A Chemical Framework for the Preservation of Fossil Vertebrate Cells and Soft Tissues

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Abstract

Reports of preserved cells and other soft tissues in pre-Pleistocene vertebrates, including dinosaurs, have been met with controversy within the field of vertebrate paleontology. To explain such reports, Schweitzer et al. (2014) hypothesized that iron-mediated radical crosslinking preserves ancient soft tissues in a manner somewhat analogous to histological tissue fixation. In 2018, Wiemann et al. proposed a second hypothesis that these soft tissues were preserved as advanced glycation/lipoxidation end products (AGEs/ALEs). The biogeochemistry underlying these hypotheses, however, remains poorly described for fossil vertebrates. This review posits a novel chemical framework describing the persistence of biological "soft" tissues into deep time. The prior iron-mediated radical crosslinking and AGE/ALE mechanisms are re-described in context of established chemistry from a diversity of scientific fields. Significantly, this framework demonstrates the hypotheses presented by Schweitzer et al. (2014) and Wiemann et al. (2018) are, in many cases, subsequent steps of a single, unified reaction mechanism, and not separate hypotheses. Knowledge of the chemical mechanisms underlying vertebrate soft tissue preservation has direct implications for molecular paleontology and archeology, including efforts at molecular sequence recovery within the ancient DNA and paleoproteomic communities. Such implications that are immediately apparent from examining the chemical framework are discussed.

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