Bone is likely the longest-studied natural biomaterial, and yet it still harbors many secrets. The immense hierarchical complexity of bone dictates that an accurate understanding of its nano-, micro- and macroscopic organization is only possible when analyzed by 3D methods (various tomographic approaches). Use of these methods for bone studies requires scrupulous awareness of structural context, often requiring correlative approaches and large-volume sampling and imaging. I will present observations and interpretations on the structural organization of bone (from the nanoscale to the macroscale) that have modified our understanding of its functional properties, and I will outline how bone structure is underpinned by common mathematical principles in biology.