Novel analytical diagnostics applied to human osteological remains for anthropological-molecular, archaeometric, and conservation research

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Osteological specimens are of fundamental importance in medical, forensic, archaeological, and paleoanthropological studies. In this respect, the diagnostic analysis and experimental characterization of the inorganic and organic components of the bone composite are the basis for the appropriate investigation, interpretation, and valorization of the specimens. In recent times, the booming development of molecular technologies has integrated the classical morphometric and mineralogical/chemical techniques of investigation of bone materials, allowing for unprecedented advances in the analysis of ancient DNA (aDNA) towards the diachronic and synchronic recostruction of human populations.

Because of the novelty of molecular anthropological techniques, protocols of assessment of the specimens to diagnose the likely presence of pristine DNA materials are under development. The present PhD project wishes to apply recently developed non-invasive or micro-invasive methods based on vibrational spectroscopy (FTIR, Raman) to a number of well characterized ancient bone specimens known to yield unaltered sequentiable DNA. The idea is to link the direct assessment of post-mortem (diagenetic) recrystallization of hydroxylapatite to the probability of successful extraction of pristine ancient molecules (aDNA). In perspective, the universal curves of bone-apatite crystallinity recently developed by our research group could be valuably applied to identify the degree of trasformation of bone, and provide diagnostic information prior to aDNA analysis. Potentially the developed methods could be included into a protocol of pre-molecular analysis aimed to the assessment of the suitability of bone material to aDNA extraction. The protocol may include X-ray tomography (μ-CT), Bragg peak diffraction broadening (XRD), and vibrational spectroscopy (FTIR, Raman), whose application would induce no or minimal damage to the prospected (often valuable and unique) specimens.

The characterization methods will be first systematically applied to a number of selected specimens available from the Estonian Biocentre (Institute of Genomics, University of Tartu), with known presence/absence of sequentiable aDNA molecules. The experimentally determined parameters will then be applied as efficient and cost-effective predictive proxy tools of DNA extraction to the extensive collection of bone samples available at the Museum of Anthropology of CAM-UNIPD, to assess their potential for molecular studies. As a side project, the investigation of the alteration state and diagenetic history of the Museum specimens will be the basis for the appropriate planning of conservation/preservation processes, incuding their 3D reproduction.

Expected results

- An empyrical spectroscopic curve of bone recrystallization as diagnostic tool for molecular extraction and aDNA sequencing
- Creation of a virtuous link between the characterization of inorganic and organic components of the bone composite, thus valorizing research and museum specimens with cost-effective protocols
- Implement practical methods for the enhancement of museum specimens into research-valuable “cultural objects”

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