Three-dimensional virtual bone histology of early tetrapods revealed by synchrotron light

Sophie Sanchez

Department of Organismal Biology, Evolutionary Biology Centre, Uppsala University, Uppsala, Sweden
sophie.sanchez@ebc.uu.se

Early tetrapods appeared a bit less than 400 million years ago. They were the first vertebrates to exhibit limbs. The fin-to-limb transition has intrigued researchers for decades. Biologists have demonstrated the diversity of developmental patterns in modern vertebrate appendages (e.g. zebrafish, mouse), assuming that they are representative of the group they belong to (respectively, ray-finned fish and tetrapods). However, long-bone microstructures in these models are highly derived and do not reflect their original function. Until the recent development of virtual palaeohistology at the European Synchrotron Radiation Facility (ESRF), molecular and morphological studies carried out on extant taxa could only rely on partial historical information to address questions of interaction and functional roles within long bones. Indeed, no histological study (with the exception of one), based on destructive classical methods, could be conducted on the precious and rare fossils of stem tetrapods. In the framework of international collaborations, we were recently able to study the limb bone histology of the famous early-tetrapod *Acanthostega* and the lobe-finned fishes *Eusthenopteron* and *Hyneria* in three dimensions (3D) using both propagation phase contrast and tomo-diffraction at the ESRF. I will demonstrate how crucial the synchrotron light has been to reveal a completely unexplored field of our palaeontological heritage and shed new lights on the origins of our limb bone microstructure. With the new developments of the X-ray beamlines BM18, ID15 and ID19 at the ESRF, virtual palaeohistology will become the only cutting-edge, non-destructive 3D imaging method able to reveal the bone microstructure of large and dense fossil tetrapods to answer key evolutionary questions.