environment for interdisciplinary collaboration, it is necessary to understand what it takes and that it represents a demanding process of increasing knowledge-sharing. She then suggests a three-phase knowledge- sharing process, moving from "multidisciplinarity," through "interdisciplinarity" toward "transdisciplinarity" (Stutz 2018). She defines the different stages in the following way. *Multidisciplinarity* denotes a model where different disciplines, each providing its own perspective, collaborate by bringing their disciplinary expertise to bear on an issue. *Interdisciplinary* work denotes a higher level of integration by analyzing, synthesizing, and harmonizing links between disciplines "into a coordinated and coherent whole." Finally, *transdisciplinarity*, even more integrated, creates a unity of intellectual frameworks beyond the disciplinary perspectives. I suggest combining the two perspectives into a single processual model (Figure 4).

However, there exists a third level of potential misunderstanding between disciplines in interdisciplinary research collaborations, which has been identified by Alexandra Ion in a recent contribution (Ion in press). She states:

> There might be two main challenges inherent to the fact that the data is very different in nature: (1) each discipline might have its own ontological reading of the studied object; (2) the scale the data operates on. For these reasons when different disciplines meet on the same territory either tensions or misunderstandings might arise (see article on terminology by Eisenmann et al. 2018). In the case of genetic analysis, osteology, cultural anthropology, isotope studies etc., each of them has their own ontological view ascribed to "a person's identity."

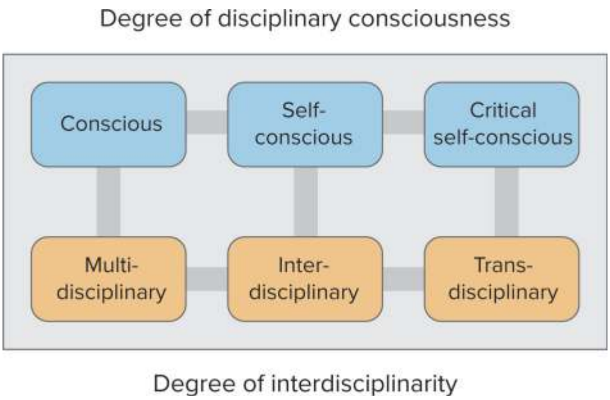

Figure 4 Model of the proposed relationship between degree of disciplinary consciousness in archaeology and degree of interdisciplinarity