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Getting a foot in the door: biomolecular archaeology in the Baltics

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ABSTRACT

This article gives an overview of the development and the current state of the art of biomolecular archaeology in the three Baltic countries – Estonia, Latvia, and Lithuania. First, a general background and the emergence of biomolecular archaeology on a global scale are outlined. Thereafter, the key trends in incorporating biomolecular analyses into Baltic archaeological research are provided. Finally, the paper discusses the main opportunities and challenges of conducting biomolecular archaeological research in smaller research institutions and countries, outlining the strengths and weaknesses of such dedicated research infrastructures. These dynamics are widely applicable to any smaller interdisciplinary research enterprises located away from world-leading research centres. This somewhat personal reflection also aims to contribute to the further development of good scientific practices within and beyond contemporary geopolitical borders and to the conceptualisation of DEI (diversity, equity, and inclusion) science in archaeology and beyond.

KEYWORDS

archaeological sciences, biomolecular archaeology, Baltic countries, historiography.

Introduction

The essence of archaeological research has always been its interdisciplinary nature – as a field tapping into human nature and experience over the past millennia, archaeology has always combined different fields from the humanities and social sciences to medical and natural sciences (Trigger 2006). The past decades have evidenced a rapid increase in the integration of biomolecular methods into archaeological research, resulting in an exponential growth of the interdisciplinarity of the field. When Kristian Kristiansen (2014) published his paper 'Towards a new paradigm? The third science revolution and its possible consequences in Archaeology', he left a question mark behind the concept of a new paradigm, but there is no question now that biomolecular methods have not only revolutionised archaeological research practice, but also the overall knowledge obtained about past societies.

One of the first uses of the term 'biomolecular archaeology' (BMA) dates back to an article by Hedges and Sykes (1992), and it was also picked up a year later by Richard P. Evershed (1993) when setting his specialisation in lipid residue analysis into the wider context of biomolecular research of ancient objects. However, the study of organic molecules had been part of archaeological research already decades before. Contrary to the common perception that BMA has its roots in DNA research, the first 'ancestral publications' focused on studying fossilised amino acids (Abelson 1954), lipid residue analysis of bog butter (Thornton et al. 1970), and isotopic studies of human diet (van der Merwe & Vogel 1978). The renowned ancient DNA (aDNA) field entered the stage somewhat later, in the 1980s, with the first attempts to analyse aDNA from extinct animal specimens (Higuchi 1984) and human remains (Pääbo 1985). For a long time, aDNA-based research was in a certain cocoon-like phase due to its methodological limitations and major authentication obstacles (Pääbo et al. 2004), only to hatch and flourish following the methodological developments of next-generation sequencing (NGS) from the late 2000s onwards (Hagelberg et al. 2015; de Groot 2023).

Meanwhile, the substantial foundational work, active methodological advancement, and applications of newly developed analytical approaches continued in lipidomics (Heron et al. 1991; Heron & Evershed 1993; Dudd et al. 1998; Craig et al. 2004; Evershed 2008a; 2008b), strontium isotope-based provenance studies (Budd et al. 2000; 2004; Price et al. 2002; 2012; Bentley et al. 2004; Bentley 2006; Montgomery et al. 2007), and stable isotope analyses encompassing carbon, nitrogen, and sulphur isotopes (Schoeninger & Moore 1992; Richards et al. 2001; Lee-Thorp 2008; Makarewicz & Sealy 2015). These were soon complemented by palaeoproteomics – both collagen peptide mass fingerprinting and shotgun approaches – that gained substantial acceleration from the various developments of mass spectrometry instruments (Ostrom et al. 2000; Tokarski et al. 2006; Buckley et al. 2009; Warinner et al. 2022).

However, the boom of BMA has gone hand in hand with the advancements of aDNA research, whilst the latter has direct correlations with the overall development of genomic research in modern medicine, biotechnology, and environmental sciences (M'Charek 2005; de Groot 2023). The increasing importance of BMA in archaeological sciences is also evident from dedicated textbooks (Brown & Brown 2011) and from the fact that BMA-related chapters form a substantial part of general archaeological science overviews (Richards & Britton 2020; Pollard et al. 2023), not to mention the increasing number of courses or even full study curricula being integrated into higher education across the world today, e.g. through the ChemArch Marie Skłodowska-Curie Actions (MSCA) doctoral training network (2021–2025), the University of York's BioArCh Centre, or dedicated master's-level programmes at e.g. Cambridge and Durham. The initiation of a dedicated scientific conference series – the International Symposium for Biomolecular Archaeology (ISBA), first held in Amsterdam in 2004 – further increased the viability of the field, leading to the foundation of the International Society for Biomolecular Archaeology in 2022.

All in all, the impact of BMA on the study of both nearby and distant communities is difficult to underestimate, and in many instances the experiences (both positive and negative) and developments in BMA can be used as guidelines and learning points for any interdisciplinary research. In fact, the field is playing a crucial role in shaping a completely new understanding of transdisciplinary research combining natural sciences and the humanities, which has led to the proposal of a new research era – the biomolecular humanities (Oras et al. 2025).

Yet, as with most cutting-edge and world-changing science, the vast majority of novel BMA work still takes place in leading, mostly western (if not Anglo-American) research centres with long-standing and well-established educational and research ecosystems, centrally supported analytical infrastructure, and, last but not least, the much-needed critical mass of active scholars and technical support staff (Ribeiro & Giamakis 2023; Luo et al. 2025; Beck et al. 2026). Evidence for this can be found in higher education ranking lists and in the most-cited BMA papers in major article databases. These centres act as knowledge hubs, serving as cross-regional magnets that bring together the brightest students and scholars, leading to exciting new discoveries, prestigious publications, and generous funding opportunities.

The key to the BMA research, however, is not only where and at what speed those new skills can be acquired and implemented, but also how these new cutting-edge methods can be put into practice and developed in sustainable and proactive ways. In this context, it is intriguing to observe if, how, where, and when the developments of BMA arrive in more distant areas and research institutions. How does the transfer of knowledge occur? How do new scientific research centres get established locally? Can, and if so how do, 'peripheral' research groups keep up with the well-oiled, efficient, well-staffed, and financially more advanced leading institutes? How can small laboratories and research groups build their reliability and accountability given their unavoidably limited human and financial resources? Are there any intrinsic values or areas of activity in which smaller research groups actually stand out or surpass larger scientific hubs? In a nutshell, what are the possibilities and obstacles of 'getting a foot in the door' in BMA for those located outside the main research centres?

The aim of this paper is to reflect on those questions by mapping the developments of BMA in the three Baltic countries. Due to academic proximity and familiarity, I will mostly focus on Estonia, but also bring in some general trends from Latvia and Lithuania to understand the roots, the current state of the art, and future perspectives of BMA in the Baltics. In doing so, I also aim to position BMA research in the Baltics within a wider international context in terms of both the research topics covered and the local facilities created. The purpose is not only to examine the obstacles, but also to highlight the opportunities that research centres in the Baltics (and other peripheral regions and smaller institutions) might create for themselves.

Yet, I aim to keep the focus on the three Baltic countries intentionally. Not only do these countries share geographical and cultural proximity, e.g. as small nations with a keen interest in historical narratives as part of the process of regaining independence, but they also share a common socio-political and historical context as well as research and educational traditions and facilities. A major impact derives from their post-Soviet background, which has shaped the development of western-oriented research infrastructure since the 1990s, conveniently overlapping with the major developments of BMA. I hope to reveal the underlying processes shaping BMA research in the Baltics today, and the implications and/or tensions that these trends have for the future development of the field in these countries.

However, several of the trends that I outline here, particularly in terms of future opportunities and perspectives, might be applicable to other small, non-central or non-western research enterprises, whether already existing or still in the planning stage, whether in the field of archaeological sciences or beyond. Furthermore, I intend to address the role of leading research hubs, acknowledging their contribution to the spread of knowledge, but also explaining when and why their input and involvement can be crucial or, sometimes, on the contrary, impeding. On a wider scale, I hope that this somewhat personal reflection contributes to the further development of good scientific practices within and beyond contemporary geopolitical borders and to the conceptualisation of DEI (diversity, equity, and inclusion) science (El Boghdady 2025; Titirici et al. 2025) in the 21st century at its best.

The history of BMA in the Baltic countries

BMA IN THE BALTIC COUNTRIES IN THE 20TH CENTURY

As in the rest of the world, natural science methods have been an integral part of archaeological research in the Baltic countries since the beginning. Active integration with environmental sciences was initiated by the local Baltic-German intelligentsia-led learned societies (Kriiska & Lõugas 2006; Vasks et al. 2025), with, e.g., excavations conducted by geologists (Grewingk 1882) or pioneering chemical analyses of archaeological materials such as metal objects (Hausmann 1905). The development of novel radiocarbon dating methods was rapidly adopted also under Soviet conditions, with a conventional dating laboratory being established in Tartu as early as at the end of the 1950s (Liiva et al. 1966).

As in the rest of the world, direct applications of BMA were introduced in the very last decade of the 20th century. However, the extensive integration of bioarchaeology, covering zooarchaeology, archaeobotany, and physical anthropology, was at the core of local archaeological research both during the period of the first republics (the 1920s–1930s) and within the later framework of Soviet occupation (1940s–1991), as well as after the restoration of independence in the 1990s. The initiation of the new central networks of national research institutes at the national academies of sciences during the Soviet period, which included multiple scholarly subsections dedicated to history, archaeology, and the natural sciences, somewhat supported scientific cross-pollination (Lang 2006; Lang et al. 2010; Vasks et al. 2025).

A clear and long-term development of expertise in zooarchaeology is visible in all three Baltic countries (Paaver 1965; Piličiauskienė & Micelicaitė 2020; Plankājs 2025). Archaeobotanical research was largely led by the Latvian expert Alfrēds Rasiņš (1959), who actively collaborated with scholars across the Baltics (Johanson et al. 2025), although palaeoenvironmental reconstructions and collaboration with geologists, especially in pollen research, were more widespread (Poska et al. 2004; Stančikaitė et al. 2012; Ceriņa 2025). At the same time, physical anthropology was at the forefront of scientific applications throughout the 20th century (Kriiska & Lõugas 2006; Jankauskas 2012; Radiņš 2025; Zariņa 2025a). Dedicated anthropological collections were created as part of archaeological collections in Estonia (Kriiska & Lõugas 2006), in direct association with the medical faculty in Lithuania (Jankauskas 2012), or as a separate archaeological collection in Latvia (Zariņa 2025c). Their main strand of research focused on osteometry, palaeopathology, and demographic reconstructions, with leading experts being actively involved in scientific communication across the Soviet Union (Mark & Heapost 2014; Radiņš 2025; Zariņa 2025a; 2025b). All these developments in bioarchaeology and environmental sciences, including the establishment of collections and the research conducted, were crucial in building the foundations for acknowledging the informative value of ecofacts and for collecting the material to which novel biomolecular techniques could be applied in the years to come.

With the fall of the Soviet Union, new westward-facing research networks were initiated, oftentimes building on the connections with scholars who had emigrated, or whose parents had emigrated, abroad during World War II. For instance, several frameworks for the exchange of knowledge, as well as practical training, were established in Estonia. One of the earliest and most flourishing was the European Council-funded PACT (European Study Group on Physical, Chemical, Biological and Mathematical Techniques Applied to Archaeology), which focused on past environmental reconstructions and resulted in three dedicated collections of articles (PACT 37; 51; 57). Baltic researchers gained new opportunities to study and visit laboratory facilities in the west, especially in neighbouring countries and research centres, primarily Finland and Sweden in the case of Estonia. More and more scholars also became integrated into worldwide scholarly networks such as the International Council for Archaeozoology and other individual collaborations within the field of bioarchaeology (Plankājs 2025), whilst, building on previous connections, older eastern contacts were also maintained for some time (Mark & Heapost 2014).

The first pioneers in the field of BMA, strictly speaking, also belong to this early post-independence period (Fig. 1). Through collaborations with the Archaeological Research Laboratory at Stockholm University, dietary stable isotope analysis was introduced to local academic audiences (Lõugas et al. 1996). Simultaneously, and in fact already in the making from the 1980s onwards, the field of genetics was emerging. The leading figure here was Professor Richard Villems at the University of Tartu, who became professor of molecular genetics in the late 1980s, followed by the professorships in molecular biology and evolutionary biology, and, crucially, a professorship in archaeogenetics in 2004. The rapid development and leading role of aDNA studies initiated by the aDNA group at the University of Tartu from 2010 onwards relied heavily on Villems' foundational work and international contacts (Villems et al. 1998; Kivisild et al. 1999), although some first encounters with aDNA analysis were established by Lithuanian scholars in late 1990s as well (Faerman & Jankauskas 2000).

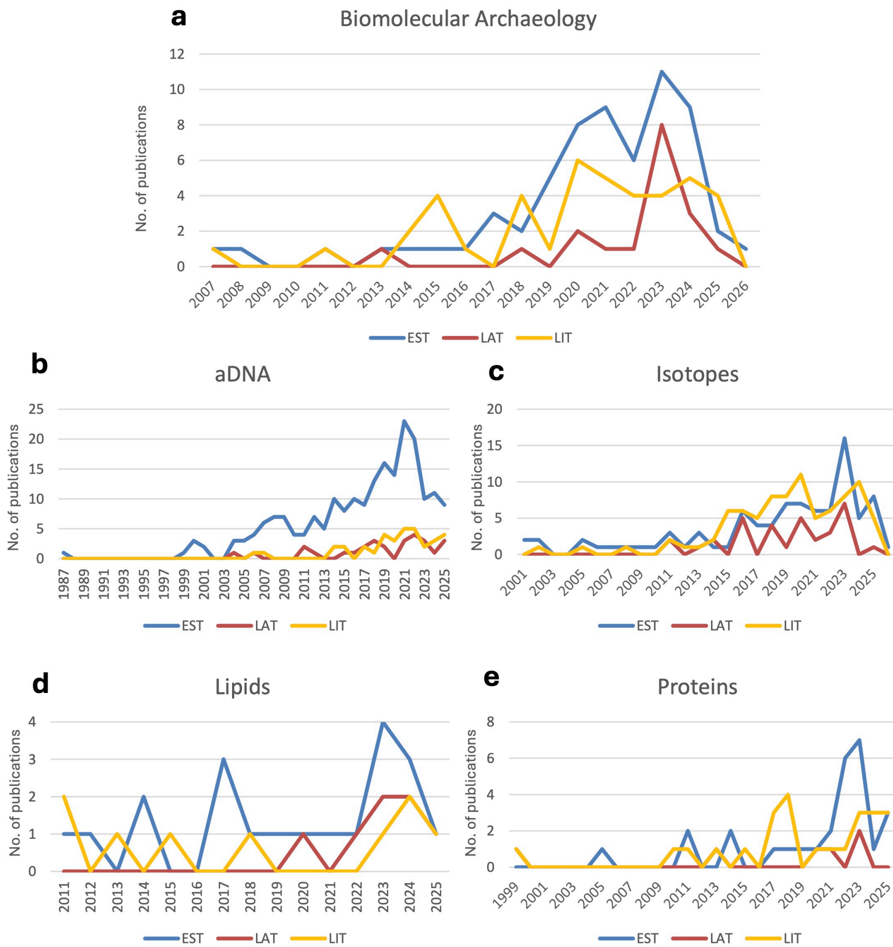

FIG. 1. Representation of the different fields of biomolecular archaeology in the Baltics based on a Scopus Boolean search combining the search term 'archaeolog*' (all fields) with a specific type of analysis (title, abstract, and keywords), by country, for the following combinations: **a** – 'biomolec* archaeolog*', **b** – 'DNA', **c** –'isotop*', **d** – 'lipid*', **e** – 'protei*', as of 11 December 2025. Abbreviations: EST – Estonia, LAT – Latvia, LIT – Lithuania.

DEVELOPMENTS IN BMA IN THE BALTIC COUNTRIES IN THE 21ST CENTURY

Since the boom of BMA across the world in the 2000s, there have been different pathways for incorporating biomolecular research into local archaeological scholarship across the three Baltic countries. The most prevailing, especially in the early 2000s, was collaboration with leading western research institutions, where the role of local Baltic scholars was often to provide access to samples and incorporate local archaeological knowledge into the interpretation of new analytical datasets. Substantial new knowledge has been obtained through these international collaborations on ancient dietary practices using stable isotope analysis, e.g. at the renowned Mesolithic and Neolithic sites of Zvejnieki and Riņņukalns in Latvia (Eriksson & Zagorska 2003; Eriksson et al. 2003; Bērziņš et al. 2014; Meadows et al. 2016), or as part of radiocarbon-focused research (Oinonen et al. 2013), but also through the first studies led by local scholars in Lithuania (Antanaitis-Jacobs & Ogrinc 2000; Antanaitis-Jacobs et al. 2009). The possibilities of reconstructing ancient foodways through pottery organic (lipid) residue analysis emerged through collaborations with leading western experts who were interested in analysing Baltic materials (Heron et al. 2015; Robson et al. 2019). More substantial adoption of novel methods by local scholars followed in subsequent years, mostly focusing on dietary stable isotope analysis (Zariņa et al. 2016; Piličiauskas et al. 2017a; 2017b; Simčenka et al. 2020; 2022; Vasks et al. 2021), sometimes also using more unconventional approaches, such as trace element or carbonate analysis (Rudoviča et al. 2009; Bliujienė et al. 2020). An important milestone in early 21st-century Estonian archaeology was the establishment of the professorship of Laboratory Archaeology, inaugurated by Professor Aivar Kriiska at the University of Tartu in 2007, with a strong emphasis on aDNA-related collaborations.

Notably, the somewhat exceptional case within Baltic BMA scholarship has been aDNA research centred around the Tartu group. Building on a strong evolutionary biology background, analytical techniques were developed and tested locally, and following the rapid methodological improvements in DNA sequencing in the late 2000s, the Tartu group grew into one of the leading research hubs for aDNA research, collaborating widely and offering its expertise across the globe (Kivisild et al. 2003; Behar et al. 2010; Chaubey et al. 2011; Karmin et al. 2015; Saag et al. 2019). At the same time, several attempts at aDNA research were conducted in Latvia as well (Kazarina et al. 2017; Krumiņa et al. 2018). Nevertheless, in the early days of aDNA and during the wake of the global aDNA hype, foreign collaborations and sample-provision-based approaches were also practised by Baltic scholars (Bramanti et al. 2009; Allentoft et al. 2015; Jones et al. 2017; Mathieson et al. 2018; Mittnik et al. 2018). In parallel with human aDNA, substantial work was conducted on faunal and pathogen aDNA research too (Korsten et al. 2009; Rannamäe et al. 2016; 2020; Hindrikson et al. 2017).

The 2010s introduced yet another way of incorporating biomolecular sciences into Baltic archaeological scholarship. This was, and still is, built on a younger generation of researchers who studied abroad, e.g. by undertaking master's degrees, doctoral studies, research projects, or postdoctoral positions in leading western BMA centres, and then returned home to establish facilities for continuing this research locally. Active involvement and hands-on practice in laboratories appear to be crucial here, as merely working with foreign scholars who provide novel datasets and publishing them together does not seem to result in obtaining practical skills and analytical knowledge needed to establish new analytical infrastructures locally. Examples of such endeavours, often building on ongoing close collaborations with foreign scholars and educators, include the foundation of an organic residue analysis facility at the University of Tartu in the mid-2010s (Oras et al. 2017a; 2017b; 2017c; 2018), the first applications of human provenance studies using strontium isotopes (Oras et al. 2016; Price et al. 2016), the locally initiated collagen stable isotope analysis of Baltic materials (Pētersone-Gordina et al. 2013; 2018; Tõrv & Meadows 2015; Tõrv 2016), the start of stable isotope analysis work at Tallinn University (Aguraiuja-Lätti & Lõugas 2019), and the establishment of a dedicated archaeobotany laboratory with a strong biomolecular angle at Vilnius University (Ananyevskaya et al. 2018; 2020; Motuzaite Matuzeviciute et al. 2019), later also established in Tartu (Johanson et al. 2025). The rapid development of aDNA research, with a younger generation of researchers willing to dedicate themselves to this field, has also instigated the establishment of aDNA laboratories in Latvia (Kazarina et al. 2021a; 2021b; Ķimsis et al. 2023; Pokšāne et al. 2025) and Lithuania (Domarkienė et al. 2025). In the case of the former, the deeper roots of the dedicated field lie in biomedical research, whereas in Vilnius the establishment of aDNA research builds upon long-term expertise in medical sciences and physical anthropology at Vilnius University.

Some of those initiatives have developed into independent BMA research laboratories and groups in the 2020s, mostly affiliated with local universities, but serving as regional hubs for the consolidation of BMA knowledge. Besides the previously mentioned long-term and newly established aDNA groups, these include, e.g., Archemy Lab at the University of Tartu and the Bioarchaeology Research Centre of Vilnius University, which are internationally recognised and capable of conducting cutting-edge BMA work independently. In other instances, this knowledge potential has not (yet) been developed into dedicated research infrastructures but remains more closely tied to local individual expert knowledge, e.g. stable isotope work in Latvia (Pētersone-Gordina et al. 2022a; 2022b; Legzdiņa & Zariņa 2023). These centres and individual experts have started to act as nodal points, attracting students and young scholars locally and internationally. Many are actively involved in international research networks through both long-standing and newly established collaborations, have started to secure local and international research funding (including, e.g., Horizon Europe widening programmes such as Twinning and European Research Council grants), and provide analytical services for scholars across the Baltic countries

(Gunnarssone et al. 2020; 2024; Spataro et al. 2021; Visocka (Haferberga) 2022) and elsewhere (Bjørnevad et al. 2019; Papakosta et al. 2019; Price et al. 2021; Wisher et al. 2025). One of the key events that placed the BMA facilities at the University of Tartu, and more broadly those of all three Baltic countries, on the global map, was certainly the organisation of the 10th ISBA conference in Tartu in 2023.

Although it is still early days, and the majority of the BMA expertise in the Baltic countries is still under development, the main analytical capacities and expertise of local research centres, as reflected in their scientific output over the last ten years, can be described as follows:

1. Archemy Lab, University of Tartu: dietary stable isotope analysis, strontium isotope provenance studies, organic residue analysis, palaeoproteomics (including ZooMS and metaproteomics), plant micro- and macrofossil analysis.
2. aDNA Lab, University of Tartu: aDNA, including population genomics, metagenomics, and metaproteomics.
3. Archaeological Research Collections, Tallinn University: dietary stable isotope analysis.
4. aDNA group, Latvian Biomedical Research and Study Centre: aDNA, including population genomics and metagenomics.
5. Institute of Latvian History: dietary stable isotope analysis, strontium isotope provenance studies.
6. Bioarchaeology Research Centre, Vilnius University: dietary stable isotope analysis, plant micro- and macrofossil analysis.
7. Centre for Human Bioarchaeology and Palaeogenetics, Faculty of Medicine, Vilnius University: aDNA, mostly population genomics.

Challenges and perspectives of BMA in the Baltic countries

There are several factors influencing the existence, growth, and sustainability of BMA research in the three Baltic countries. Some of them are intrinsic, i.e. related to how the work in these rather newly established facilities is organised and executed. Others, however, are extrinsic, relating to the perception of and support for these new laboratories from BMA infrastructures abroad, but also from local archaeological and wider research communities. I reflect on these issues from a Baltic perspective, particularly drawing on my experience of establishing and maintaining Archemy Lab in Tartu, but the majority of these observations are applicable to any BMA research group located away from leading western centres. In particular, I want to highlight two crucial phenomena: collaboration and recognition.

INTERNATIONAL AND REGIONAL COLLABORATIONS

One key aspect of the success of BMA research in the Baltics is international collaboration. The vast majority of the currently existing groups stem from deeply rooted, active collaborations with leading BMA research centres, where the local experts gained their first-hand experience and laboratory training. Maintaining these connections is crucial for several reasons. First, as the majority of the new laboratories are rather small in terms of human and financial resources, and their critical mass of dedicated scholars is not compatible with that of the leading centres, involvement in these international networks allows researchers to keep abreast of recent developments in the field, learn and test novel approaches, and perhaps even facilitate access to instruments that are not available locally.

On the other hand, maintaining these connections may be beneficial for foreign centres as well, providing first-hand input regarding local history and archaeological context, while also allowing a certain division of labour when it comes to sampling and analysing new materials. The active involvement of local laboratories in major international projects should not be underestimated, as, with the exponential growth of BMA research, one of the major criticisms of such endeavours is the phenomenon of so-called helicopter or parachute science (Stefanoudis et al. 2021; Odeny & Bosurgi 2022; Brache 2025). The latter often entails, e.g., overlooking or underestimating local, especially indigenous, research communities (Yanou et al. 2023; Reid et al. 2024; Ijatuyi et al. 2025), or a tendency to oversimplify obtained results without sufficient consideration of regional archaeological information and relevance. The mutually beneficial structure and active collaboration of central and newly established laboratories allow small groups to avoid isolation while simultaneously highlighting the dedication of leading centres to the global transfer of knowledge and to increased epistemic and cognitive justice. The latter is an investment leading towards a more balanced regional coverage of scientific opportunities – the concept of DEI science – not to mention increased encouragement of international collaborations across all academic sectors.

A more intrinsic aspect of future developments is the collaboration of BMA facilities across the Baltic countries. Given the restricted financial and human resources available to each country, it will probably never be possible to develop and master all the novel methods locally. Here, close research collaboration between laboratories should not be underestimated. Expertise available in one group can be transferred to others through joint research projects, cross-use of laboratory facilities, and making them accessible to one another in the long term via, e.g., the training of students and early-career researchers. The first step here is to be fully aware of existing expertise.

Activities such as regular open seminars showcasing ongoing research, exemplified by the establishment of the Baltic Biomolecular Archaeology Group (initiated by Archemy Lab in Tartu) in 2023, are effective channels for disseminating knowledge. On the other hand, the inclusion of multiple laboratories in different research and training networks and projects will certainly increase opportunities to learn together and from one other. Here, the initiation of Horizon Europe widening actions such as the so-called Twinning projects, e.g. the ECHO project (lead by the aDNA group in Tartu), bringing together aDNA facilities from the three Baltic countries to learn best practices from the world-renowned aDNA groups at the Globe Institute (University of Copenhagen) and KU Leuven, has proven to be particularly useful.

Interactions with local research infrastructures, both at the level of one's home university and within one's home country, should not be underestimated. As laboratory work is expensive and investment-intensive, both in terms of the working environment and the development of specific expertise, access to and support for establishing laboratory infrastructures are the pledge of success. Finding the right people is crucial here, as some are more willing to collaborate, open their facilities for wider use, stand out for their approachability and trustworthiness, and provide free training than others. For example, the Archemy Lab has obtained immense support from institutes across the University of Tartu, especially those specialising in analytical chemistry, geology, and aDNA research. Without their help and contribution, the development of a brand-new laboratory and research group would have been impossible. The need for cross-institutional access to expert knowledge and analytical infrastructures is also evident from the co-authorship lists of works published by Latvian and Lithuanian scholars (Indrulėnaitė-Šimanauskienė et al. 2022; Ķimsis et al. 2023; Pokšāne et al. 2025; Shoda et al. 2025).

Indeed, one of the benefits of small countries and research institutions is the almost complete absence of hierarchy. It is easy to get in touch and ask for help, whilst solutions to practical problems, such as finding financial or technical support, can often be worked out quickly and informally. The latter, by the way, often results in a rapid turnover of analytical measurements and access to instruments, with more flexible booking schedules and easier access to apparatus in case of urgency. This is perhaps one of the many strengths of smaller analytical infrastructures, where they may outperform large western centres. At the same time, such cross-use of facilities and shared access to laboratories should be explicitly encouraged and evaluated, both in research evaluation and in the allocation of funding within home institutions and at the national level.

INTERNATIONAL AND REGIONAL RECOGNITION

The second crucial factor contributing to the success and sustainability of newly established BMA laboratories is the recognition of their expertise and endeavours. The starting point here is the general perception of, and trust in, newly built analytical infrastructures by the local research community, especially archaeologists, other scholars, museum curators, and related stakeholders. The avoidance of collaboration with local experts and the decision not to use their analytical capacities can sometimes be problematic.

There are probably several reasons for such attitudes. First, and often the most important one, is the fact that local research communities have not been fully informed and are therefore simply unaware of the new possibilities. This is where newly established laboratories should place greater emphasis on awareness-raising through, e.g., dedicated seminars, open laboratory visits, and similar activities. The second reason could be the existence of long-standing collaborations with leading foreign institutes. 'If it works, do not try to fix it' is an understandable attitude. Sometimes, the opportunities and prestige associated with well-known institutions can also have an effect. Although there are many reasons to remain satisfied with this status quo, considerations regarding regional knowledge advancement and support for the sustainability and growth of local research infrastructures should also be highlighted. Local scholars often understand the problems and nuances without detailed explanation, speak the same professional language (e.g. regarding periodisation, sites, and socio-cultural context), are capable of being more involved in research design, and can respond to and explain novel results more rapidly and accessibly. Hence, a preference for the services of 'big names' is not always beneficial, especially considering that the expertise and analytical services provided by local scholars are comparable to, and indeed often derive directly from, those leading centres and scholars.

At the same time, the decision to avoid local expertise will have an impact on the development and future availability of these unique areas of expertise and may impede the diversification and flourishing of the local research ecosystem. No laboratory can maintain itself without any external interest and demand in the long term, whether in the form of dedicated funding, inclusion in publications and projects, or the provision of services to different stakeholders. Hence, local recognition and active involvement are important components in keeping laboratories and experts active. Moreover, when working in research institutions and small laboratories with limited resources, one always needs to find a balance between serving the wider public (including through commercial services) and pursuing one's own curiosity-driven research. The majority of BMA laboratories in the Baltics tend to concentrate on the latter, i.e. research, while incorporating collaborations with other public stakeholders according to their available time and analytical capacity.

Turning to international recognition, the perceived quality and status of new BMA laboratories cannot rely solely on ongoing foreign collaborations and local service provision. There are several criteria that need to be fulfilled in order to become an internationally recognised research centre, and no concessions are made for smaller laboratories; they face the same fierce competition as the leading hubs. One clear proof of concept is the acquisition of funding, especially prestigious and highly competitive international grants such as those provided through the European Research Council and other Horizon programmes, the European Molecular Biology Organization (EMBO), the Wellcome Trust, and similar schemes. These frameworks not only contribute financial support for establishing and maintaining laboratories, but also serve as proof that the work conducted in the region and in smaller centres is of high international quality, novel, and trustworthy both locally and internationally. Perhaps worth mentioning in this context, however, is the almost complete absence of private foundations and philanthropic enterprises in the three Baltic countries that could provide large-scale financial support for research. Put simply, the range of available research funding is much narrower here, making access to limited funds even more competitive.

The second indicator of international approval for the conducted work is the output of high-quality publications in leading international journals. The question is not so much the research material presented, nor the name of the first author, but rather the recognition of the research group and/or institution from which the work originates. Scholars from smaller laboratories (including those who have moved from leading centres back to their home universities) have probably considered, if not faced, the inescapable and infamous problem of implicit bias in grant evaluation and article peer-review processes (McGillivray & De Ranieri 2018; Giannakakos et al. 2025). As much as we would like to emphasise the utmost importance of scientific excellence and academic rigour, the reputation and brand-awareness of a country, university, research group, or individual scholar can still influence decisions and feedback. This is not specific to BMA, but applies to almost any globally applicable field. ‘Big names’ and enormous outputs, building on richer and larger research infrastructures and sheer human investment, do serve as stronger signals of community approval and reliability. However, the question remains: what do you do when you simply cannot have them all? The introduction of implicit-bias tests before evaluation procedures, advocacy for double-blind peer-review, or the introduction of certain quotas in cases of equal candidates may have an encouraging and uplifting effect on members of smaller research institutions. Yet such measures will never change the sheer fact that research facilities, available resources, and scientific outputs vary considerably between regions and disciplines, and the scales or metrics suitable for larger institutions do not necessarily fit everyone else.

The latter brings me to a point that is more closely related to the organisational culture and leadership of newly established BMA centres. As setting up new analytical facilities and research groups such as BMA laboratories in smaller countries and research institutions can be intensive in terms of labour and emotional investment, building resilience and contingency plans is crucial, at least in my own experience. In this context, shared responsibility and joint effort in establishing such infrastructures, not to mention the distribution of the mental load and the creation of true team spirit, should not be underestimated. There is only so much that one person can know or do, and avoiding overdependence on individuals by expanding the team with different experts who share responsibility, both for research and funding, while also investing in team-building, can turn out to be the key to success and sustainability (Marx 2025). In circumstances where all resources required to keep a laboratory operational (including personnel, instruments, and daily consumables) are entirely project-based, as is the case for Archemy Lab in Tartu, sustaining all this under a single principal investigator is basically impossible. Hence, in Tartu, we have introduced a broader and more inclusive leadership model by setting up an Archemy Board that consists of experts in specific fields (organic residue analysis, stable isotope analysis, zooarchaeology, and archaeobotany), who contribute not only to the strategic planning and decision-making of the laboratory, but also to funding acquisition, daily administration, outreach activities, project writing, and supervision. Such a strategic approach, especially when it comes to shared PI roles and collective responsibility for acquiring funding, not only relieves the burden on a single person, but also makes the whole infrastructure more active and sustainable.

Finally, I would like to outline some suggestions for internal development that could be beneficial for the future of continuous and active BMA research in the Baltics. One aspect where we still need to improve is our broader strategy for internationalisation. As we ourselves are mostly rooted in international collaboration, it is necessary to open up our laboratories to the international research community more explicitly, i.e. to transform local centres into knowledge transfer facilities and to attract new intelligence via visiting researchers and more permanent early-career researchers. Solutions here are manifold, ranging from international postdoctoral programmes (e.g. MSCA) and PhD training networks to building European-wide international teaching programmes for master's students (e.g. Erasmus Mundus). We must also invest in increasing our international visibility through, e.g., active online presence and recruitment activities, providing active grant-writing support for incoming scholars. Furthermore, the proposed actions for opening ourselves up to the world should not be merely formal, but should also involve ensuring accessibility in terms of language and culture. The things to be considered are diverse: supporting daily communication (particularly in English), explaining local academic rules and norms (and withdrawing from these where necessary), making sure to avoid any discrimination against foreign (and indeed local) scholars, supporting newcomers in settling into local towns and universities, and investing in their overall emotional well-being.

Explicit recognition of individual scholars' merits, multiple opportunities for self-fulfilment, space for personal development, appreciation of DEI, tailored mentoring, incorporation of academic and research freedom into daily research practice, and investment in transferable skills and future career development perspectives – in short, taking thoughtful and individualised care of our people according to their capacities, needs, and aspirations – are perhaps some of the aspects in which smaller laboratories are better equipped and motivated. Here, broader institutional support from local universities or institutions in the form of active human resources, financial, and communications strategies may prove tremendously beneficial, and special efforts have to be made to secure the highest-quality support of this kind in smaller countries and research organisations. Crucially, all these costs may prove to be investments in the future success of laboratories (and universities in general), because the loss of expertise is much harsher in smaller groups, as it is more difficult and time-consuming to find suitable replacement, especially when this must be done rapidly, as is often necessary in a laboratory context. On a wider scale, however, all these proposed endeavours ought to be viewed within the framework of science diplomacy. The foreign scholars who join, and later leave, our laboratories and research groups in these remote regions may ultimately become spokespersons for our countries and universities across the globe.

Conclusion and food for thought

Despite its long-term history, BMA is a relatively new field that has perhaps reached its (late) teenage years by the mid-2020s. Indeed, this parallel could hardly be more accurate, considering that many scholars have left their safe 'home-sweet-homes' and apprenticeship positions, and are now starting to build their own careers further away from the parent hubs. However, believing that scientific rigour and advancement can only happen through the active exchange of knowledge and involvement in global scholarship, there are several critical aspects – some deriving from our history and generational values, others from our cultural and academic contexts – that the new BMA facilities and scholars working in the Baltics (and beyond) ought to consider.

First, it is crucial to find a balance between international collaborations and seeking academic prestige, and serving the needs of local stakeholders. As the saying goes, 'No man is an island', and no laboratory infrastructure, at least from the perspective of BMA research, can exist in isolation from wider scholarship networks. Active and intentional collaboration and networking are key to keeping oneself updated and securing or providing access to recent developments in the field. At the same time, one has to be careful not to underrate local expertise and scientific achievements. Given the historical development of BMA facilities in the Baltics, we must start to overcome our imposter syndrome and recognise ourselves as peers of the leading centres and scholars that shaped our field. Extending the list of renowned grants and publications as proof of high-quality research could be one way to do that; another would be not to undersell our knowledge, heritage materials, and analytical capacity. To continue the family analogy, it takes time to face one's 'parents' on an equal footing, but when it happens, the beauty of these relationships becomes truly vivid and new adventures may begin.

At the same time, there is little point in conducting world-class international research if the local scholarly community does not see the merit and tangible outcomes of this work. Hence, we must put extra work into communicating our capacities and remaining open to analytical consultancy and collaborations with different stakeholders (academic, the heritage sector, museums, and public outreach initiatives) at the regional level as well. Furthermore, as we operate with more limited human and financial resources, it is important for each research facility to explicitly articulate its values, interests, and expertise – the magnets that can help attract and enable the flourishing of new and young scholars.

Finally, as examples of new interdisciplinary research infrastructures, the establishment of BMA facilities in the Baltics is of more than minor importance. The research agendas we set, the values we adhere to, and the teams we create will shape not only the future of our field, but also, more broadly, the future of cross-sectional research that breaks down traditional boundaries between the humanities, natural sciences and medicine, at our home universities and countries, and also on a global scale. The unique experiences, actions, and decisions of smaller research institutions, such as BMA laboratories in the Baltics, contribute to the broader development of 21st-century science – not only by raising awareness of and appraising cognitive justice, multilateral scientific capacity-building, and the democratisation of research, but also by tackling contemporary geopolitical tensions and supporting balanced regional development.

DATA AVAILABILITY STATEMENT

All data are contained within the article.

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Jalga ukse vahele saamas: biomolekulaarne arheoloogia Baltikumis

Ester Oras

RESÜMEE

Arheoloogia on alati olnud interdistsiplinaarne valdkond, mis ühendab humanitaar-, sotsiaal- ja loodusteadusi. Viimastel kümnenditel on biomolekulaarsed meetodid – vana DNA analüüs, stabiilsed isotoobid, lipiidide analüüsid ja paleoproteoomika – arheoloogiat sügavalt mõjutanud. Kui 2010. aastate alguses arutleti, kas tegemist on uue teadusparadigmaga, siis nüüdseks on selge, et biomolekulaarne arheoloogia (BMA) on mõjutanud arheoloogide igapäevast uurimistegevust ja ka arusaamist minevikust olulisel määral.

Kuigi BMA juured ulatuvad 20. sajandi keskpaiga aminohapete, lipiidide ja isotoopide uuringuteni, toimus tõeline murrang koos DNA-sekveneerimise metoodilise arenguga 2000. aastate lõpus. Siiski on BMA valdkonna keskused koondunud peamiselt Lääne-Euroopasse ja Angloameerika teadusruumi, kus on tugev laboratoorne infrastruktuur, kriitiline mass teadlasi ja suuremad rahastusvõimalused, mis loovad soodsad tingimused BMA kui teadussuuna kiireks arenguks.

Käesolevas artiklis vaadeldakse BMA kujunemist Eestis, Lätis ja Leedus ning arutletakse selle üle, millised on väiksemate ja nn perifeersete teaduskeskuste võimalused ja takistused tipptasemel BMA viljelemisel.

Loodusteaduslike meetodite kasutamine ei ole Baltikumi arheoloogias uus nähtus. Juba 19. sajandi lõpul kaasati kaevamistele geolooge ning tehti esimesi keemilisi analüüse. 20. sajandil kujunes välja tugev zooarheoloogia, arheobotaanika ja füüsilise antropoloogia koolkond. Nõukogudeaegne teadusinstituutide süsteem toetas samuti teataval määral interdistsiplinaarsust, kuigi rahvusvaheline suhtlus oli piiratud.

Pärast taasiseseisvumist 1990. aastatel toimus ka teadusvõrgustike ümberkujunemine just lääne suunal. Loodi kontaktid Soome, Rootsi ja teiste Euroopa keskustega ning Baltikumi teadlased liitusid rahvusvaheliste võrgustikega. Just sel perioodil jõudsid piirkonda esimesed biomolekulaarsed analüüsid – stabiilsete isotoopide uuringud ja geneetilised uuringud. Viimase puhul kujunes juba varakult omalaadseks pioneeriks Richard Villemsi algatatud uurimisgrupp Tartus.

2000. aastatel toimus BMA kiire areng ka Baltikumis. Alguses tähendas see peamiselt koostööd lääne tippkeskustega: kohalikud teadlased pakkusid arheoloogilist materjali ja konteksti, analüüsid tehti sageli välismaal. Selline mudel pakkus uut ja olulist teadmust, kuid ei tähendanud veel kohaliku analüütilise suutlikkuse väljakujunemist.

Oluline muutus toimus 2010. aastatel, kui välismaal koolitatud noorem põlvkond hakkas rajama kohalikke laboreid. Eestis kujunesid välja Archemy labor ja jätkuvalt kiiresti arenes Tartu Ülikooli aDNA grupp; Leedus ja Lätis loodi samuti stabiilsete isotoopide, arheobotaanika ja vana DNA uurimisrühmad. Mõned neist keskustest on 2020. aastateks saavutanud rahvusvahelise tunnustuse ning suudavad pakkuda tipptasemel analüüse nii Baltikumis kui ka välisriikides.

Tänaseks hõlmavad Baltikumi BMA keskused laia spektrit meetodeid: toitumise stabiilsete isotoopide analüüs, strontsiumi isotoobid päritolu-uuringuteks, orgaaniliste jääkide analüüs, paleoproteoomika, arheobotaanika ja vana DNA uuringud – ning suur osa neist on esindatud kõigis kolmes riigis.

Need arengusuundumused on esile toonud mitmeid väljakutseid, aga ka võimalusi. Väiksemate teaduskeskuste edu sõltub tugevalt rahvusvahelisest koostööst. Tihe side juhtivate laboritega võimaldab püsida kursis metodoloogiliste arengutendentsidega ja vältida teaduslikku isolatsiooni. Samas peab koostöö olema vastastikku kasulik ja vältima nn helikopterteadust, kus kohalikud teadlased ja kogukonnad on üksnes proovide väljaandja rollis ja jäävad tipptasemel teaduse tegemisest praktikas ning tunnustuse osas kõrvale.

Sama oluline on regionaalne koostöö Baltimaade vahel. Arvestades piiratud ressursse, ei ole realistlik arendada kõiki meetodeid igas riigis eraldi. Teadmiste ja infrastruktuuri jagamine, ühised projektid ja koolitusvõrgustikud on jätkusuutliku arengu eelduseks. Üks selline näide on Archemy uurimisgrupi initsiatiivil Baltikumi biomolekulaararheoloogia grupi loomine 2023. aastal.

Väikeste riikide teadustegevuse eelisteks on paindlikkus, kiirus ja vähene hierarhia. Otsused sünnivad kiiremini, ligipääs aparatuurile võib olla paindlikum ning institutsioonidevaheline koostöö sujuvam kui suurtes süsteemides.

Uute laborite kestlikkus sõltub aga ka kohalikust ja rahvusvahelisest tunnustusest. Kohalik arheoloogiakogukond peab olema informeeritud olemasolevatest võimalustest ja usaldama kodumaist kompetentsi. Väljakutseks võib siin olla harjumuspärane koostöö suurte väliskeskustega või nende prestiiži mõju.

Rahvusvahelisel tasandil määravad kvaliteeditaju sageli konkurentsitihedad grandid ja kõrgetasemelised publikatsioonid. Väiksemad keskused seisavad silmitsi piiratud rahastusvõimaluste ja mõnikord ka varjatud eelarvamustega hindamisprotsessides, seda nii rahastustaotluste kui ka tipptasemel publikatsioonide osas. Samas on rahvusvaheliste projektide ja tippajakirjades avaldamise kaudu võimalik tõestada oma teaduslikku taset ning kindlustada positsioon võrdväärse partneri ja tipptasemel teaduskeskusena.

Samas nõuab uute laborite rajamine suurt tööd ja pühendumust. Archemy kogemuse põhjal tagab jätkusuutlikkuse jagatud vastutus, meeskonnatöö ja kaasav juhtimine. Väikeses rühmas võib ühe inimese lahkumine tähendada suurt kaotust; seetõttu tuleb panustada teadmiste jagamisse, järelkasvu koolitamisse ja rahvusvahelisse avatuse suurendamisse. Rahvusvahelistumine ei tähenda üksnes projektipõhist koostööd, vaid ka vastloodud laborite avamist välisteadlastele, ingliskeelse töökeskkonna võimaldamist ja individuaalset lähenemist grupi liikmetele, nt mentorlust ning mitmekesisuse, võrdse kohtlemise ja sisulise kaasatuse tagamist. Nii kasvab Baltikumi enda teaduslik võimekus ja siinsete uurimisasutuste tuntus üle maailma.

BMA on Baltikumis jõudnud etappi, kus esimesed iseseisvad keskused on end edukalt tõestanud. Edasine areng sõltub tasakaalust: rahvusvaheline tipptase ja koostöö ühelt poolt, kohalik vastutus ja kogukondlik vastutus ning toetus eri ressursside näol teiselt poolt. Väiksemad teaduskeskused ei pea jääma kaugeteks üksiküritajateks. Nende tugevusteks on paindlikkus, tihedad koostöösidemed ja teadlik väärtuspõhine tegutsemine ning oma uurimisgrupi kompetentsi sügavam hindamine. Väikeriikide infrastruktuuride, sealhulgas enamiku Baltimaade BMA laborite areng ei mõjuta üksnes regionaalset teadust, vaid panustab laiemalt ka 21. sajandi teaduse kujundamisse – teadusesse, mis ületab distsiplinaarseid ja geopoliitilisi piire ning väärtustab mitmekesisust ja võrdseid võimalusi.