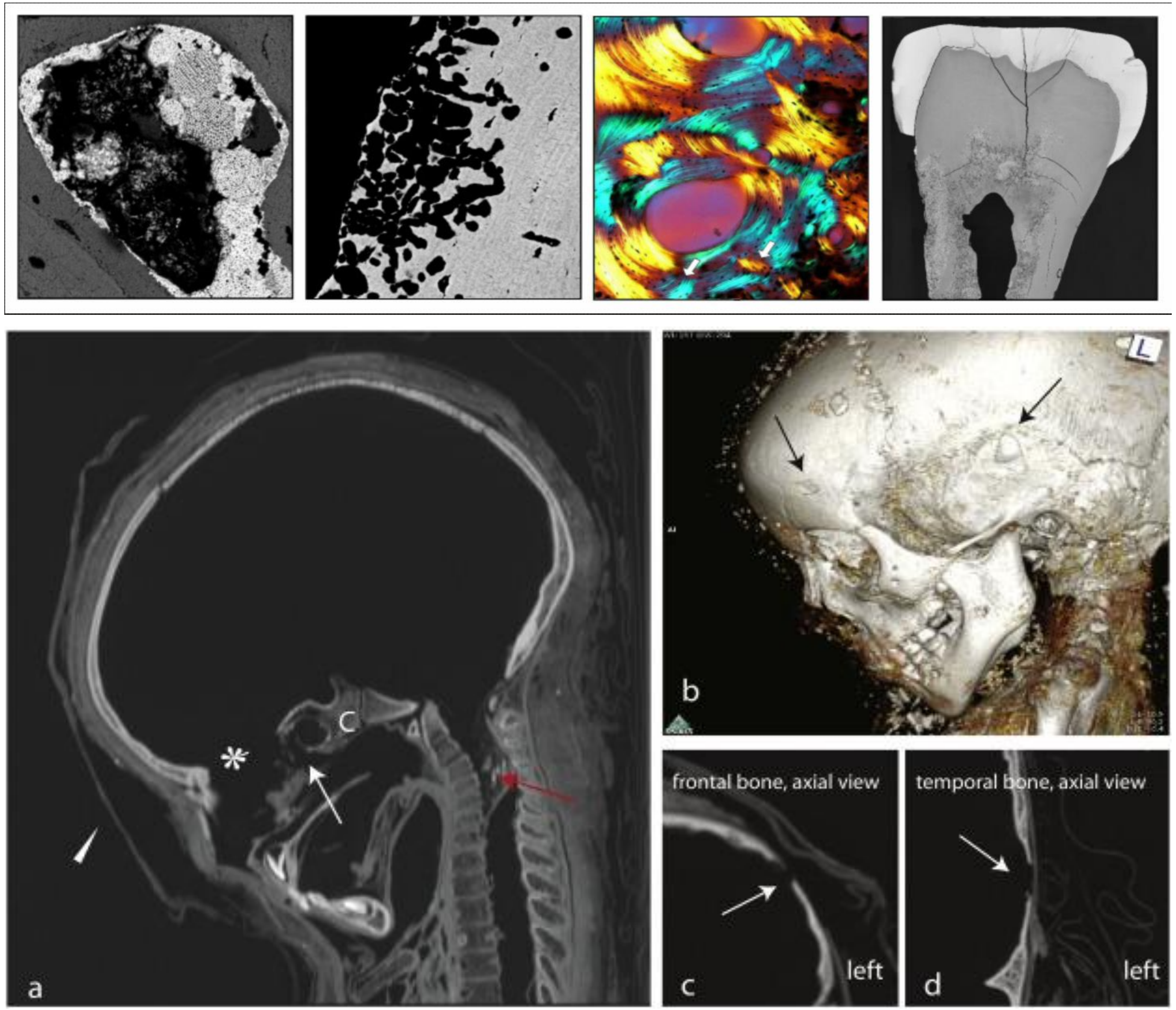
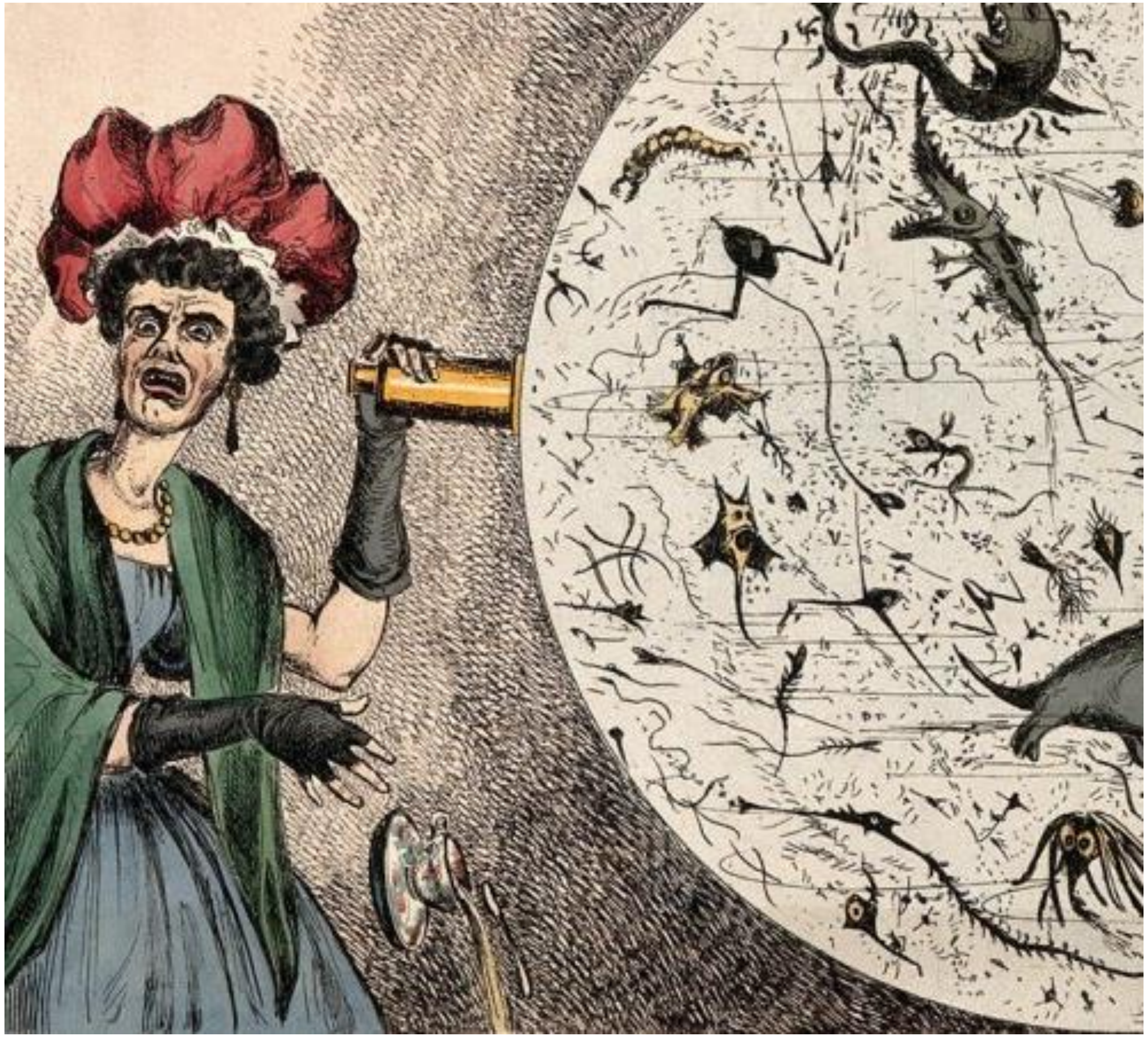


Bone & Dental Histology

Dr Arwa Kharobi



- **4 centuries ago**: Inventory of composite microscope opening a new dimension in the observation of nature
- The microscope's technical capabilities had profound epistemological, metaphysical, and methodological implications for science, **leading to a "recalibration of human knowledge"**
- It **raised questions** about living forms's origin, continuity & relationship with human diseases
- In medicine, the microscope enabled innovative **anatomical dissection**, allowing the examination of tissues, cells, and organ physiology
- Microscopy significantly contributed to **disease diagnosis**, providing rapid insights into diseased structures

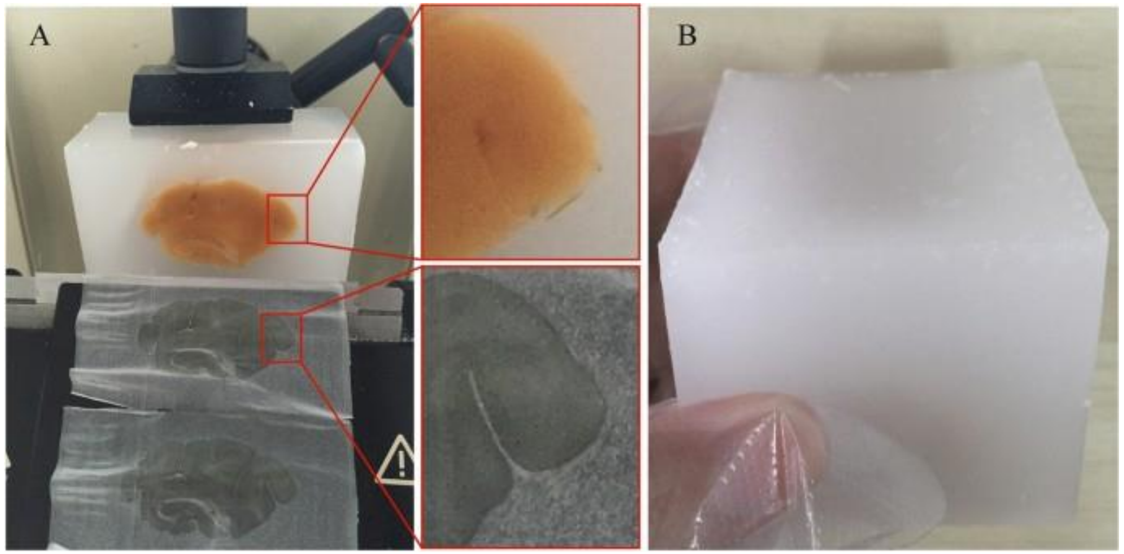
- Histology's application to paleopathology traces back to the 19th century, with J. N. **Czermak** describing arteriosclerosis in an Egyptian mummy in 1879
- Sir Armand Ruffer ‘father of paleopathology’, revolutionized mummified tissue analysis in the early 20th century through innovative rehydration methods
- His method involved embedding sectioned material in alkaline salts & alcohol cycles, revealing various pathological conditions in mummified & bone remains
- Ruffer emphasized the systematic use of histology as a complement to macroscopic observation in his 1911 paper on Egyptian mummies

What is histology?

histos & logos = 'web or tissue’ & 'speak or account’.

➔refers to the microscopic study of all animal and plant cells or tissues.

soft tissues are embedded in a soft substrate (paraffin wax) before being cut into fine slices using a microtome.



These slices may then be stained & examined using optical or transmission electron microscopy (TEM).

- bone is much harder & more brittle than the body's soft tissues

- difficult to section with a microtome in the usual way

demineralised

- using mineral acids or a calcium chelating agent such as ethylenediamine-tetraacetic acid (EDTA)
- Then: sectioning in the same way as soft tissues

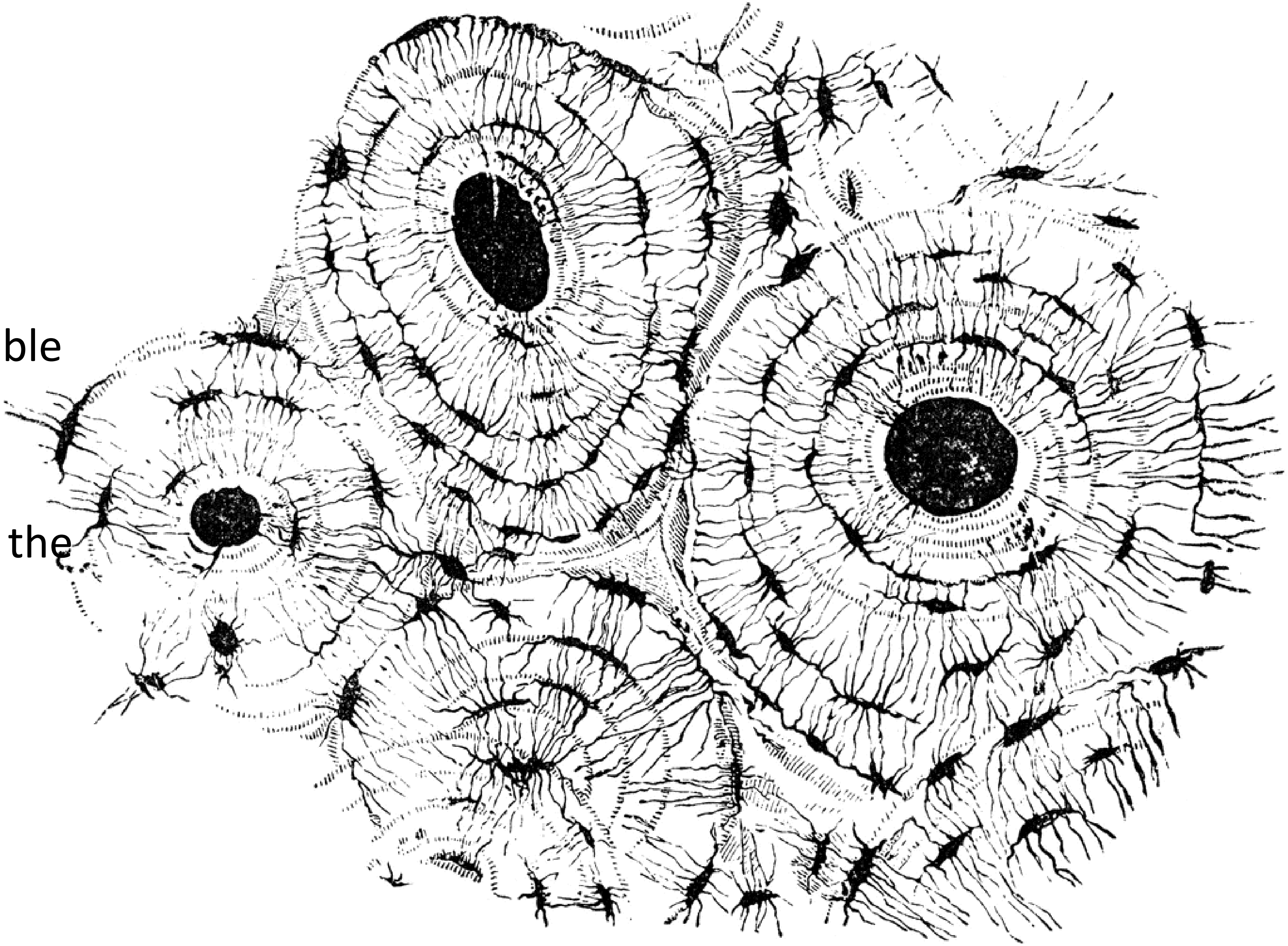
sawn sections of whole bone

- ground and polished with abrasives to the required thickness
- Then: examination in reflected light or by scanning electron microscopy (SEM).

In light microscopy:

Wide range of structures is visible in thin sections of whole bone

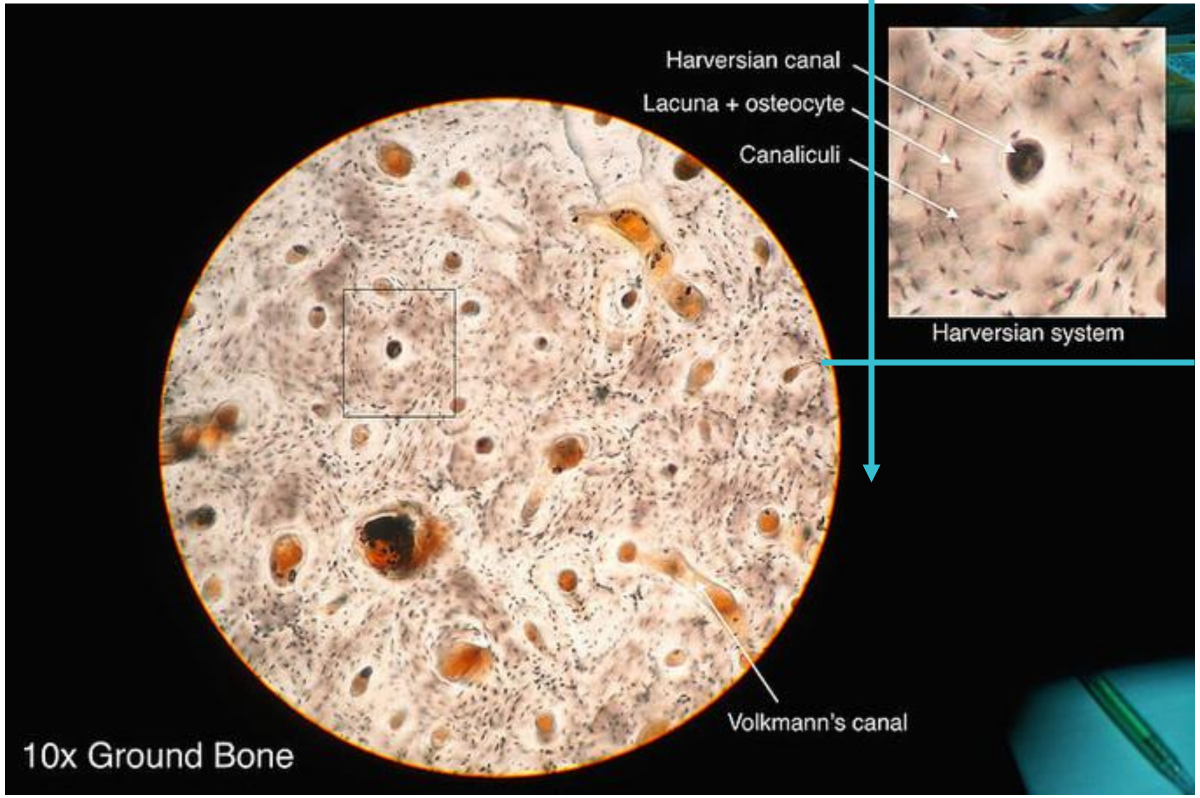
The most prominent feature is the presence of numerous circular structures.



Each of these represents a structural unit known as a Haversian system /osteon

consists of concentric lamellae surrounding a central Haversian canal, enclosing:

- blood vessels,
- nerves,
- loose connective tissue



1. secondary bone tissue
2. formed during the remodeling of primary bone tissue,
3. contributes to the strength & vitality of the bone.

Haversian system /osteon

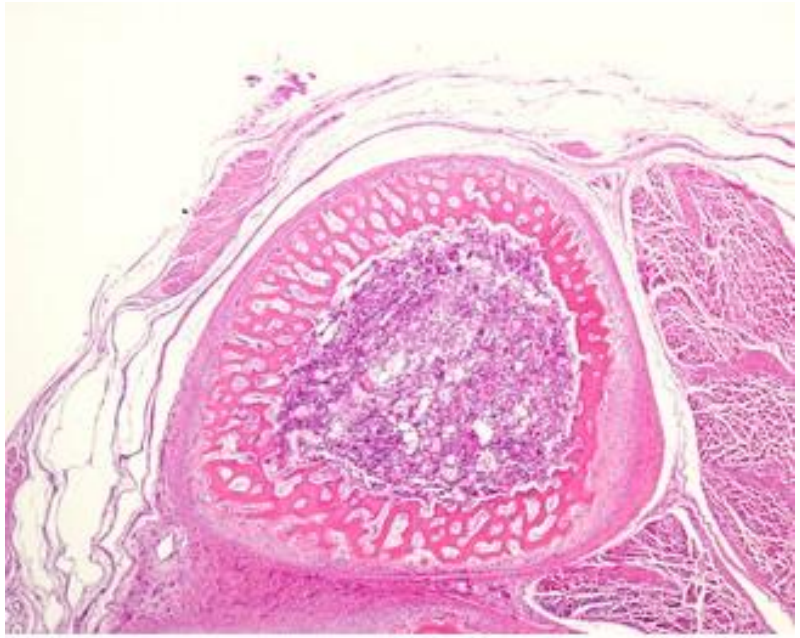
restricted to larger mammals:

whose longer lifespans necessitates more developed mechanism for bone maintenance & repair

Primary bone tissue (woven bone)

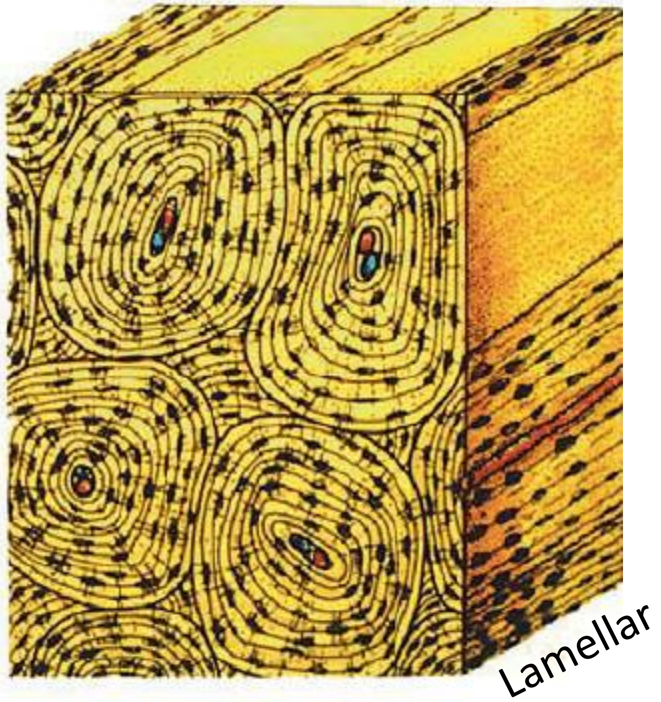
1. the first to form in bone growth & repair.
2. temporary structure: gradually replaced by resorption around blood vessels & subsequent deposition of secondary bone,
3. leading to the characteristic form of osteons
4. often persists in the tendon insertions & ligaments
5. It has:

- irregular arrangement of collagen fibres,
- higher proportion of bone cells or osteocytes
- lower mineral content than the denser secondary bone.

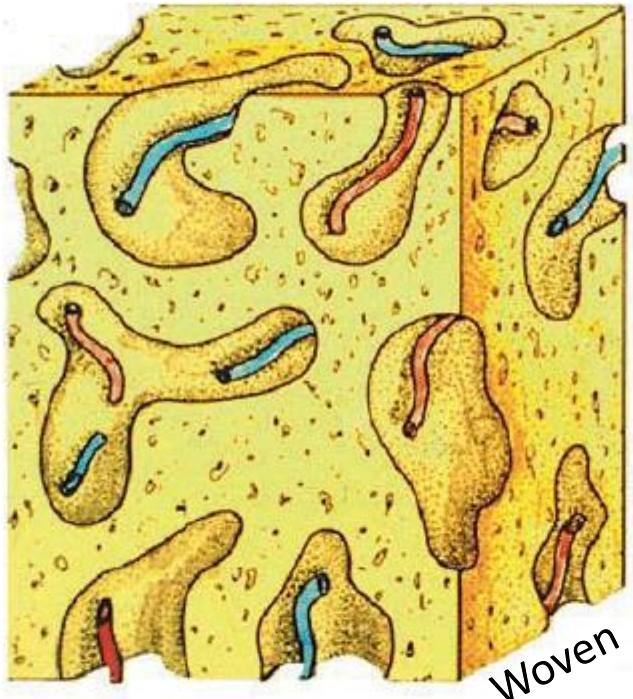


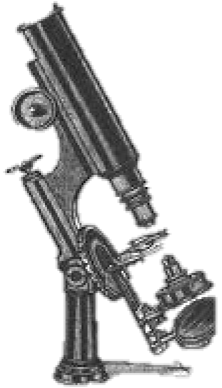
a continuous destruction and rebuilding of **secondary** bone tissue (Haversian systems) during growth & adult life,

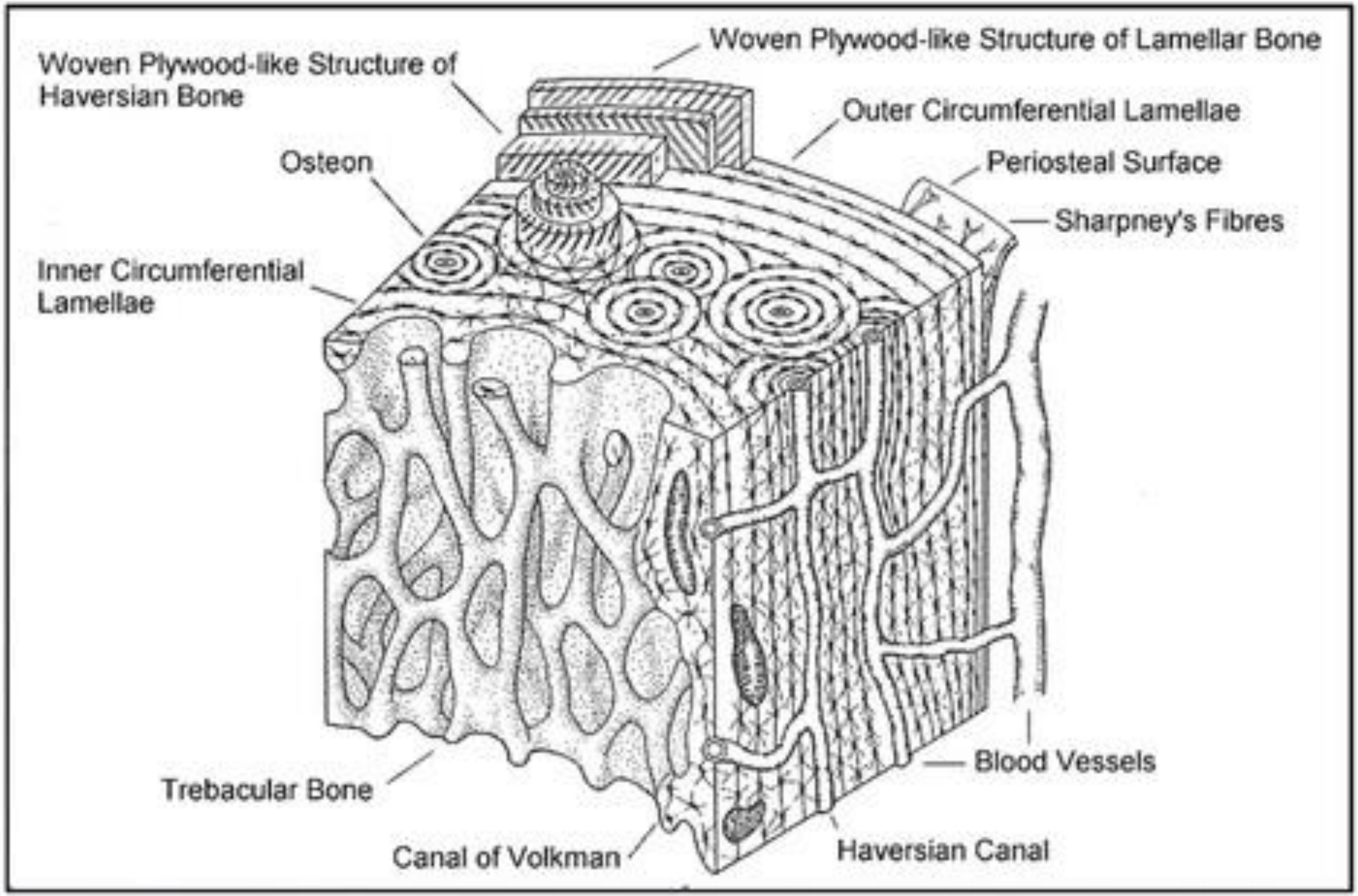
''this succession is often reflected in overlapping osteons''.



Primary bone (woven bone) can often still be distinguished in the outer & inner circumferential lamellae lying close to the external & internal surfaces of bones.







A 3-dimensional representation of the key features seen in bone histology

Which machine?

At a microscopic level, the structure of ancient bone can be examined in a number of different ways:

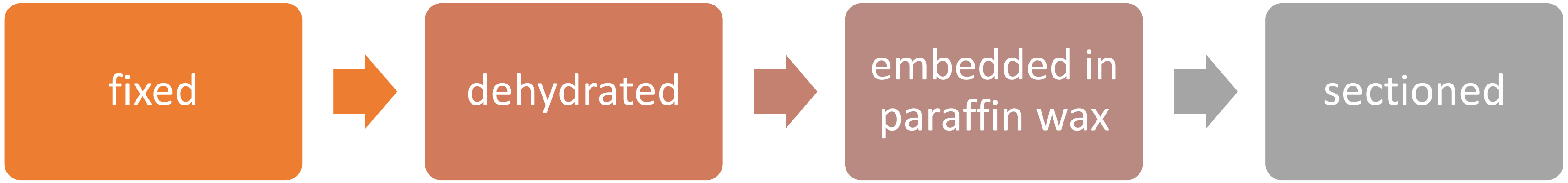
1. optical microscopy (OM),
2. scanning electron microscopy (SEM)
3. microradiography (µR),
4. transmission electron microscopy (TEM)
5. confocal laser scanning microscopy (CLSM),
6. near-field scanning optical microscopy (NSOM),
7. atomic force microscopy (AFM)
8. X-ray microtomography (µCT),
9. development of medical computed axial tomography (CT).

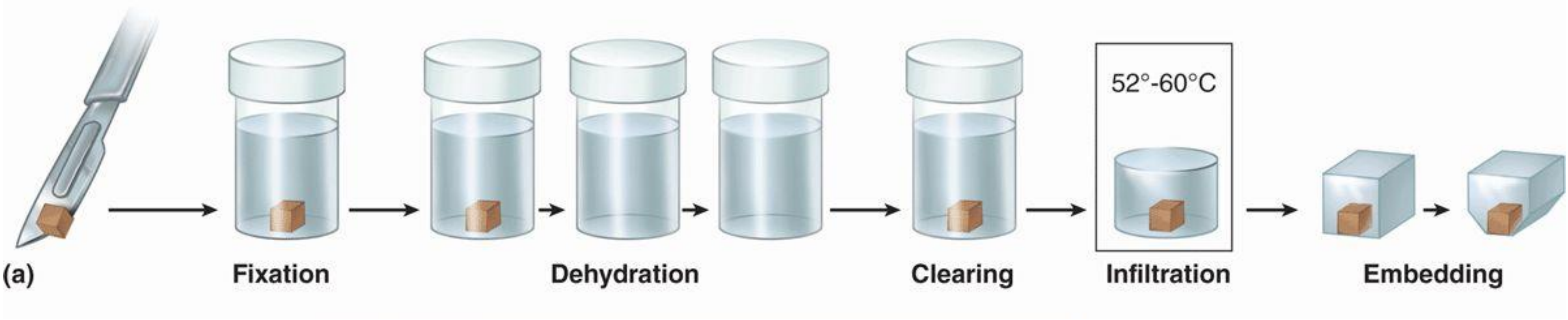
most common applied to archaeological specimens

Samples & sample preparation

The techniques used for archaeological bones grew out of standard histological methodologies of modern tissues (soft & mineralized tissues).

- same as for (biopsies, surgery or autopsy)
- common to decalcify the samples to leave only collagen and its associated cells which can then be:





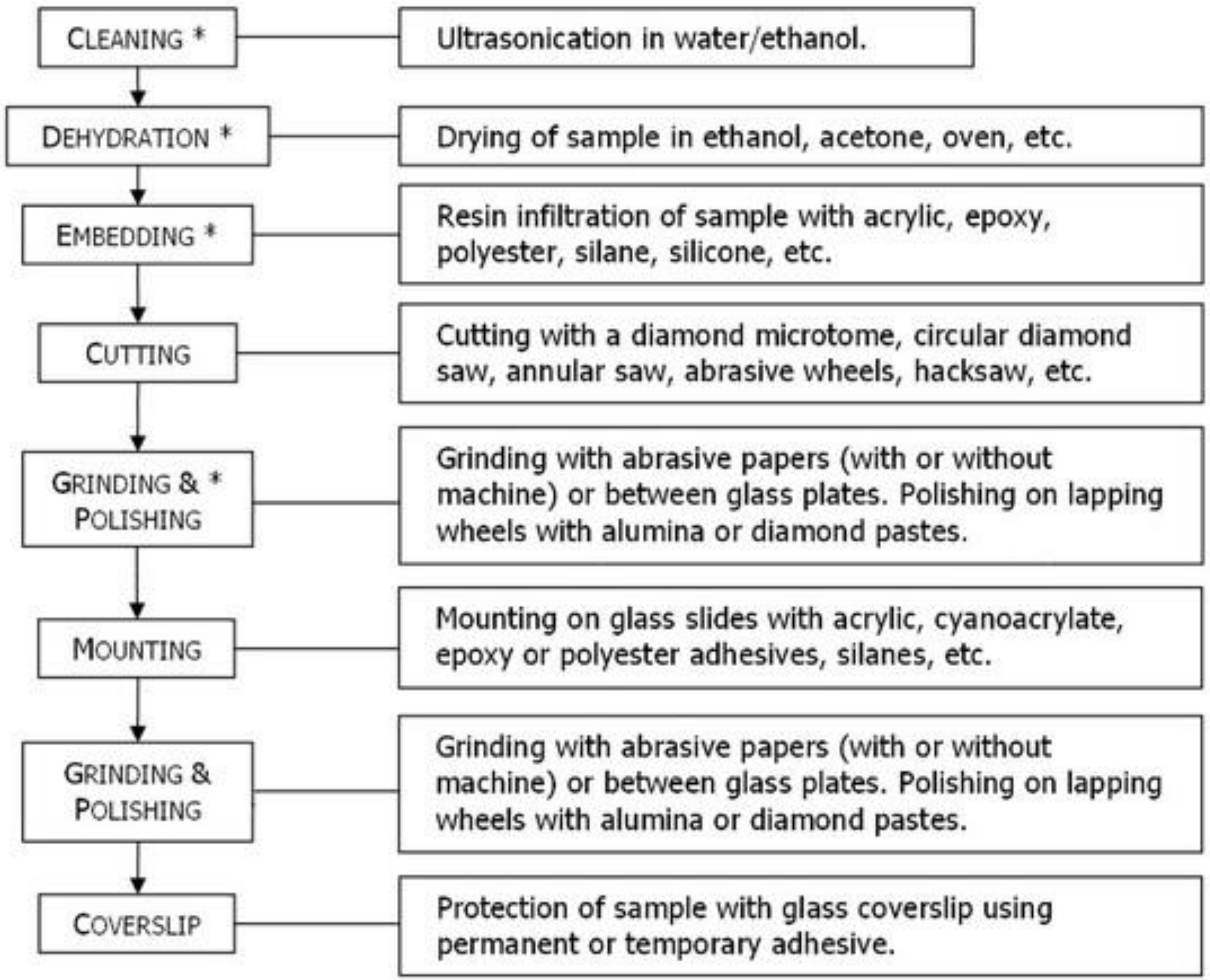
Samples & sample preparation

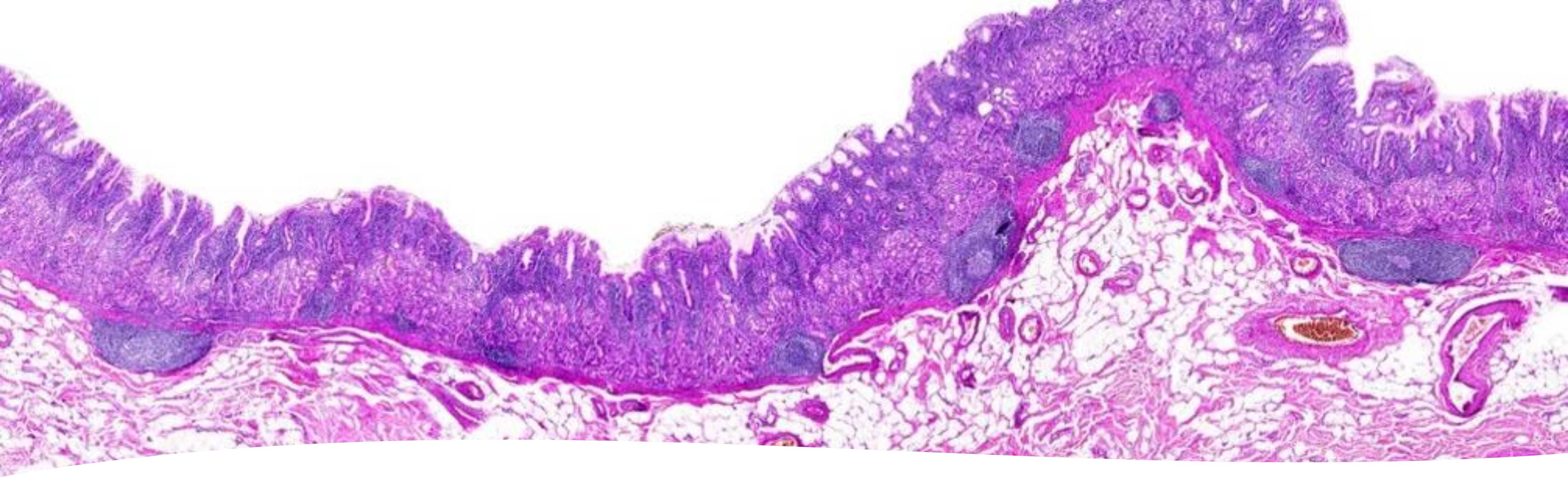
- In fresh bone specimens it is necessary to first stabilise the cells and other soft tissues from putrefaction by “fixing” them with a cross-linking agent, normally a 10% solution of formaldehyde in phosphate buffered saline.
- In archaeological specimens bacterial degradation and other diagenetic processes have normally left the bone devoid of all cellular materials, so there is no requirement to fix them.
- However, they are usually cracked & friable and it is necessary to saturate them with a suitable resin before attempting to prepare any kind of section.

suitable for the preparation of:

- thick sections (for electron microscopy)

-- thin sections (for light microscopy)





Multiple Applications of Histology

1. Differentiation between human, nonhuman remains, and other structures
2. Taphonomic processes
3. Identification of burned remains
4. Estimation of age at death in skeletonized human remains
5. Ontogeny, phylogeny, and the skeletal response to biomechanical stress
6. Mummy studies
7. Bone paleopathology
8. Tooth alterations
9. Bone cut marks
10. Forensic anthropology

1. Human or nonhuman?

Histology is a useful tool to distinguish between human & nonhuman bone remains

especially when bone is fragmentary (e.g. Harsanyi, 1993; Croker et al., 2009; Greenlee and Dunnell, 2009; Mulhern and Ubelaker, 2012).

JOURNAL OF FORENSIC SCIENCES

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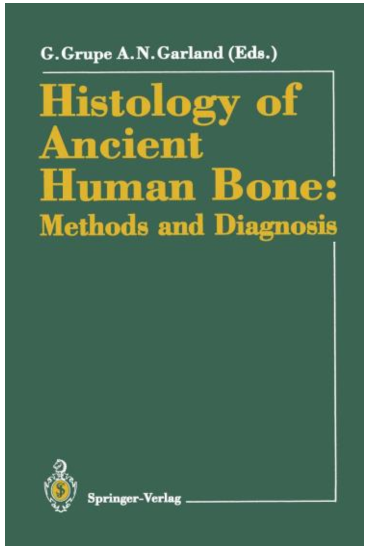
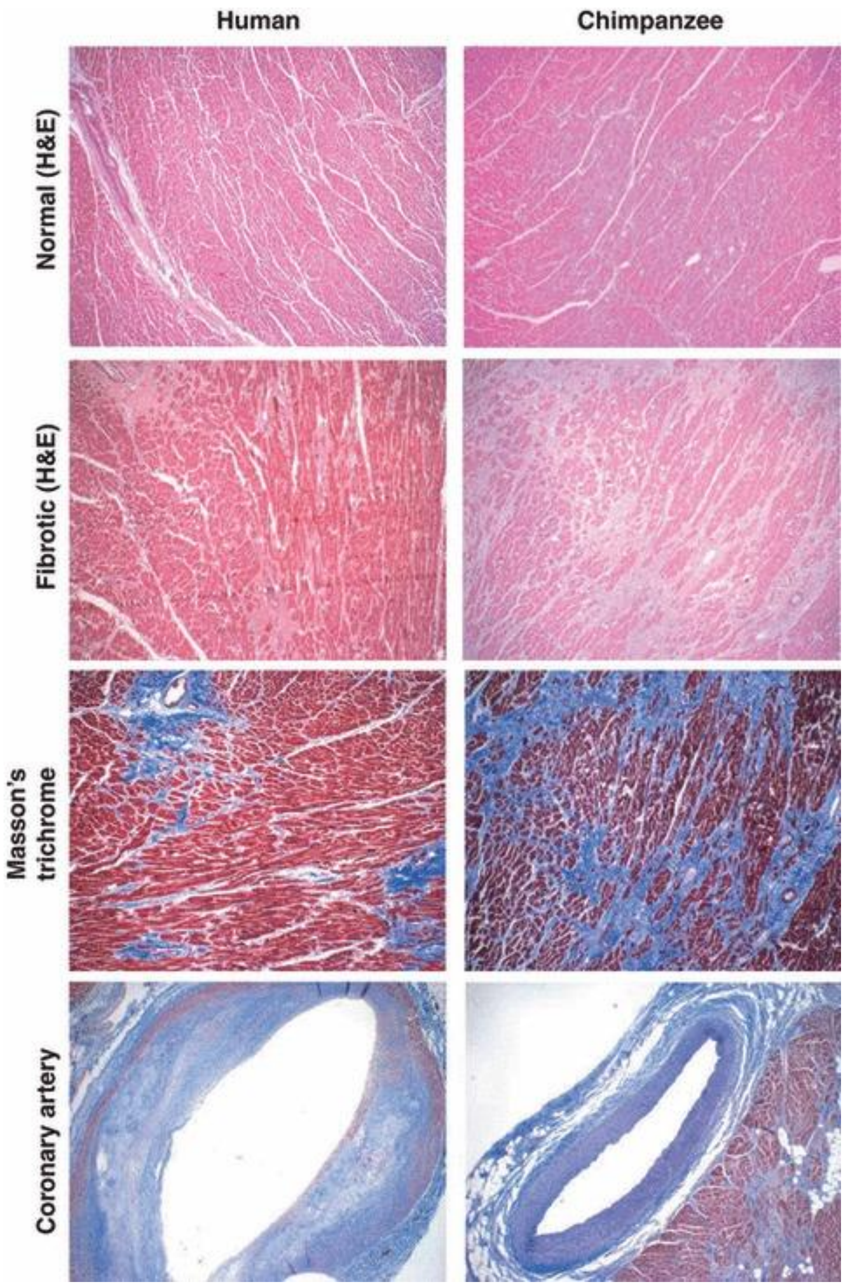
Differentiating Human Bone from Animal Bone: A Review of Histological Methods

Maria L. Hillier M.Sc., Lynne S. Bell Ph.D.

First published: 06 February 2007 | https://doi.org/10.1111/j.1556-402

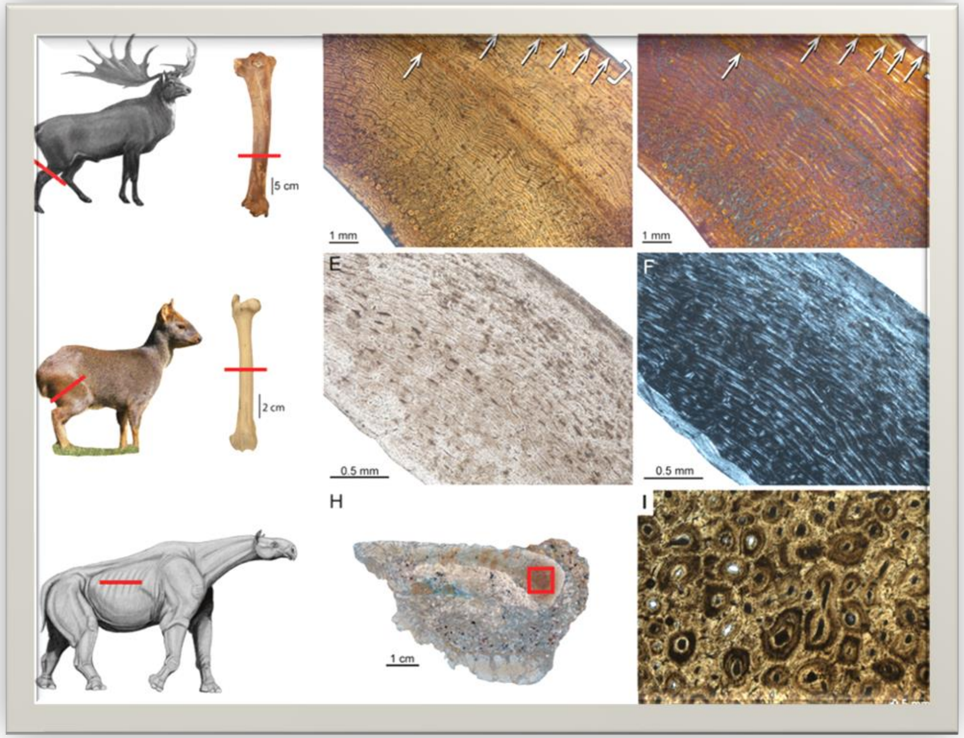




1. Human or nonhuman?

Differentiation is possible because:

Humans	Mammals
Have scattered distribution of cortical osteons	Have plexiform pattern
primary bone types	show osteon banding



1. Human or nonhuman?

Apart from nonhuman primates (i.e. chimpanzees)

We share a similar bone microstructure & age-related changes

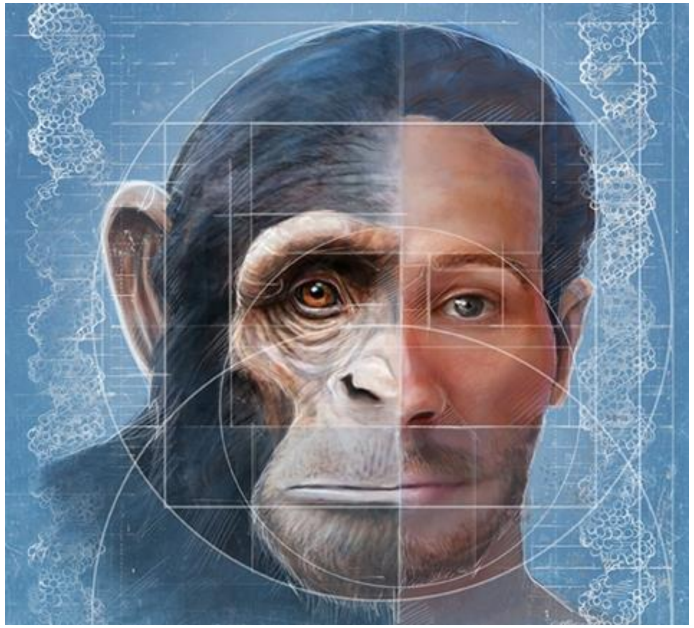
AMERICAN JOURNAL OF
BIOLOGICAL ANTHROPOLOGY
The Official Journal of the American Association of Biological Anthropologists

Research Article

Histologic examination of bone development in juvenile chimpanzees

Dawn M. Mulhern, Douglas H. Ubelaker

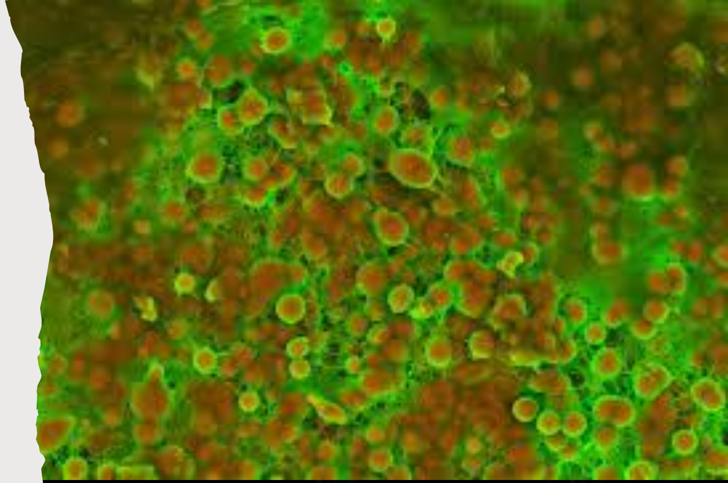
First published: 19 May 2003 | https://doi.org/10.1002/ajpa.10294 | Citations: 25

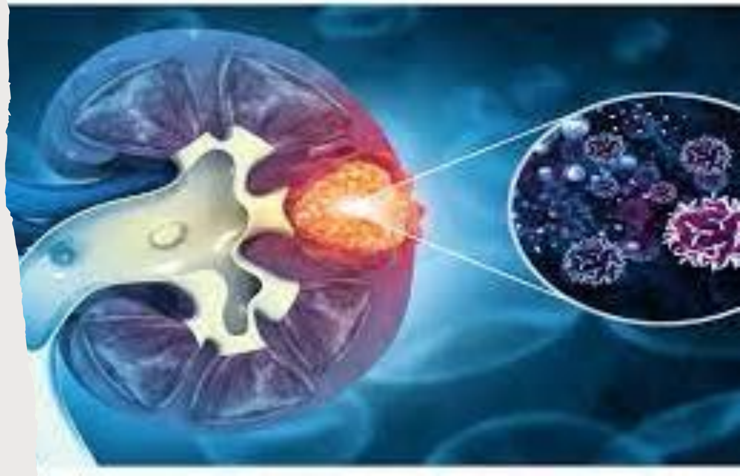


1. Human or nonhuman?

Histology has also played a role in the identification of strange bodies recovered from human skeletal remains:

1. renal & biliary calculi (e.g. Morris and Rodgers, 1989; Sanchez and Etxeberria, 1991)
2. calcified tissues & organisms (e.g. Perry et al., 2008; Quintelier, 2009)
3. fossilized body fluids & faecal deposits (Maat, 1991; Blondiaux & Charlier, 2008; Shillito et al., 2011)
4. parasites & contaminating substances (e.g. Oh et al., 2010)





International Journal of Osteoarchaeology
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Differential Diagnosis of a Calcified Object from a 4th–5th Century AD Burial in Aqaba, Jordan

M. PERRY,[a*] J. NEWNAM[b] AND M. GILLILAND[c]
[a] East Carolina University, Department of Anthropology, Flanagan 231, Greenville, North Carolina 27858, US
[b] Department of Anthropology, University of Arkansas, US
[c] Department of Pathology and Laboratory Medicine, Brody School of Medicine at East Carolina University, US

ABSTRACT In 1997 a calcified object was recovered from the pelvic region of an adult male excavated from an ancient cemetery in Aqaba, Jordan. The cemetery ($n = 48$) dates to the middle 4th to early 5th century AD and is associated with the Byzantine-period marine trading centre of Aila located on the Gulf of Aqaba in the Red Sea. The oblong calcification consisted of linearly aligned tubules within a thin shell. Twenty-eight conditions potentially resulting in calcification within the pelvic region were considered. Of these, five were retained as possible diagnoses due to the object's location and size and the presence of a thin shell and fully calcified tubules. In the end, the object appears to be a calcified, but unidentified, parasite. Copyright © 2008 John Wiley & Sons, Ltd.

Key words: Aila; calcification; echinococcosis; cryptorchidism; testicular microlithiasis; Sertoli cell tumour; gonadoblastoma; calcified parasite

Introduction

Discussion of calcified or ossified masses associated with ancient skeletons remains a rare component of palaeopathological research due to complications surrounding their discovery and diagnosis (Baud & Kramar, 1991). Archaeologists may not always notice these extraskeletal objects (Gladykowska-Rzeczycka, 1991; Tenney, 1991), thus preventing recovery or resulting in disturbed contextual information. If recovered, taphonomic factors such as root growth or animal burrowing can disturb the object's original location. Careful archaeological excavation none the less may pinpoint the approximate location of a mass in the human body. Classifying these archaeologically-derived extraskeletal calcifications and ossifications can reveal valuable information about the history and incidence of disease in specific geographical areas, time periods and populations. The discovery of a calcified object in the grave of an adult male from a mid-4th century AD cemetery in Aqaba, Jordan (Figure 1), can assist significantly in the differential diagnosis of extraskeletal calcifications or ossifications.

Bioarchaeological analysis of the A.10:10 burial

In 1997, an isolated calcified mass was recovered from the pelvic region of an adult male (burial

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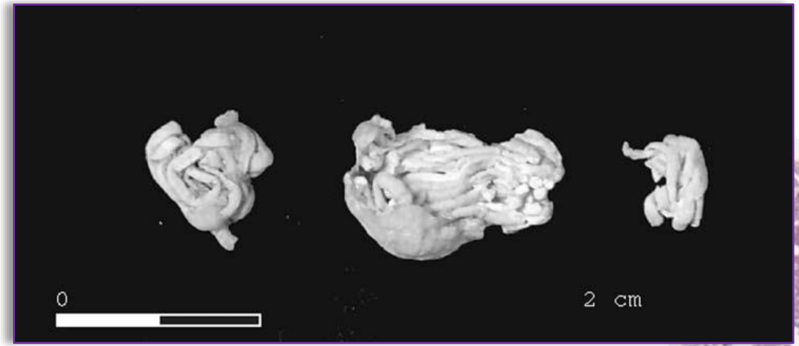
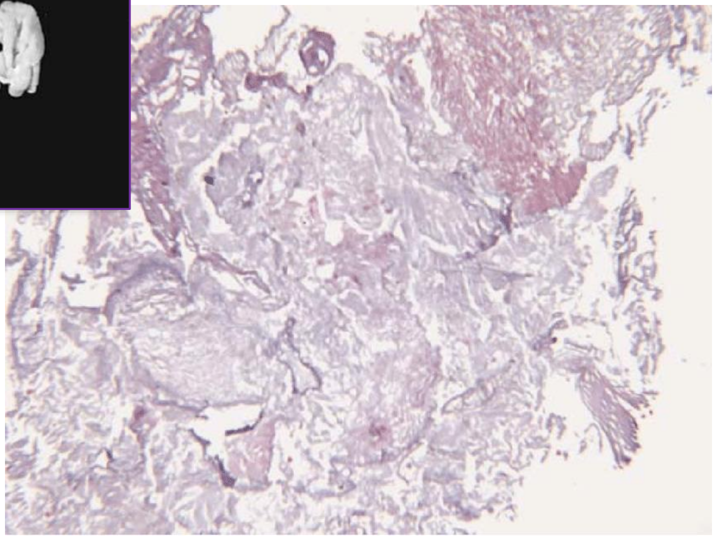
The calcified object recovered from the pelvic region of an adult male





view of a fragment including the cyst wall and worm-like structure

- ✓ **28 conditions** potentially resulting in calcification within the pelvic region were considered.
- ✓ **5 retained** as possible diagnoses due to the object's location & size and the presence of a thin shell and fully calcified tubules.
- ✓ In the end, the object appears to be a calcified, but **unidentified, parasite**.

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A Case of Ancient Bladder Stones from Oluz Höyük, Amasya, Turkey

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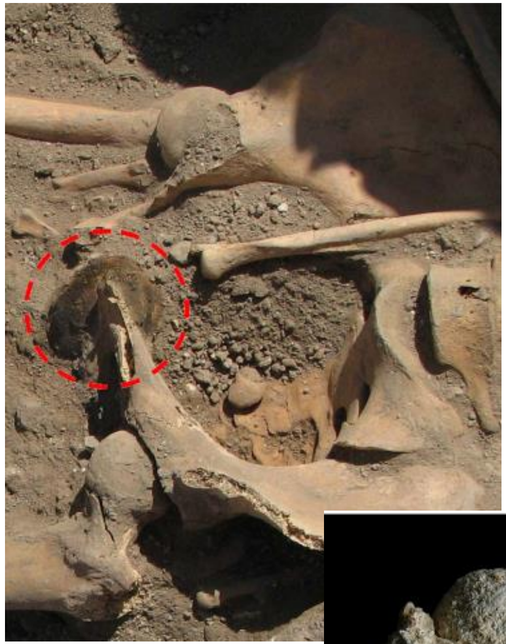
[a] Department of Anthropology, Faculty of Letters, Hacettepe University, Ankara, Turkey
[b] The Conservation and Restoration of Cultural Property Department, Fine Art Faculty, Gazi University, Ankara, Turkey

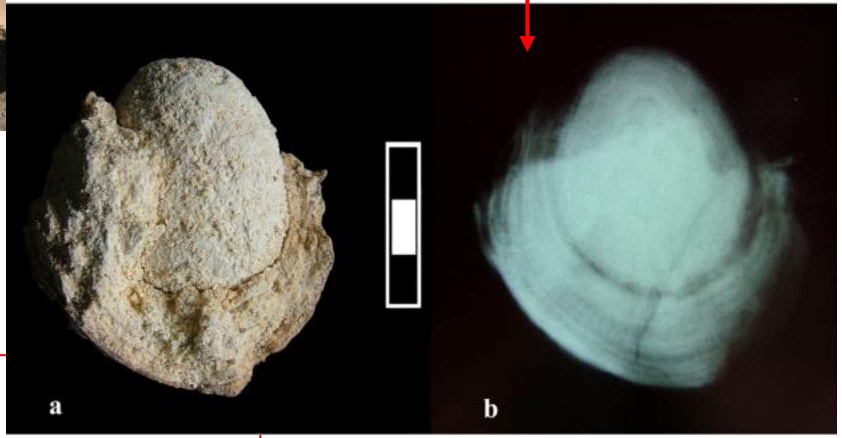
(a)

ion of an adult woman coded to SK13 unearthed from Oluz the medieval period on the basis of the burial customs and as a bladder stone on morphological, radiographic and ffraction, polarised energy dispersive X-ray fluorescence nicroscopic techniques. The mineralogical composition of ate (apatite). Bladder stone disease is endemic in poor sed on grain carbohydrate consumption with scarce intake ons, Ltd.

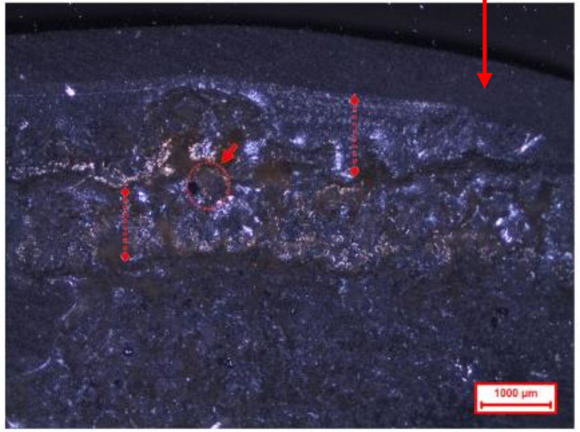
Ca/P calculus; palaeopathology; urolithiasis



The oval-shaped bladder stone with visible concentric layers. (b) The radiographical view of the bladder stone.



(a) Thin section microphotograph of the outer concentric layers (calcium phosphate [Ca3(PO4)2] lump between the layers). (b) A close photograph showing the layers. T



Methods:
radiographic and chemo-analytical grounds
X-ray diffraction,
polarised energy dispersive X-ray fluorescence spectroscopy, confocal Raman spectroscopy
microscopic techniques

The mineralogical composition of urinary stone was found to be as calcium phosphate (apatite). Bladder stone disease is endemic in poor agricultural regions where the typical diet is mostly based on grain carbohydrate consumption with scarce intake of animal protein.

2. Taphonomic processes

bone exposed to the burial environment -> structural changes induced by:

1. physical,
2. chemical
3. biological agents

postmortem alterations?

decomposition phenomena?

normal physiological processes?

disease lesions?

Microscopy used to evaluate the integrity of bone microstructure in different environmental contexts

Palaeogeography, Palaeoclimatology, Palaeoecology 266 (2008) 227–235

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

Reconstructing taphonomic histories using histological analysis

Gordon Turner-Walker [a,*], Miranda Jans [b]

[a] Department of Cultural Heritage Conservation, National Yunlin University of Science and Technology, Taiwan
[b] Institute for Geo and Bioarchaeology, Vrije Universiteit, Amsterdam, the Netherlands

ARTICLE INFO

Article history:
Accepted 26 March 2008

Keywords:
Bone diagenesis
Histology
SEM
Cyanobacteria
Framboidal pyrite
Bioerosion

ABSTRACT

Recent years have seen rapid advances in the understanding of diagenetic changes to bone tissues and how these influence the chemistry, microstructure and histological appearance of ancient bone. It is now possible to recognise many characteristic features of diagenetically modified bone and this has led to the potential use of these parameters in estimating the potential survival of biogenic signals such as DNA, lipids, proteins and stable isotopes. These characteristic features also hold the potential for preserving a record of different post-mortem environments in individual bones or assemblages of bones from the same site. In sites where the burial conditions have changed over archaeological or geological timescales, histological analyses can shed light on these different burial environments and permit the reconstruction of taphonomic histories of some bones. Examination of polished sections of bone using BSE-SEM has been used to identify characteristic features attributed to aerobic soil bacteria, cyanobacteria, and sulphate reducing bacteria. The approach shows promise for providing supplementary evidence when phasing complex sites, such as graveyards, which developed over several hundred years.

polished sections of bone
using BSE-SEM
to identify characteristic
features attributed to:
aerobic soil bacteria,
cyanobacteria,
sulphate reducing bacteria.

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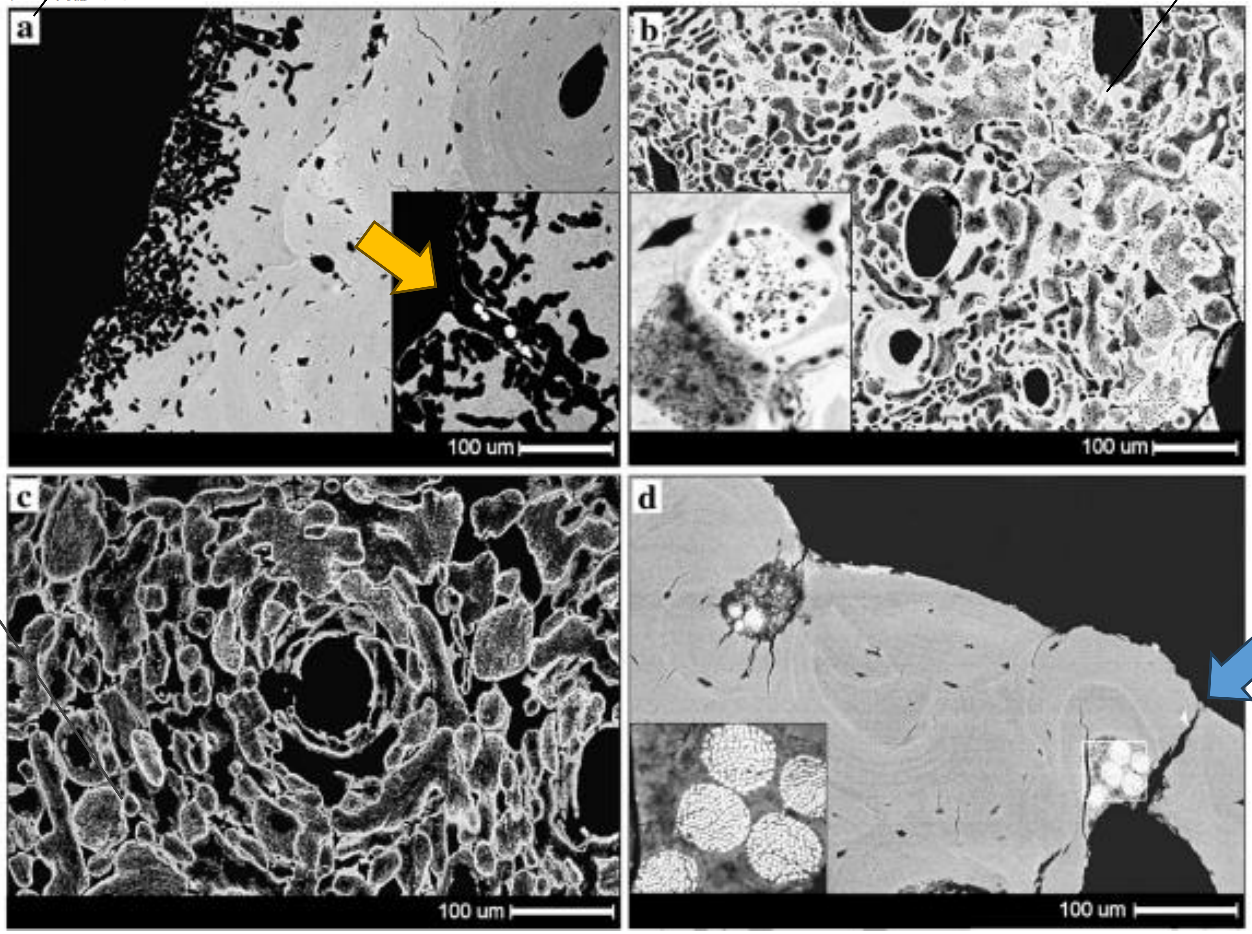
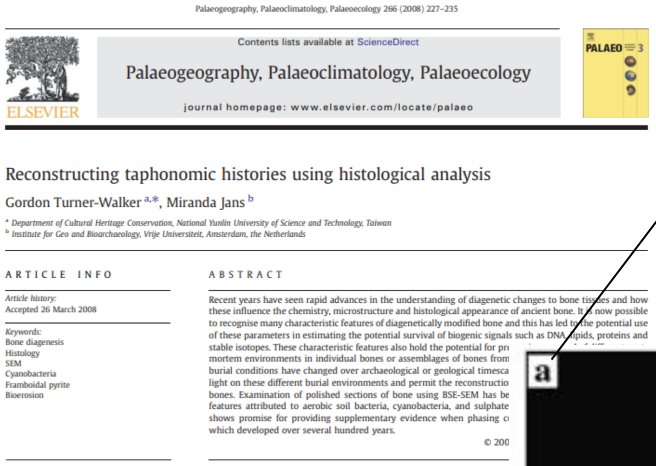
recent bone a gravel beach (Cyprus)
Note the meandering tunnels & small pyrite framboids (inset).

bacterially degraded Medieval bone (UK)
Note the zones of demineralised & hypermineralised bone and bimodal nature of micro-porosity (inset).



Highly degraded Iron Age bone (Scilly).
This represents the final stages of bacterial attack

Well preserved Medieval bone (Norway). no evidence of bacterial attack on bone tissues but the presence of framboids (inset) indicates the presence of sulphate reducing bacteria & an anoxic burial environment.



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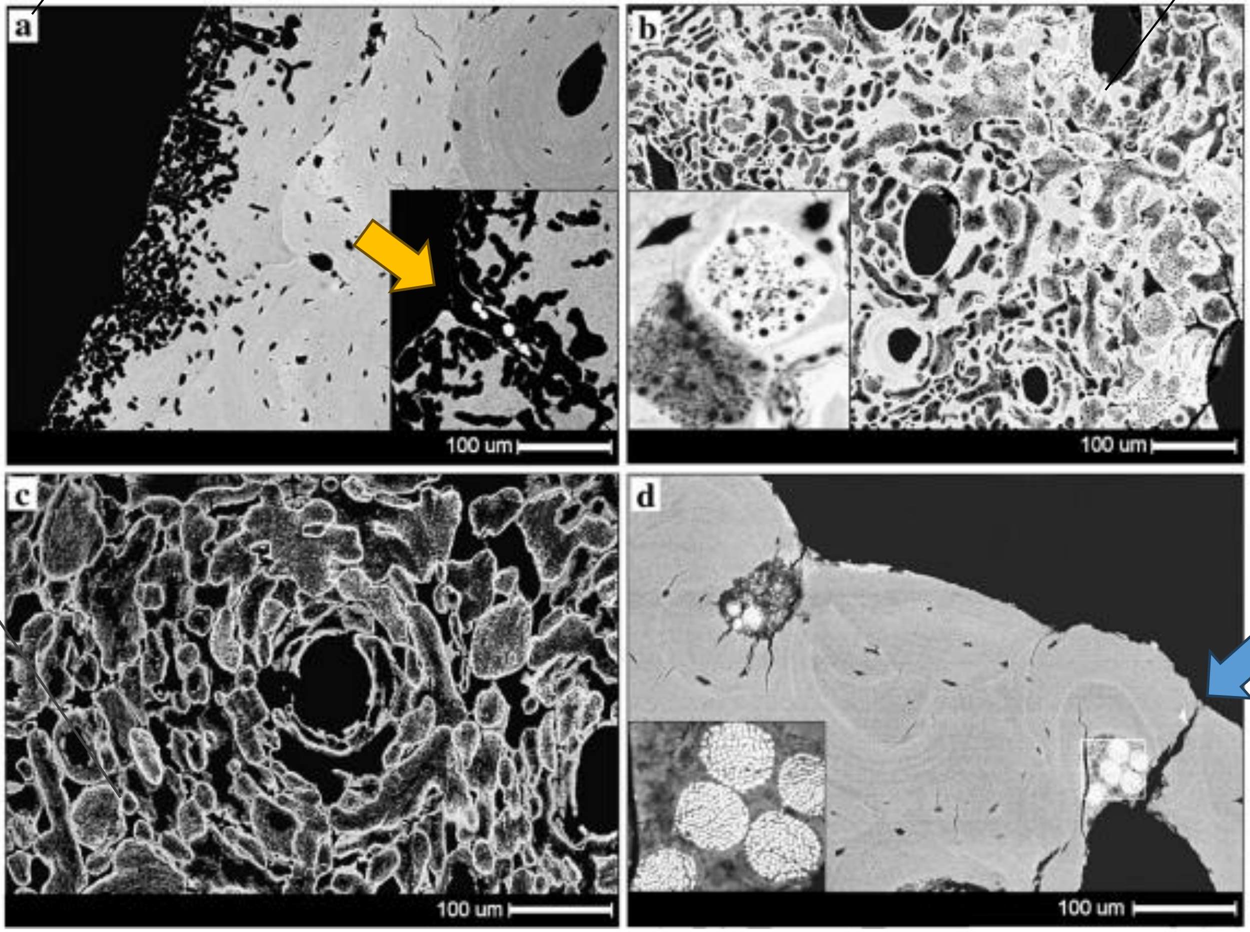

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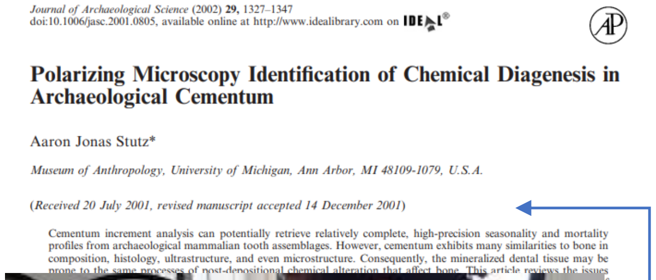
The approach shows promise for providing supplementary evidence when phasing complex sites e.g. graveyards, which developed over several hundred years

2. Taphonomic processes

In zooarchaeological studies **Microscopy** also contributes to understanding the diagenetic processes that affect buried bones & teeth (Haynes *et al.*, 2002; Stutz, 2002).



Journal of Archaeological Science (2002) **29,** 1327–1347
doi:10.1006/jasc.2001.0805, available online at http://www.idealibrary.com on IDEAL®

Polarizing Microscopy Identification of Chemical Diagenesis in Archaeological Cementum

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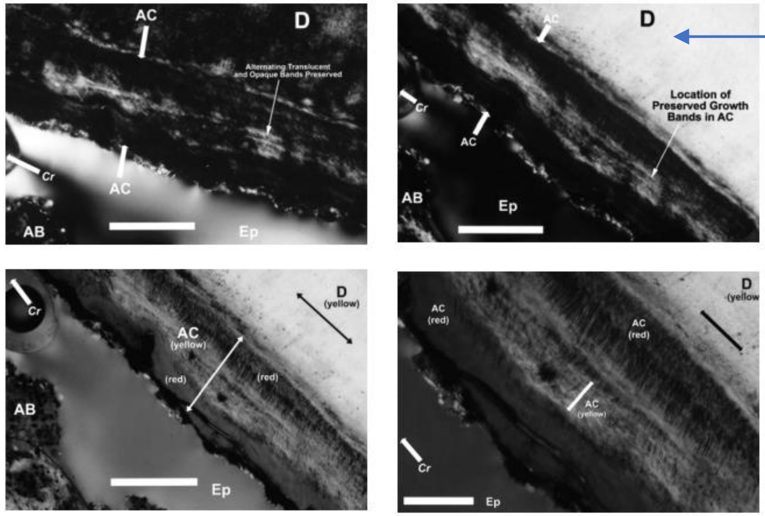
(*Received 20 July 2001, revised manuscript accepted 14 December 2001*)

Cementum increment analysis can potentially retrieve relatively complete, high-precision seasonality and mortality profiles from archaeological mammalian tooth assemblages. However, cementum exhibits many similarities to bone in composition, histology, ultrastructure, and even microstructure. Consequently, the mineralized dental tissue may be prone to the same processes of post-depositional chemical alteration that affect bone. This article reviews the issues



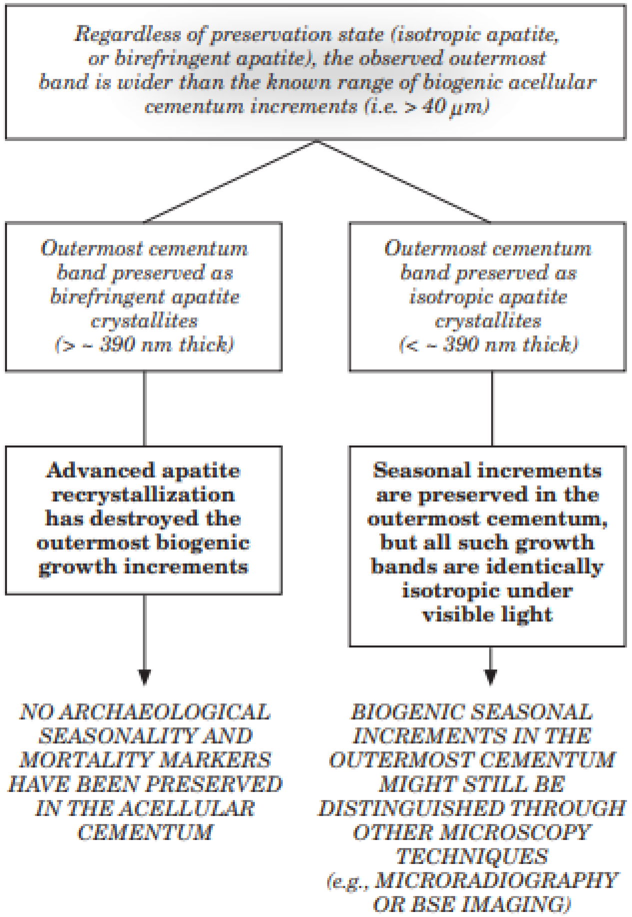


Figure 9. Decision tree for λ plate analysis of acellular cementum, when a diagenetic outermost cementum band wider than the known range of biogenic growth increments (>c. 40 μm) is observed.

Polarizing photomicrographs of the archaeological reindeer tooth specimen HAS4 in greyscale. The sub-alveolar crest acellular cementum, AC, on the mesial root of the archaeological specimen is shown, demonstrating thorough collagen leaching, with varying levels of apatite recrystallization.

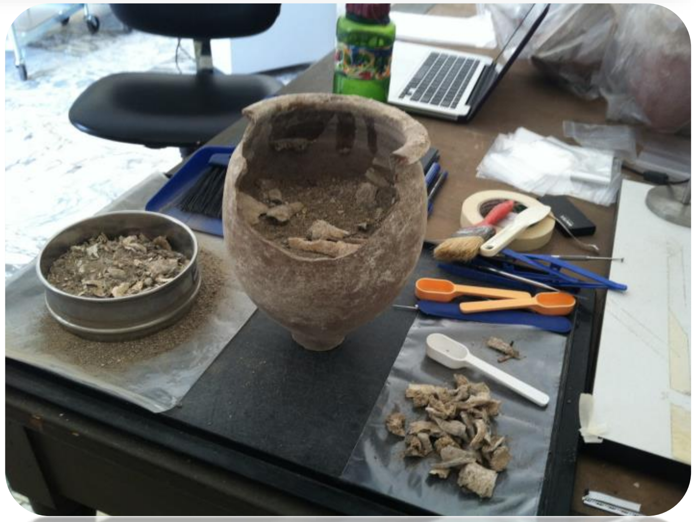
3. Identification of burned remains

also of great value for:

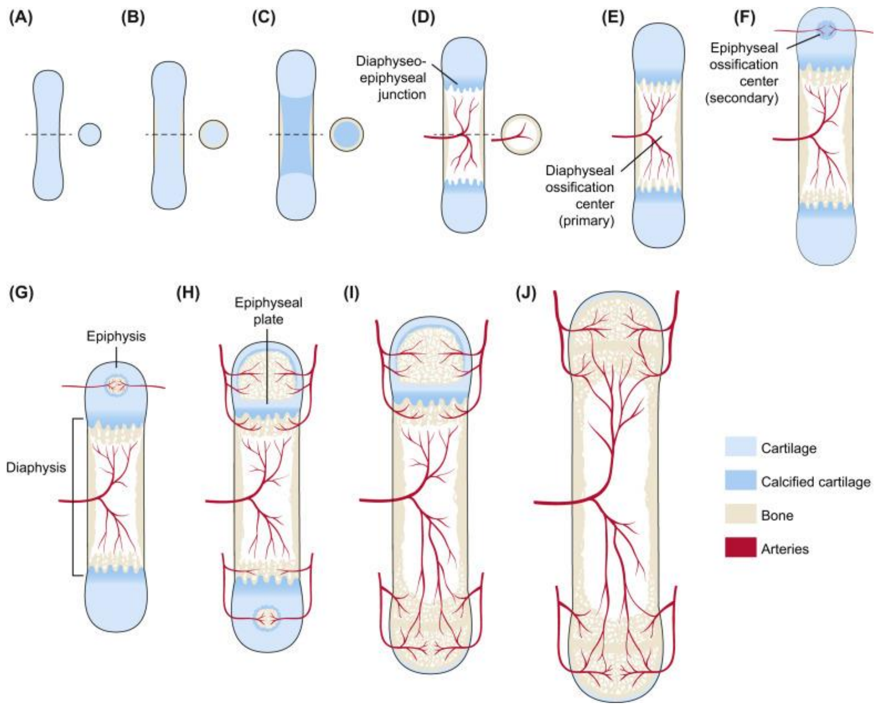
1. examining pathological conditions
2. estimating age at death

} of cremated remains

(e.g. Holden et al., 1995; Schultz, 1997; Hanson and Cain, 2007; Squires et al., 2011).



4. Estimation of age at death



Several histological methods in:

✓ ancient & modern

✓ bone & dental remains

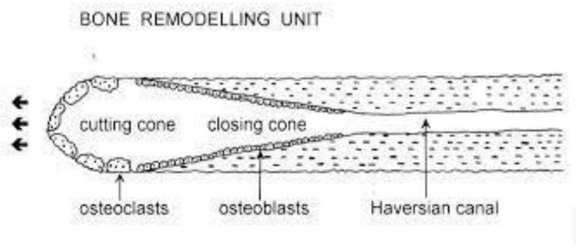
Bone growth, modeling, & remodeling are responsible for a mature cortex with particular features that can be quantified using histomorphometric analysis

➔ that is, the quantitative study that consists in counting or measuring tissue components:

cells

or extracellular constituents

or both



Bone	Histological Methods
ribs & clavicle	e.g. Stout & Paine, 1992; Stout et al., 1996; Crowder & Rosella, 2007; Kim et al., 2007; Pavön et al., 2010; Cho & Stout, 2011
long bones	e.g. Kerley, 1965; Singh and Gunberg, 1970; Kerley & Ubelaker, 1978; Pfeiffer, 1980; Stout and Gehlert, 1982; Frost, 1987; Stout & Stanley, 1991; Wallin et al., 1994; Ericksen, 1991 and 1997; Ericksen & Stix, 1991; Lynnerup et al., 2006; Maat et al., 2006b; Chan et al., 2007; Robling and Stout, 2008; De Donno et al., 2009; Han et al., 2009; Villa and Lynnerup, 2010
ilium	e.g. Boel et al., 2007

4. Estimation of age at death

-> Histological indicators of age are based on:

1. grade of remodeling of osteons
2. their respective quantification in adult cortical bone

-> On different skeletal elements

frontiers in Bioengineering and Biotechnology

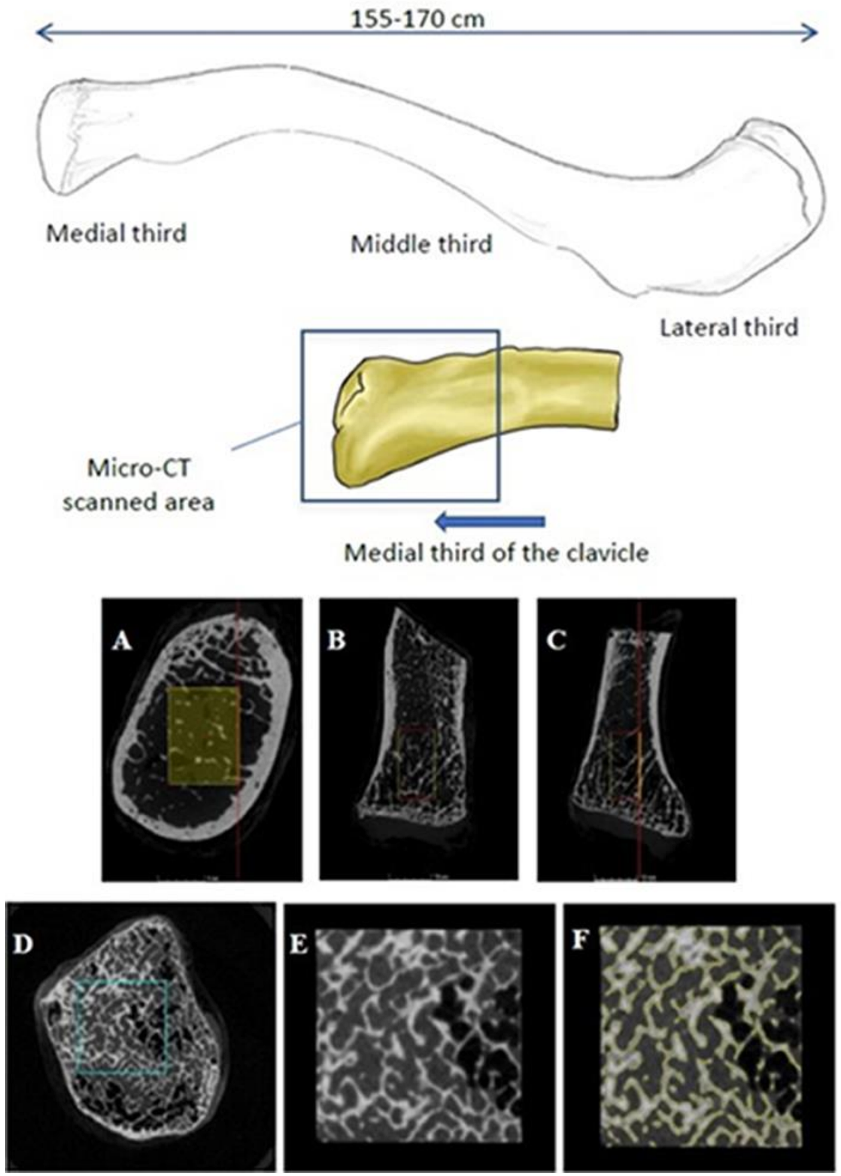
BRIEF RESEARCH REPORT
published: 22 January 2020
doi: 10.3389/fbioe.2019.00467

Check for updates

Age-Related Trends in the Trabecular Micro-Architecture of the Medial Clavicle: Is It of Use in Forensic Science?

Hannah McGivern[1], *Charlene Greenwood*[2], *Nicholas Márquez-Grant*[1], *Elena F. Kranioti*[3,4], *Bledar Xhemali*[5] *and Peter Zioupos*[1*]

[1] Cranfield Forensic Institute, Cranfield University, Defence Academy of the United Kingdom, Shrivenham, United Kingdom, [2] School of Chemistry and Physical Sciences, Keele University, Keele, United Kingdom, [3] Edinburgh Unit for Forensic Anthropology, School of History Classics and Archaeology, University of Edinburgh, Edinburgh, United Kingdom, [4] Forensic Medicine Unit, Department of Forensic Sciences, Faculty of Medicine, University of Crete, Heraklion, Greece, [5] Institute of Forensic Medicine, Tirana, Albania



Shape and size of a human clavicle. (A–C) ROI selection process using VGStudio Max 2.1 representing maximum volume of trabeculae in the (A) transverse (x-y), (B) sagittal (y-z), and (C) coronal (x-z) planes. (D–F) Sequential process of surface determination for the VGStudio Max 2.1 software progressing through the (D) volume selection, (E) subsequent isolation of the ROI, and (F) segmentation of the bone material.

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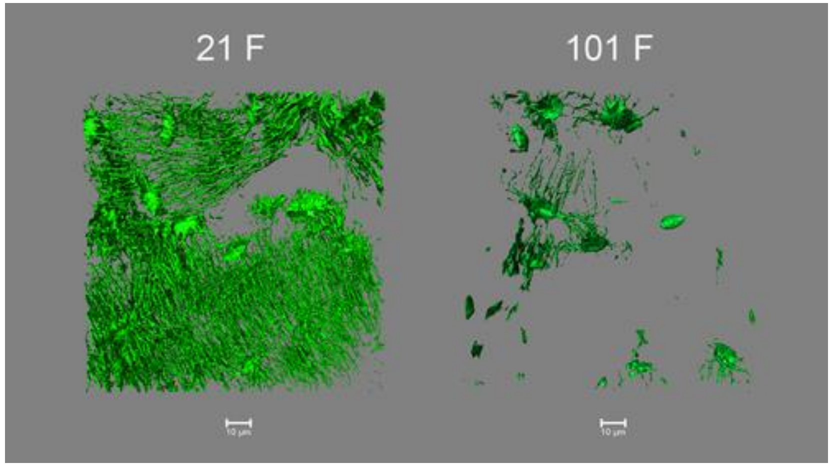
Advanced Review | Full Access

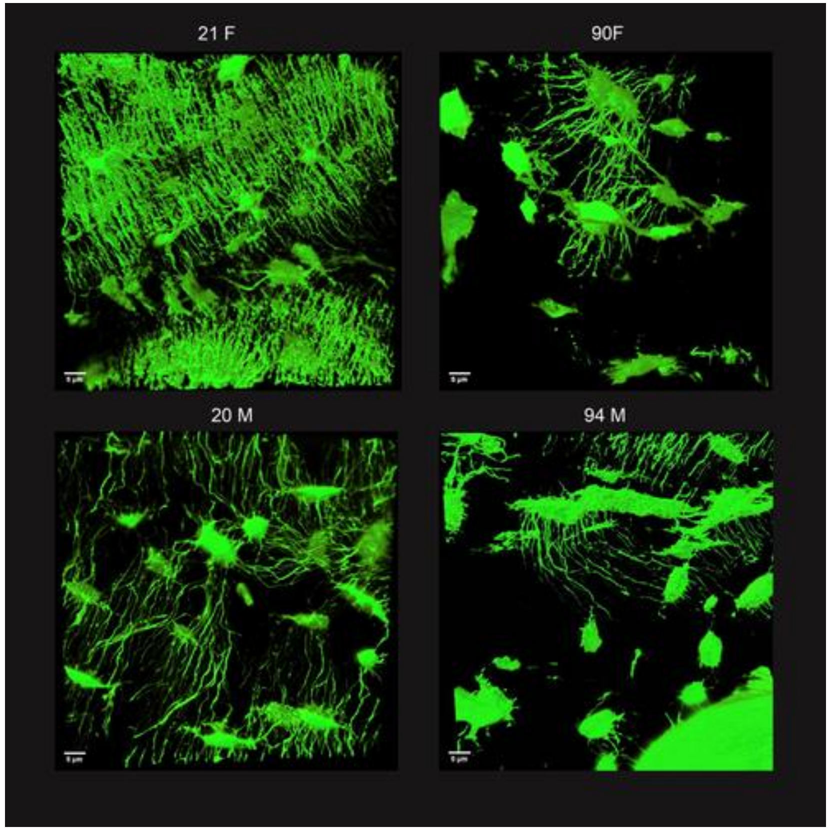
Current and emerging histomorphometric and imaging techniques for assessing age-at-death and cortical bone quality

Janna M. Andronowski, Mary E. Cole

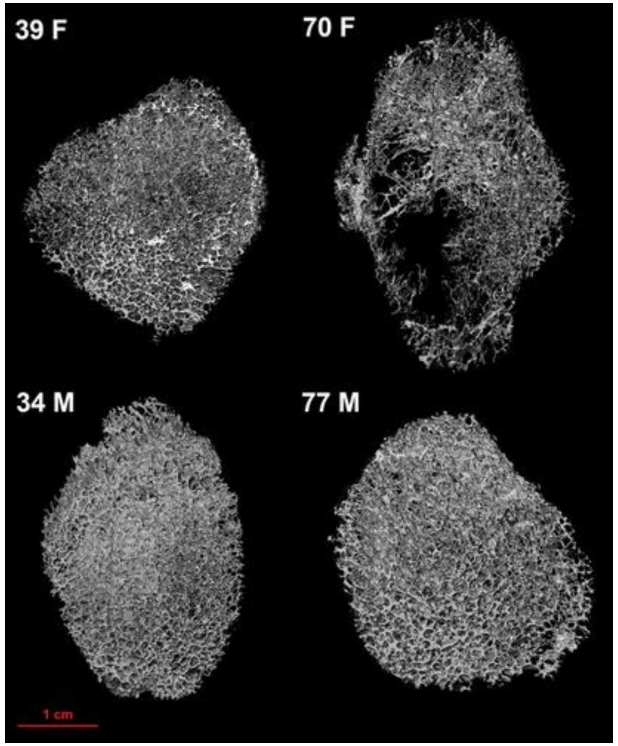
First published: 25 October 2020 | https://doi.org/10.1002/wfs2.1399 |



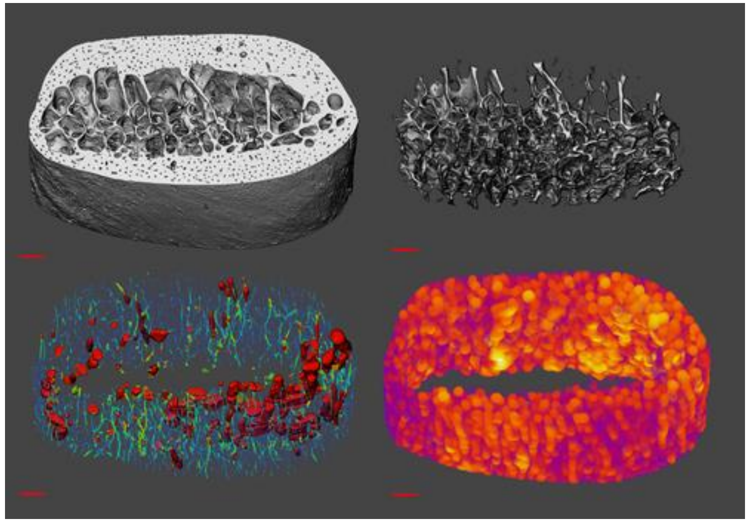
Micro-computed tomography 3D renders of the human femoral neck reveal age-associated trabecular bone loss. Females (aged 39 and 70, top row) tend to decrease in trabecular number and connectivity and increase in trabecular spacing. Males (aged 34 and 77, bottom row) tend to lose trabecular bone through the thinning of individual struts. Scale =1,000 µm. (Photo Credit: Mary Cole)



A 2D image slice generated with confocal laser scanning microscopy demonstrates age-associated reduction in the osteocyte lacunar-canalicular network in females (aged 21 and 90, top row) and males (aged 20 and 94, bottom row). Scale bar = 5 µm. (Photo Credit: Janna Andronowski)



Micro-computed tomography 3D renders of the human femoral neck reveal age-associated trabecular bone loss. Females (aged 39 and 70, top row) tend to decrease in trabecular number and connectivity and increase in trabecular spacing. Males (aged 34 and 77, bottom row) tend to lose trabecular bone through the thinning of individual struts. Scale =1,000 μm. (Photo Credit: Mary Cole)

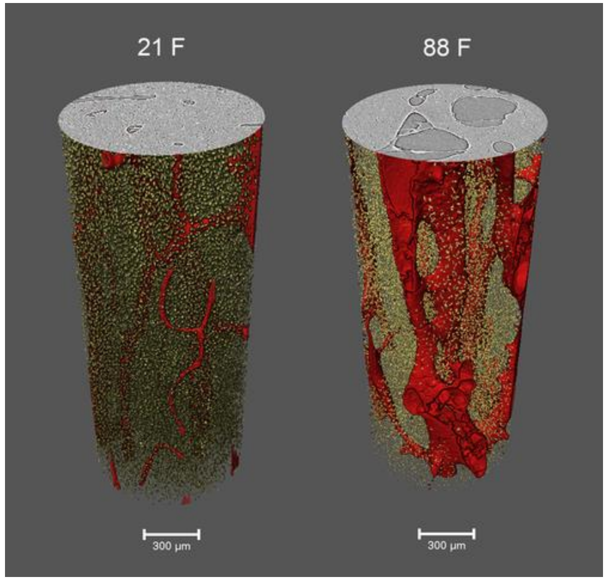


Laboratory micro-computed tomography provides 3D visualization of the midshaft of a sixth rib from a 26-year-old male. Image processing of the original 3D reconstruction of the cortex (upper left) can extract trabecular architecture (upper right), cortical pore networks colored by local thickness (lower left) and maps of pore separation (lower right). Scale bar = 1,000 μm. (Photo Credit: Mary Cole)

4. Estimation of age at death

also been discussed

- ✓The reliability of using weight-bearing bones,
- ✓The effect of intrinsic (sex & population variability) and extrinsic (adequate bone sampling) factors on age at death estimation

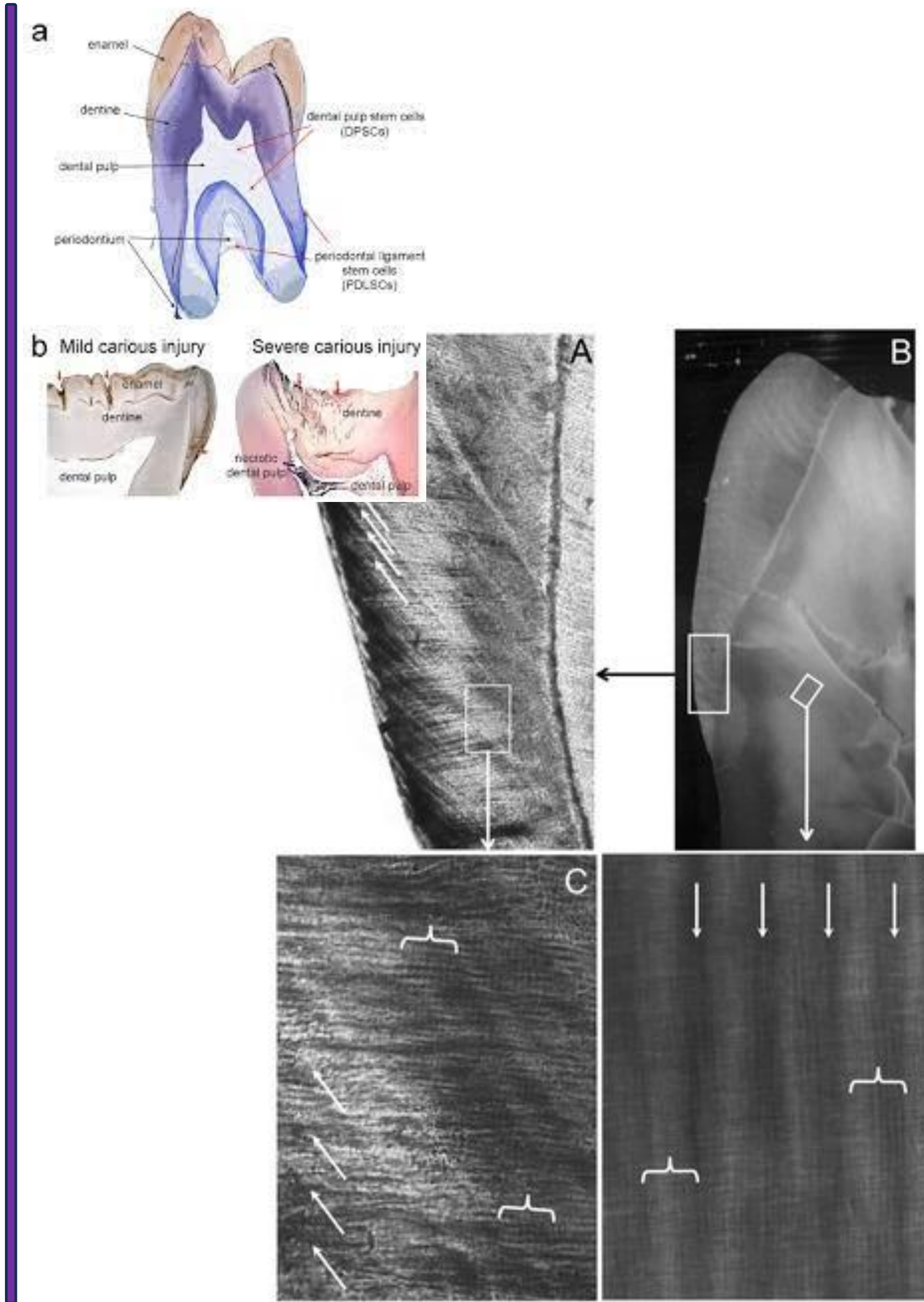


(e.g. Aiello & Molleson, 1993; Drusini, 1996; Iwaniec et al., 1998; Macho et al., 2005; Paine & Brenton, 2006; Robling & Stout, 2008; Henning & Cooper, 2011)

4. Estimation of age at death

Dental histological techniques on the basis of the study of:

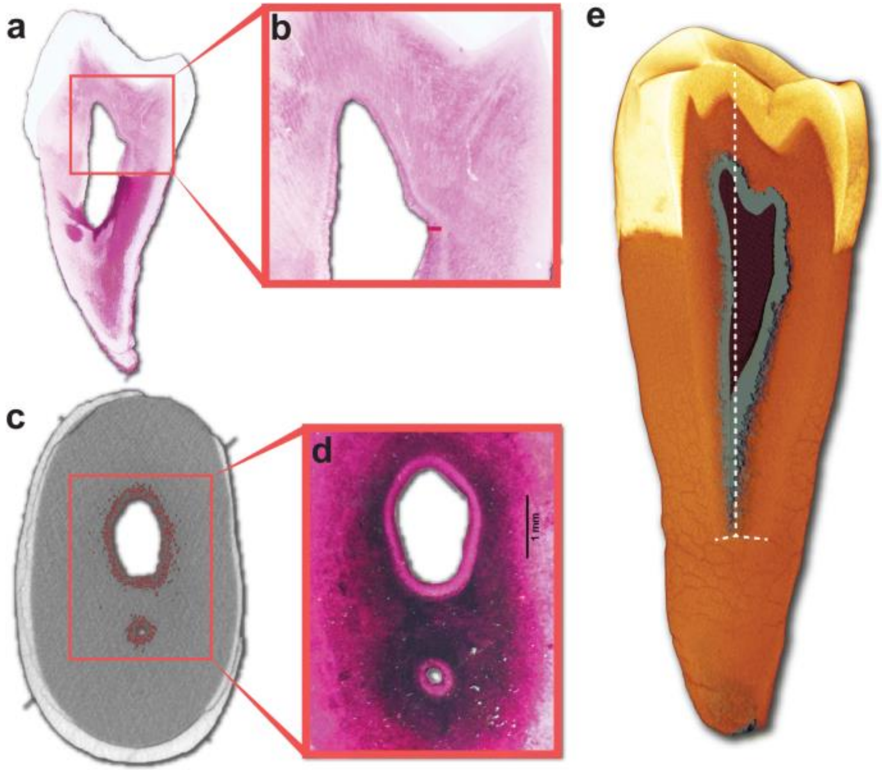
1. secondary dentin formation (e.g. Charles et al., 1986; Maat et al., 2006)
2. cementum annulation (e.g.; Roksandic et al. 2009; Wittwer-Backofen et al., 2004)
3. striae of Retzius in enamel (e.g. FitzGerald and Saunders, 2005)
4. daily cross striations (e.g. Martin et al., 2008)
5. root dentine translucency (e.g. Chandler and Fyfe, 1997)



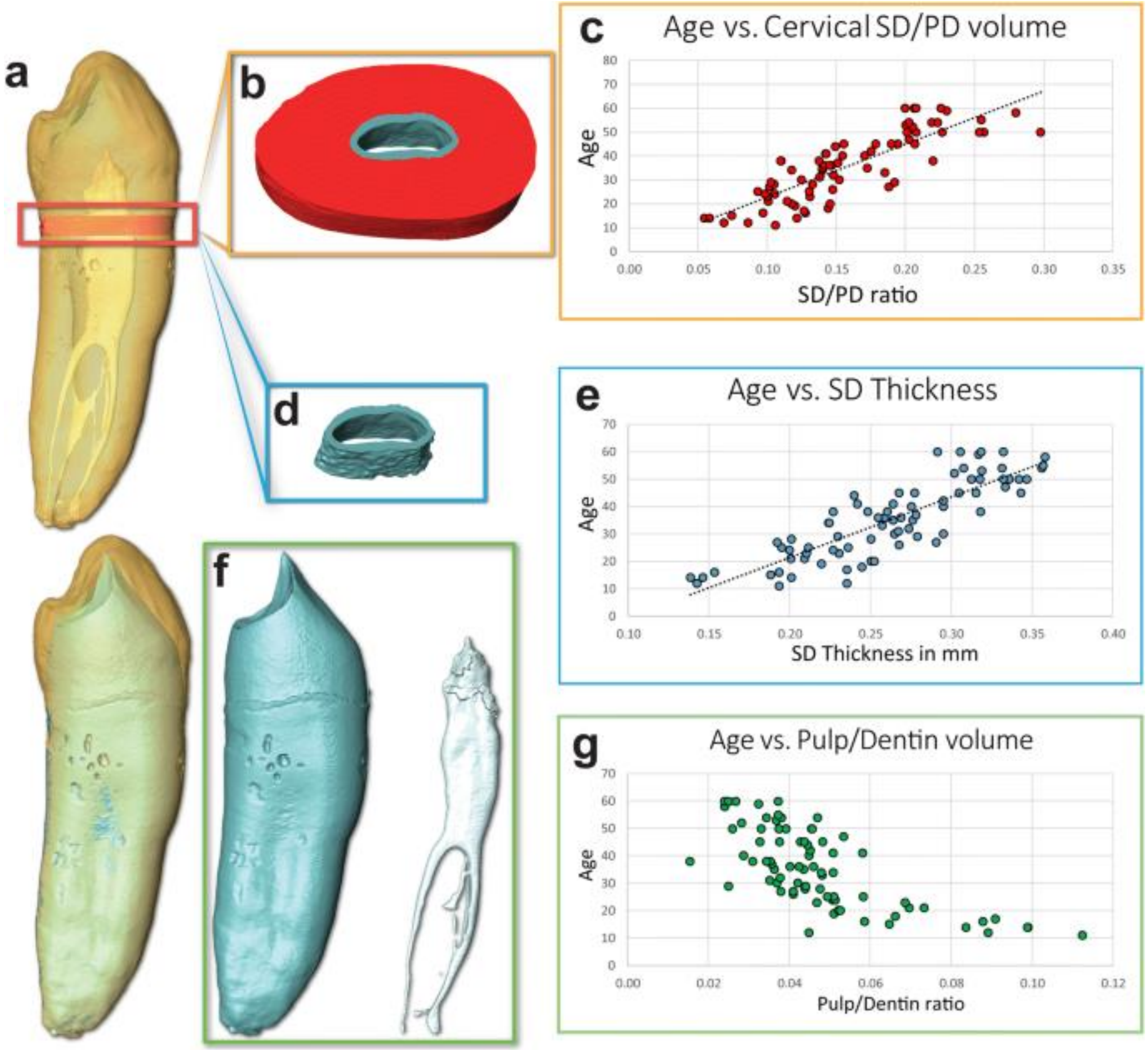
Age estimation of fragmented human dental remains by secondary dentin virtual analysis

Itay Nudel, Ariel Pokhojaev, Bryan S. Hausman, Yoli Bitterman, Nir Shpack, Hila May & Rachel Sarig

International Journal of Legal Medicine 134, 1853–1860 (2020) | Cite this article



Validation of µCT scans for the evaluation of secondary dentin (SD): Histological SD and primary dentin (PD) measurements were compared with segmented µCT slices, with an accuracy of ±27 µm. **a** Histological slice, coronal cross section, paragon stain. **b** Magnified section (SD marked by a red bar). **c** µCT scan, horizontal section, central SD area engulfed in red. **d** The histological slice corresponding to (c). **e** Corner cut of lower premolar volume rendering. SD designated in gray

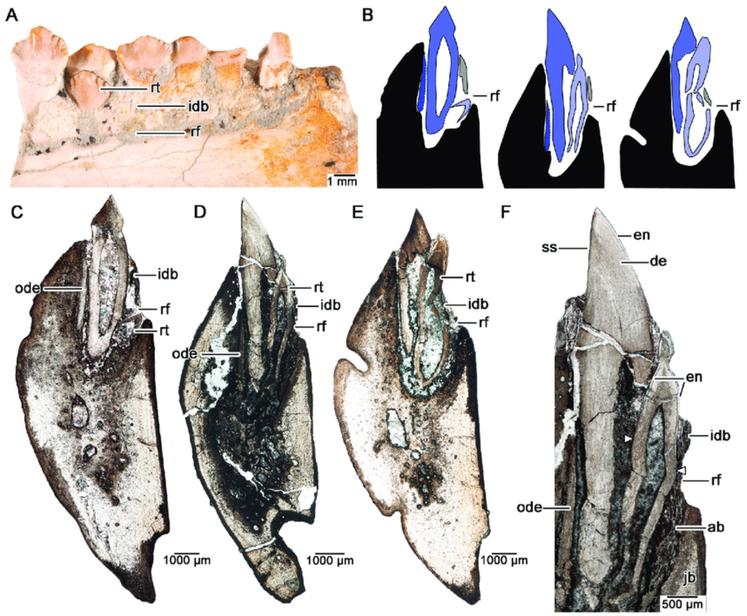


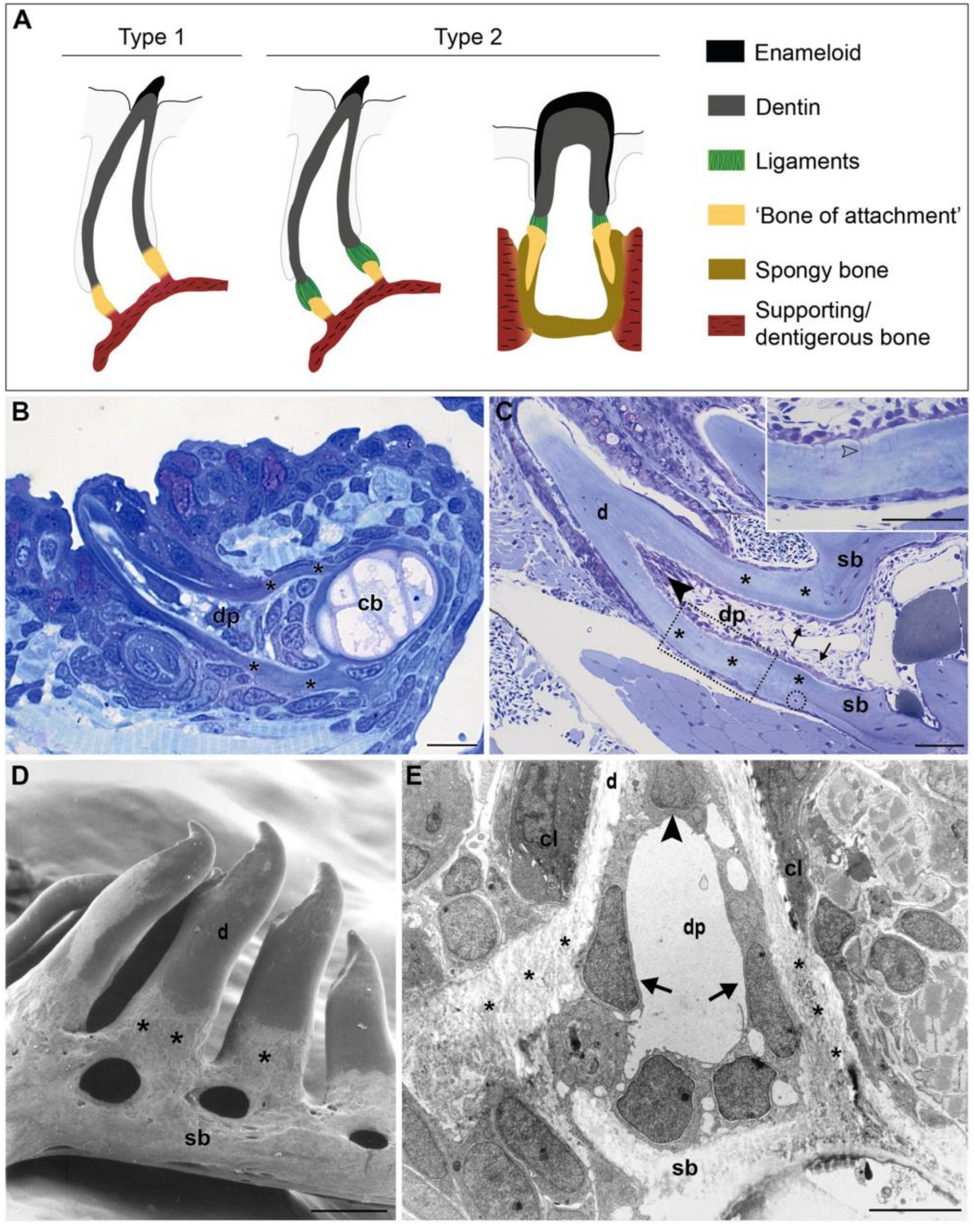
Age and SD measurements: a–b Analysis of SD (gray) and PD (red) cervical slice. Volumes were computed for 1 mm slices taken below the CEJ after tooth alignment and computed as SD/PD. c Age vs. SD/PD volume. Linear trend line, r=0.83*. d Average thickness for SD in mm. e Age vs. SD thickness, r=0.84*. f Segmentation of dentin and pulp for volume analysis. g Age vs. pulp/dentin volume ratio, r=−0.71*. All correlations were found to be significant at *p<0.05. n=77 (50 males, 27 females)

4. Estimation of age at death

Dental histological techniques also applied to the study of faunal remains

(e.g. Beasley et al., 1992; Burke and Castanet, 1995; Wendy, 1998; Dirks et al., 2002).





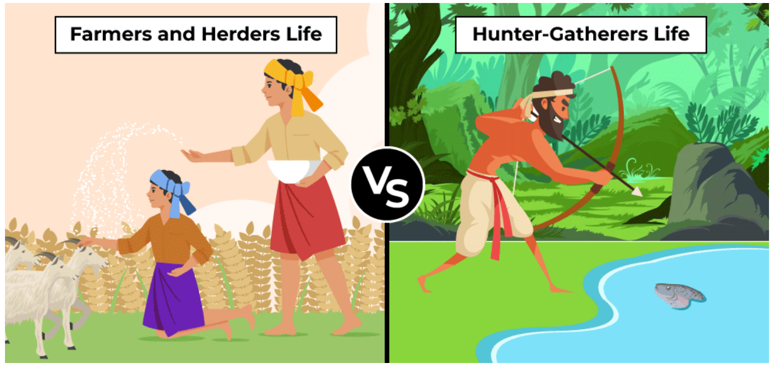
5. Skeletal response to biomechanical stress

During the individual's lifetime, skeleton has the capacity to adapt to biomechanical stress

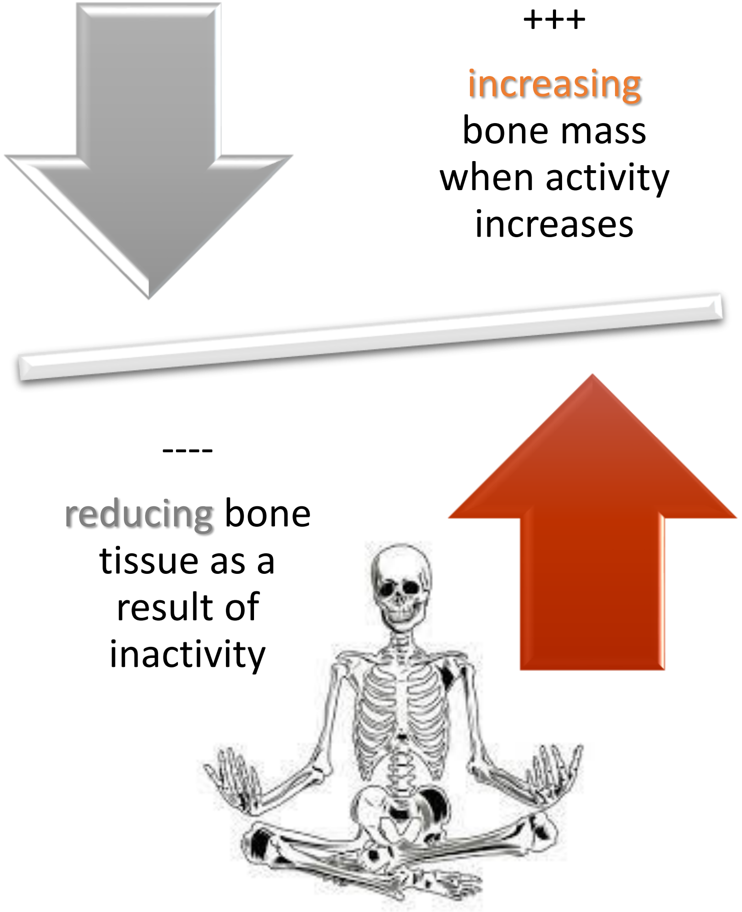
I. histo-morpho-metric analysis: infer strain levels & bone dynamics within populations /human groups of:

1. different chronologies
2. different geographic provenance,
3. different modes of subsistence


AMERICAN JOURNAL OF BIOLOGICAL ANTHROPOLOGY
The Official Journal of the American Association of Biological Anthropologists
Research Article | Full Access
Modeling and remodeling responses to normal loading in the human lower limb
Michelle S.M. Drapeau, Margaret A. Streeter



(i.e. hunter-gatherers vs. agriculturalists)



5. Skeletal response to biomechanical stress

II. histo-morpho-metric analysis: provides insights into the dynamics of bone growth & remodeling over the course of <u>human ontogeny & evolution</u> (e.g. Martin & Armelagos, 1979; Oyen et al., 1979; Abbott et al., 1996; Gosman & Ketcham, 2009).

III. histo-morpho-metric analysis: allows for the development of standards for comparison with other nonhuman primates (e.g. Schaffler & Burr, 1984; Havill, 2003; Mulhern & Ubelaker, 2003).

Osteon Remodeling Dynamics in *Macaca mulatta*: Normal Variation with Regard to Age, Sex, and Skeletal Maturity

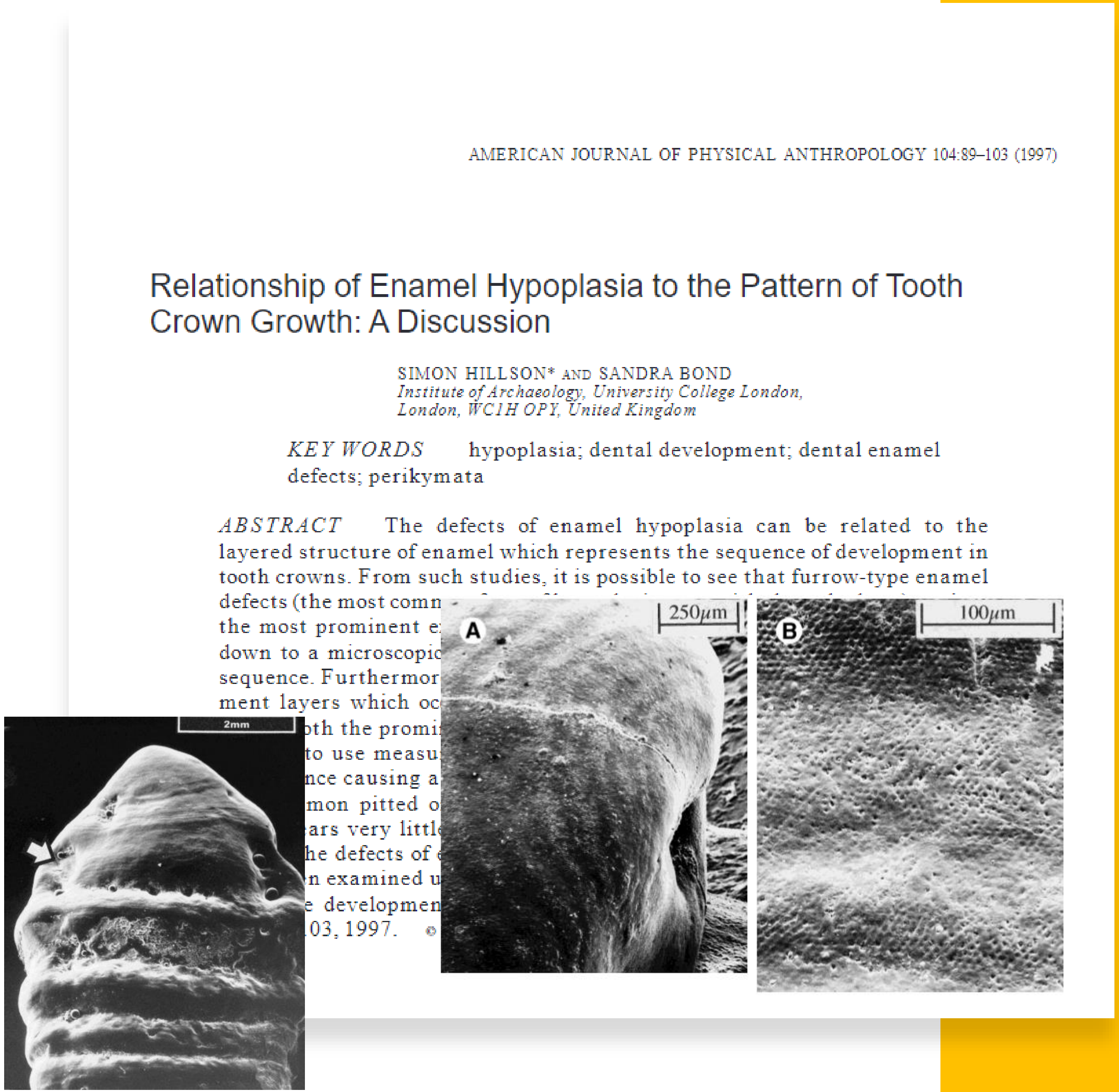
L. M. Havill

Calcified Tissue International **74**, 95–102 (2004) | Cite this article

5. Skeletal response to biomechanical stress

A similar contribution is made by the histological study of dentition

(e.g. Molnar et al., 1981; Hildebolt et al., 1986, Mann et al., 1991; Anemone et al., 1996; Hillson and Bond, 1997).


AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY 104:89–103 (1997)

Relationship of Enamel Hypoplasia to the Pattern of Tooth Crown Growth: A Discussion

SIMON HILLSON* AND SANDRA BOND
Institute of Archaeology, University College London, London, WC1H OPY, United Kingdom

KEY WORDS hypoplasia; dental development; dental enamel defects; perikymata

ABSTRACT The defects of enamel hypoplasia can be related to the layered structure of enamel which represents the sequence of development in tooth crowns. From such studies, it is possible to see that furrow-type enamel defects (the most comm
the most prominent e
down to a microscopic
sequence. Furthermor
ment layers which oc
oth the promi
to use measu
nce causing a
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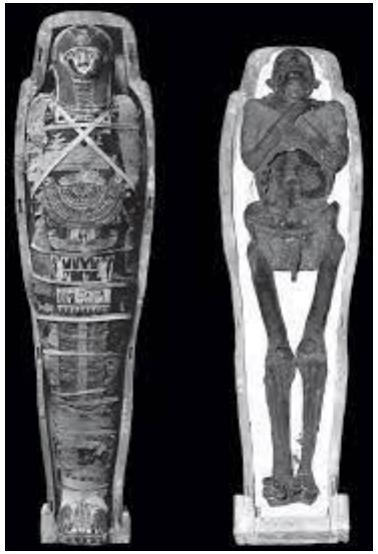
03, 1997.

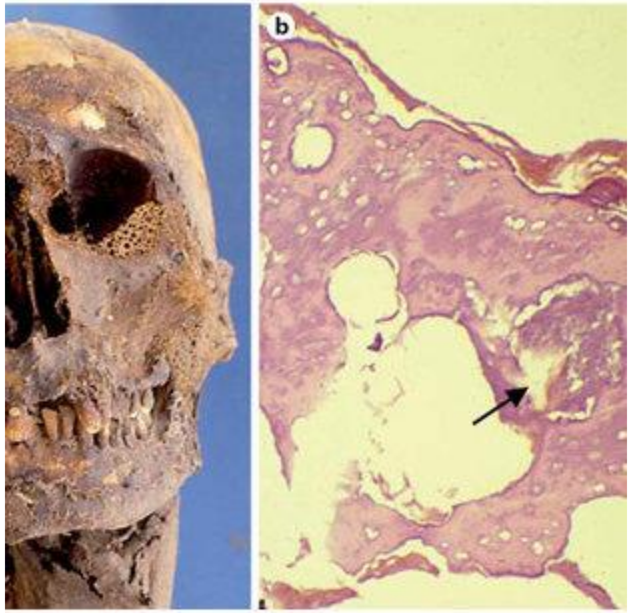
6. Mummy studies



One of the first applications of histology to the study of ancient remains

Nowadays it continues…………

- simple identification of soft tissues
- study of abnormal lesions & taphonomic changes



International Journal of Paleopathology
Volume 1, Issue 2, October 2011, Pages 75-80

Invited Commentary

Soft tissue taphonomy: A paleopathology perspective

Arthur C. Aufderheide

ELSEVIER

International Journal of Paleopathology
Volume 31, December 2020, Pages 34-37

First report in pre-Columbian mummies from Bolivia of *Enterobius vermicularis* infection and capillariid eggs: A contribution to Paleoparasitology studies

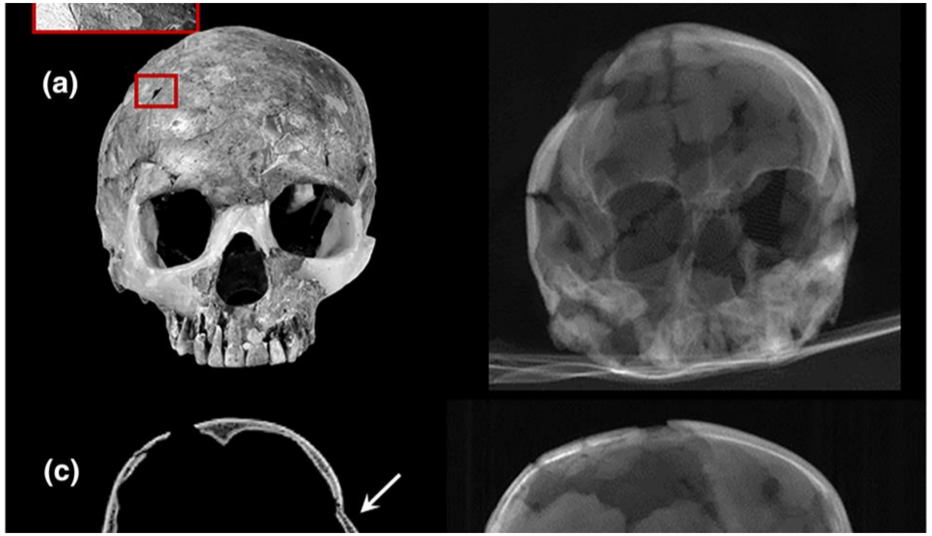
Guido Valverde [a], Viterman Ali [a b], Pamela Durán [a b], Luis Castedo [c], José Luis Paz [c],
Eddy Martínez [a b]

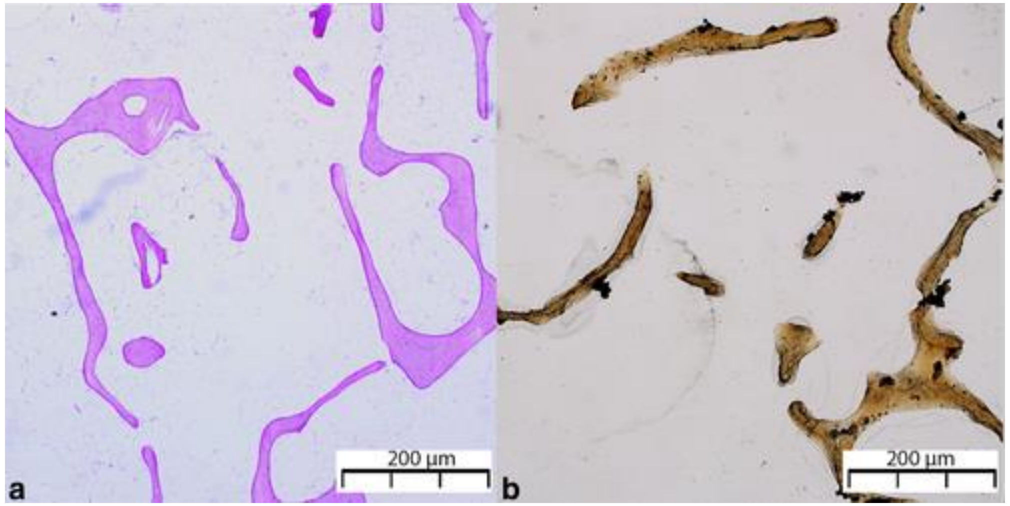
- 12 Bolivian mummies / Microscopic analysis of rehydrated samples (coprolites and abdominal content)
- Eggs of Enterobius vermicularis were identified in coprolites from one mummy, and capillariid eggs in the organic abdominal content from another individual.

7. Bone paleopathology

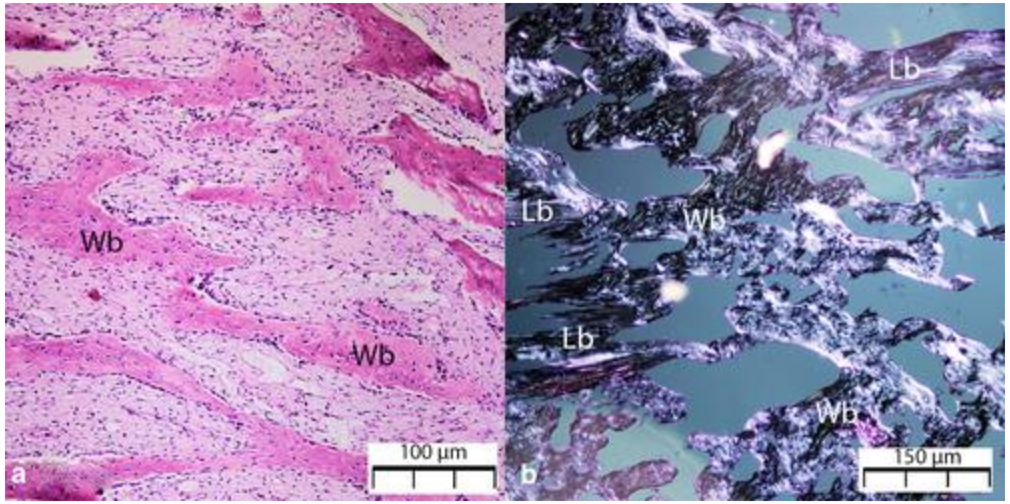
1. long history (paleopathology & histology) -> improvement disease diagnosis
2. Residual application to the study of dry bones compared with other technical approaches
3. Used as an auxiliary diagnostic tool & not as a primary source for paleopathological evidence:

- metabolic conditions, 34%
- benign and malignant tumors, 27%
- specific and non-specific infectious diseases, 23%
- combined pathologies 5.3%
- bone trauma 4.3%

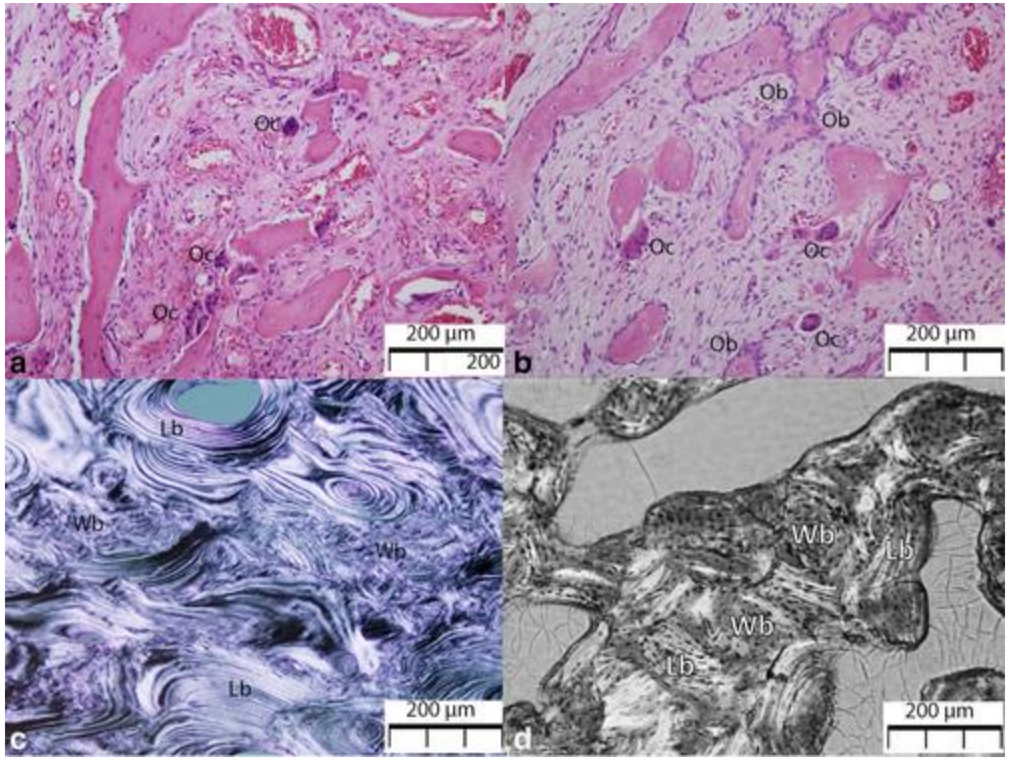




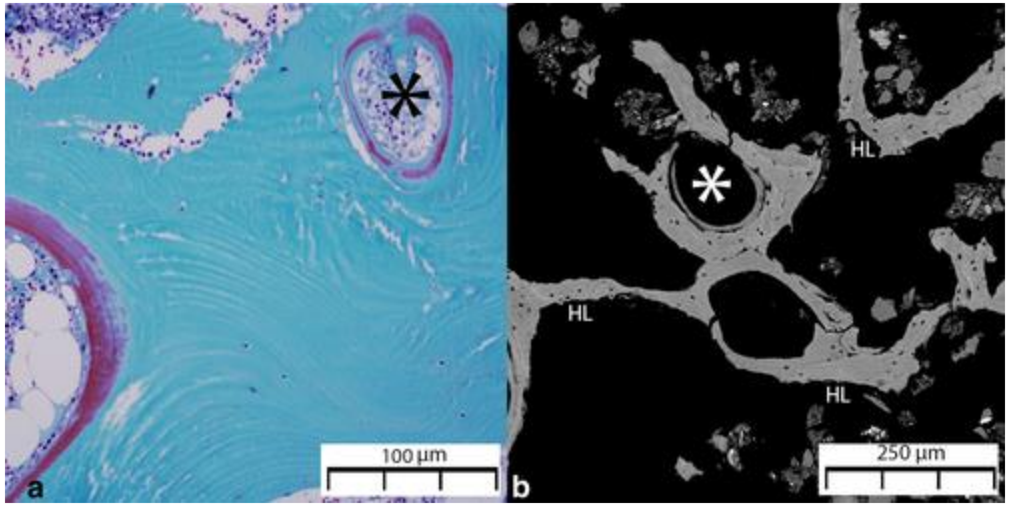
Fresh and dry bone histology of **osteoporotic** bone tissue



Fresh and dry bone histology of woven bone deposition in **fracture** repair.

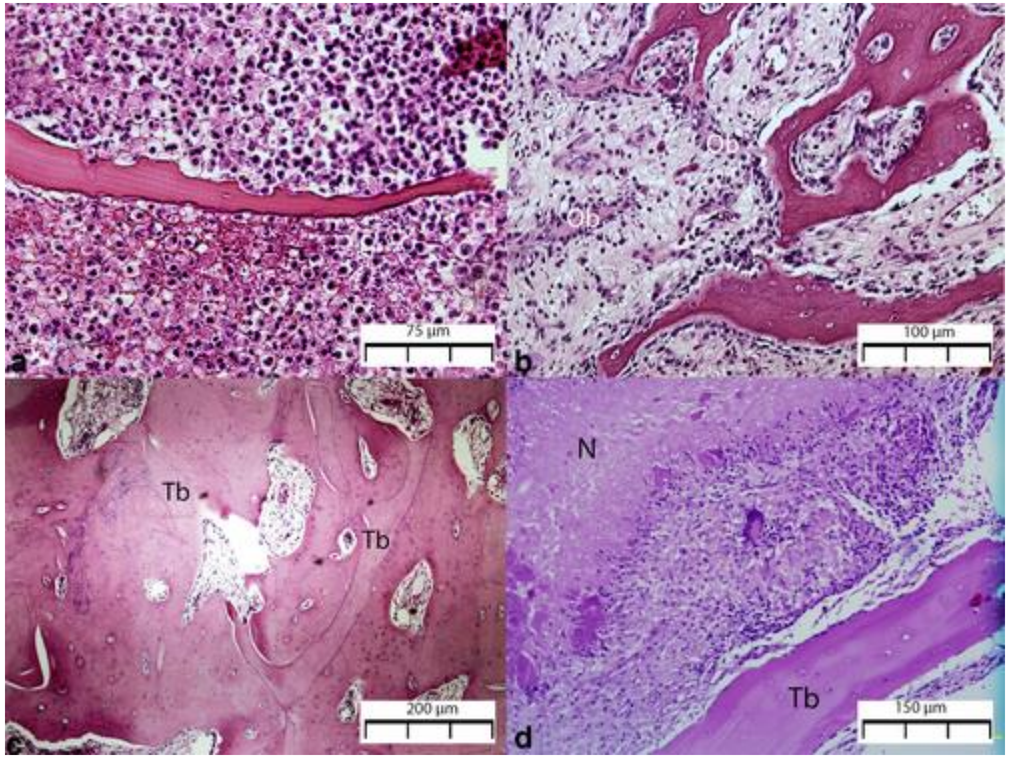


Fresh and dry bone histology of **Paget's disease** of bone

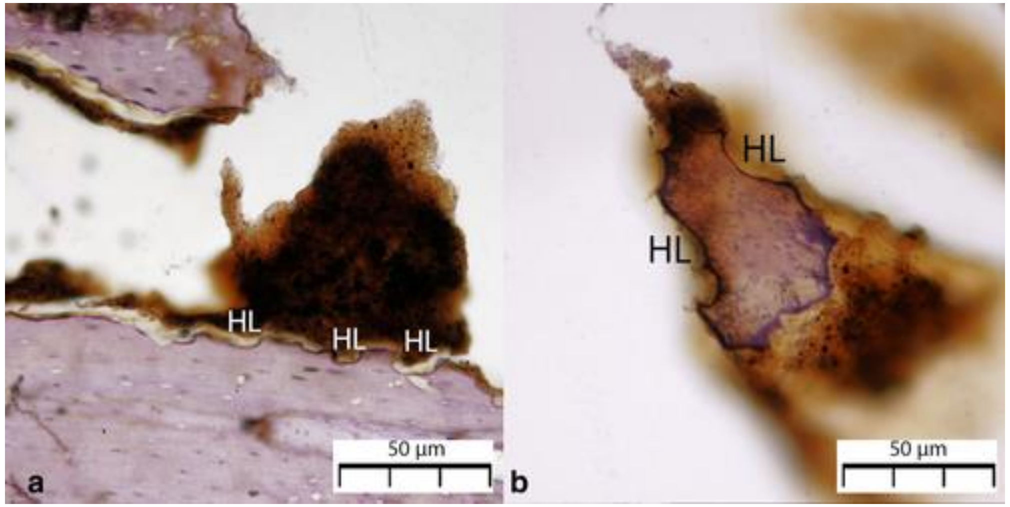


Fresh and dry bone histology of "defective cement lines" in osteomalacia.

Dry bone histology of an ossified hematoma



Fresh tissue histology of **osteomyelitis**.



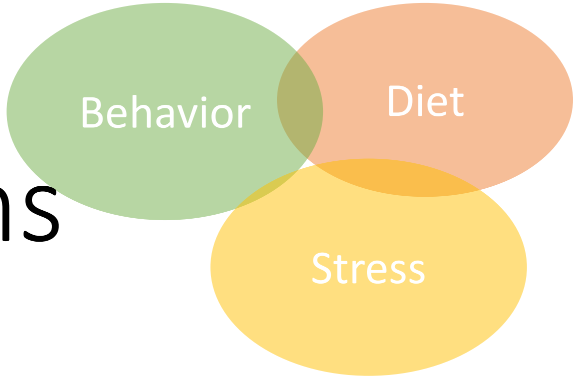
Dry bone histology of **osteomyelitis**.

7. Bone paleopathology

Limits:

1. low specificity of some bone histo-morphometric features
2. invasive nature of most histological techniques
3. high level of scientific proficiency needed to interpret bone morphology at the microscopic level

8. Tooth alterations



Dental microwear : compare dietary habits & seasonal changes in food resources among:

1. **fossil hominins** (e.g. Estebaranz et al., 2009)
2. **modern humans** (e.g. Ma and Teaford, 2010)
3. **nonhuman primates** (e.g. Scott et al., 2006)

ELSEVIER

Journal of Human Evolution

Volume 57, Issue 6, December 2009, Pages 739-750

Testing hypotheses of dietary reconstruction from buccal dental microwear in *Australopithecus afarensis*

F. Estebaranz, L.M. Martínez, J. Galbany, D. Turbón, A. Pérez-Pérez

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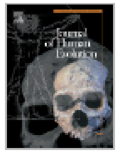
Journal of Human Evolution

Volume 51, Issue 4, October 2006, Pages 339-349



Dental microwear texture analysis: technical considerations

Robert S. Scott [a], Peter S. Ungar [a], Torbjorn S. Bergstrom [b], Christopher A. Brown [b], Benjamin E. Childs [b], Mark F. Teaford [c], Alan Walker [d]

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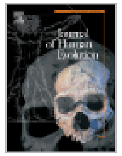
Journal of Human Evolution

Volume 132, July 2019, Pages 80-100



Dental microwear texture analysis of Pliocene Suidae from Hadar and Kanapoi in the context of early hominin dietary breadth expansion

Ignacio A. Lazagabaster [a b]

8. Tooth alterations

behavioral or "cultural" practices / teeth as a third hand

scratches produced when flake tools involved in processing materials held between the anterior teeth came into contact with the labial enamel face

manipulative activities unique to ancient humans

International Journal of Osteoarchaeology

Research Article | Full Access

Non-dietary Marks in the Anterior Dentition of the Krapina Neanderthals

CARLES LALUEZA FOX, DAVID W. FRAYER

146 C. L. Fox and D. W. Frayer

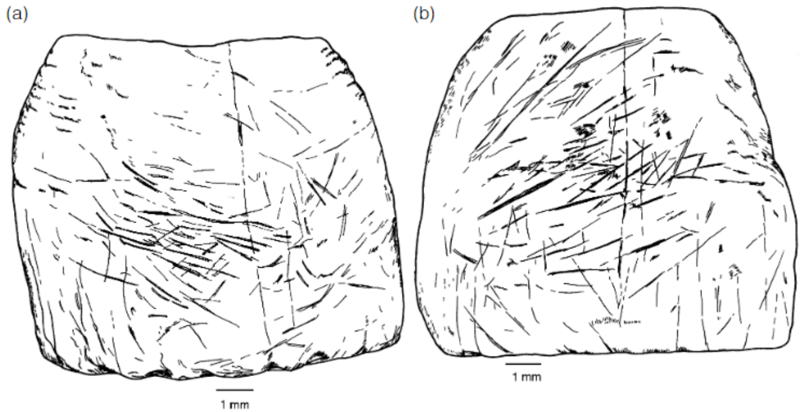
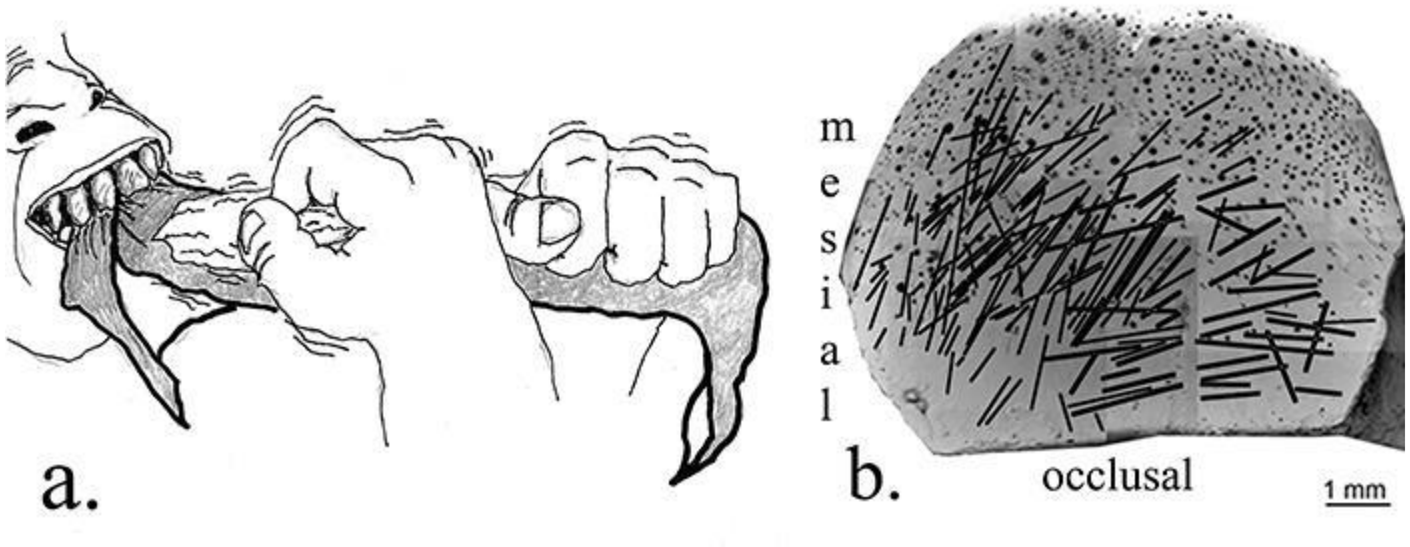


Figure 9. Reconstructed images of the labial surfaces of two right maxillary central incisors: (a) KDP 4 (tooth no. 154); (b) individual 'Q' (tooth no. 132). Some vertical lines are natural cracks.

Study Finds Earliest Evidence in Fossil Record for Right-Handedness

Homo habilis fossil 1.8 million yrs old moved from left to right, indicating the earliest evidence in the fossil record for right-handedness.

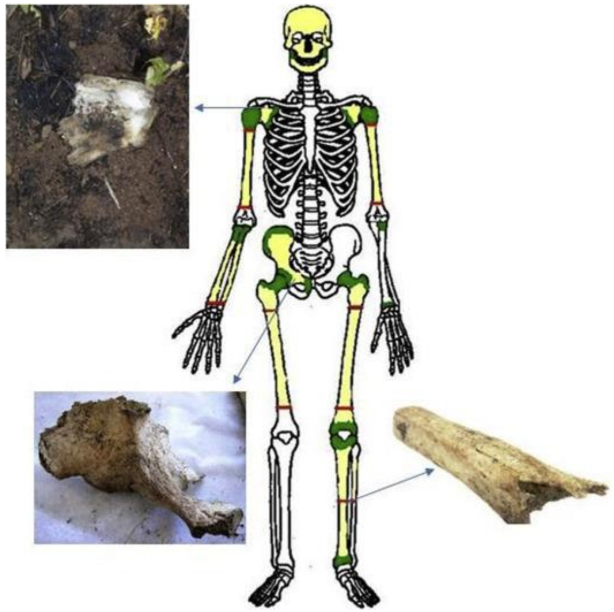
Researchers believe the marks came from using a tool to try to cut food being pulled from the mouth with the left hand.



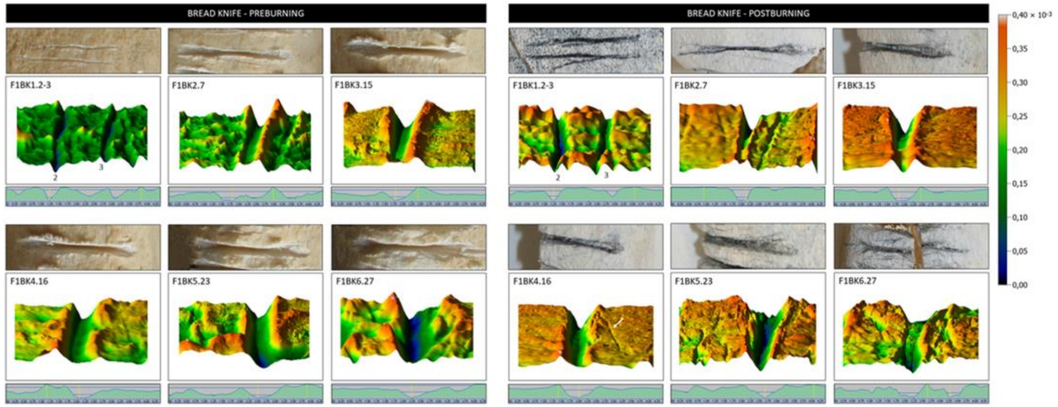
David W. Frayer *et al*. 2016

9. Bone cut marks

in past populations
& forensic contexts



1. hacking trauma (Hutchinson, 1996)
2. dismemberment (Alunni-Perret et al., 2005)
3. traces of defleshing in hominin fossil remains (e.g. White, 1986)
4. marks of butchering on faunal remains and their role in understanding the evolution of hominin handedness (e.g. Pickering and Hensley-Marschand, 2008).



Femur cut with a bread knife

scientific reports

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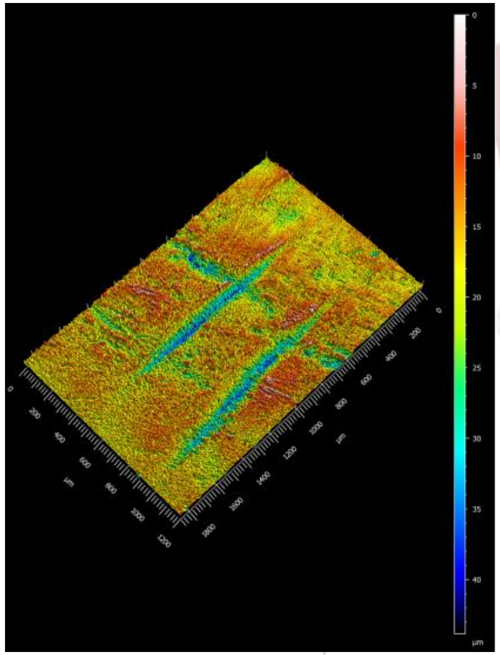
OPEN

Early Pleistocene cut marked hominin fossil from Koobi Fora, Kenya

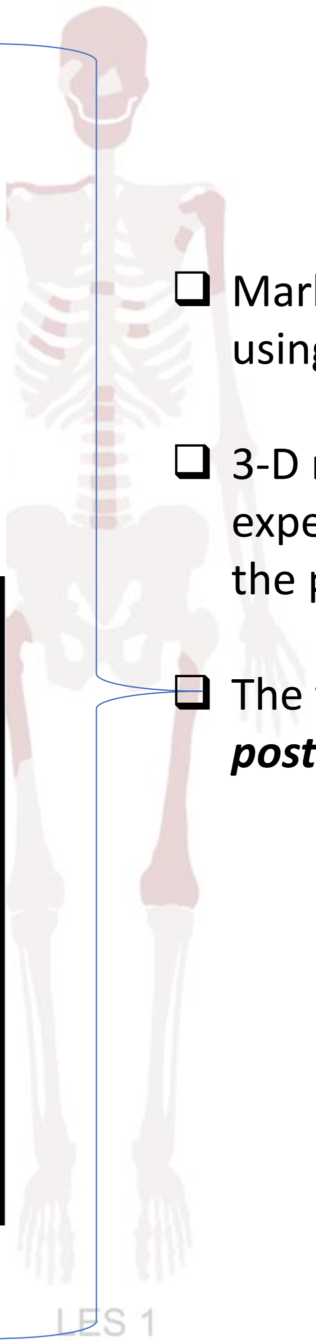
Briana Pobiner[1], Michael Pante[2] & Trevor Keevil[3]

Identification of butchery marks on hominin fossils from the early Pleistocene is rare. Our taphonomic investigation of published hominin fossils from the Turkana region of Kenya revealed likely cut marks on KNM-ER 741, a ~1.45 Ma proximal hominin left tibia shaft found in the Okote Member of the Koobi Fora Formation. An impression of the marks was created with dental molding material and scanned with a Nanovea white-light confocal profilometer, and the resulting 3-D models were measured and compared with an actualistic database of 898 individual tooth, butchery, and trample marks created through controlled experiments. This comparison confirms the presence of multiple ancient cut marks that are consistent with those produced experimentally. These are to our knowledge the first (and to date only) cut marks identified on an early Pleistocene postcranial hominin fossil.

Complete view of tibia (KNM-ER 741) and magnifed area that shows cut marks perpendicular to the long axis of the specimen. Scale=4 cm.

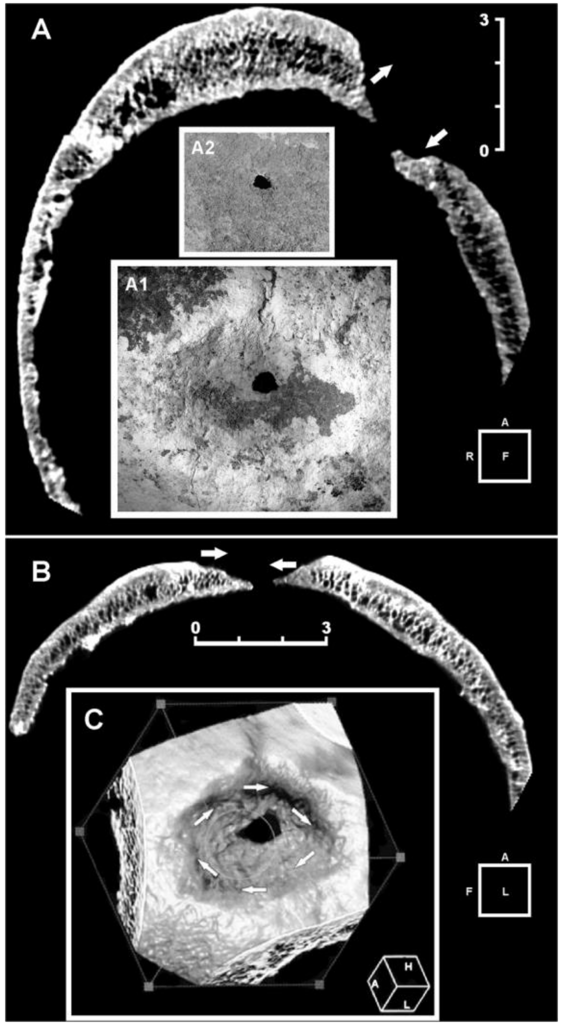


3D model of marks 7 and 8 identifed as cut marks by the quadratic discriminant model.



- ❑ Marks replicated with dental molding material & analyzed using a Nanovea white-light confocal proflometer.
- ❑ 3-D models of the marks compared with a database of 898 experimental tooth, butchery, & trample marks, confirming the presence of ancient cut marks.
- ❑ The first & only cut marks identified on an ***early Pleistocene postcranial hominin fossil***.

9. Bone cut marks



Cutmark micromorphology is also considered in the study of surgical or ritual bone incisions, such as trephinations, and their differentiation from taphonomic changes

(e.g. Stevens and Wakely, 1993; Fabbri et al., 2012)

10. Forensic anthropology

cremated remains (civil or criminal contexts)

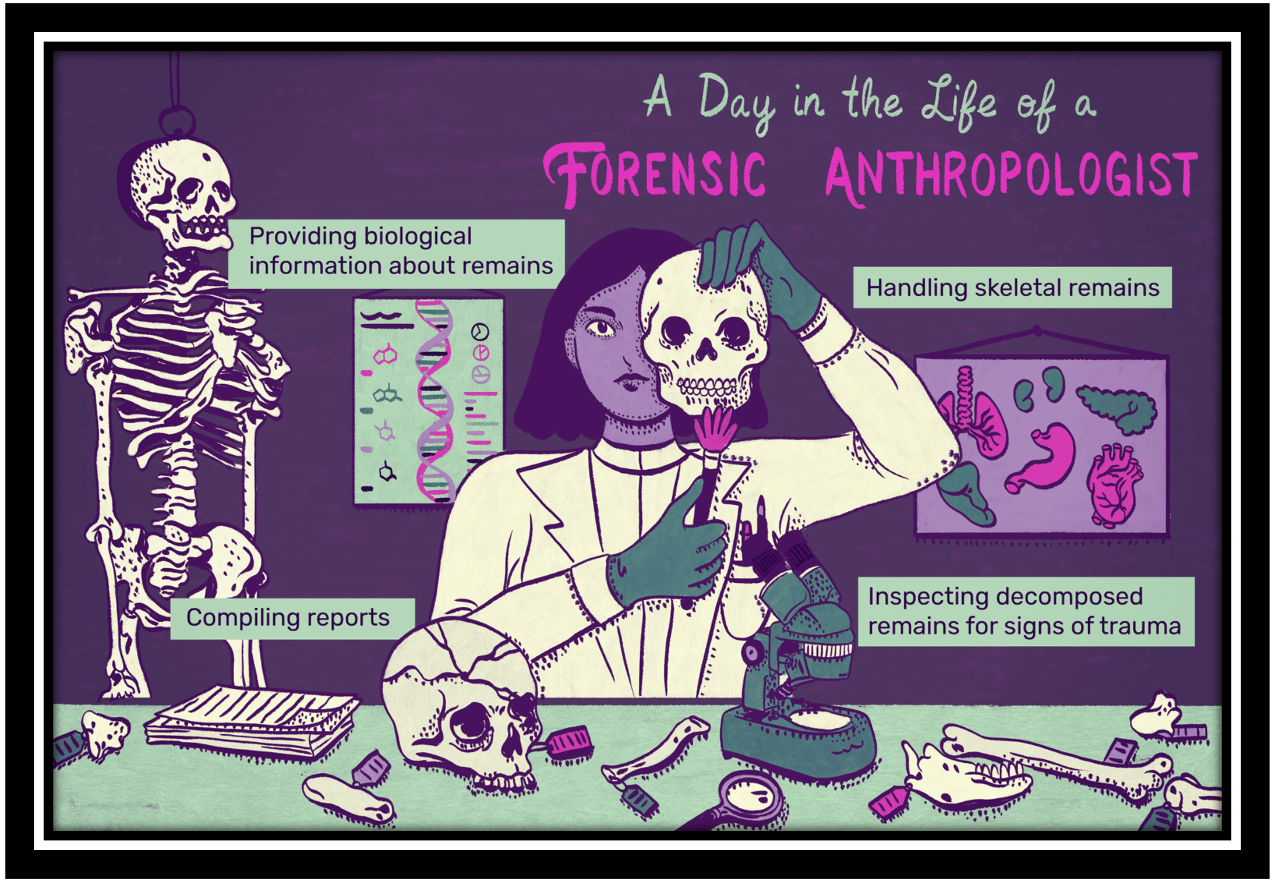
Time since death or postmortem events

age at death

In commingled, fragmented, and burned bone or teeth remains, human from nonhuman remains

Presence of bone or teeth in remains thought not to be of skeletal origin & vice versa

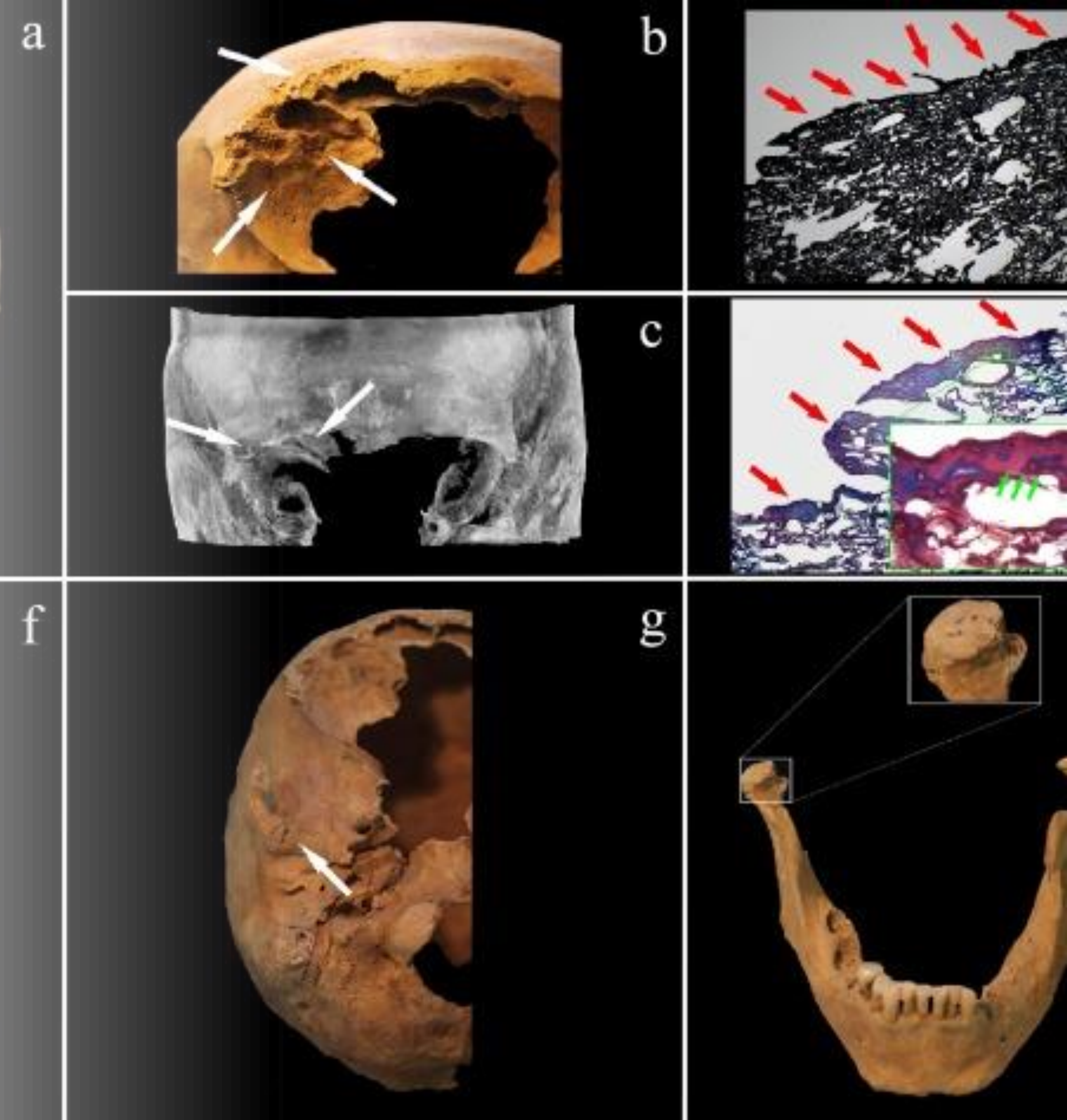
Rich data on using microscopies in forensic anthropology



10. Forensic anthropology

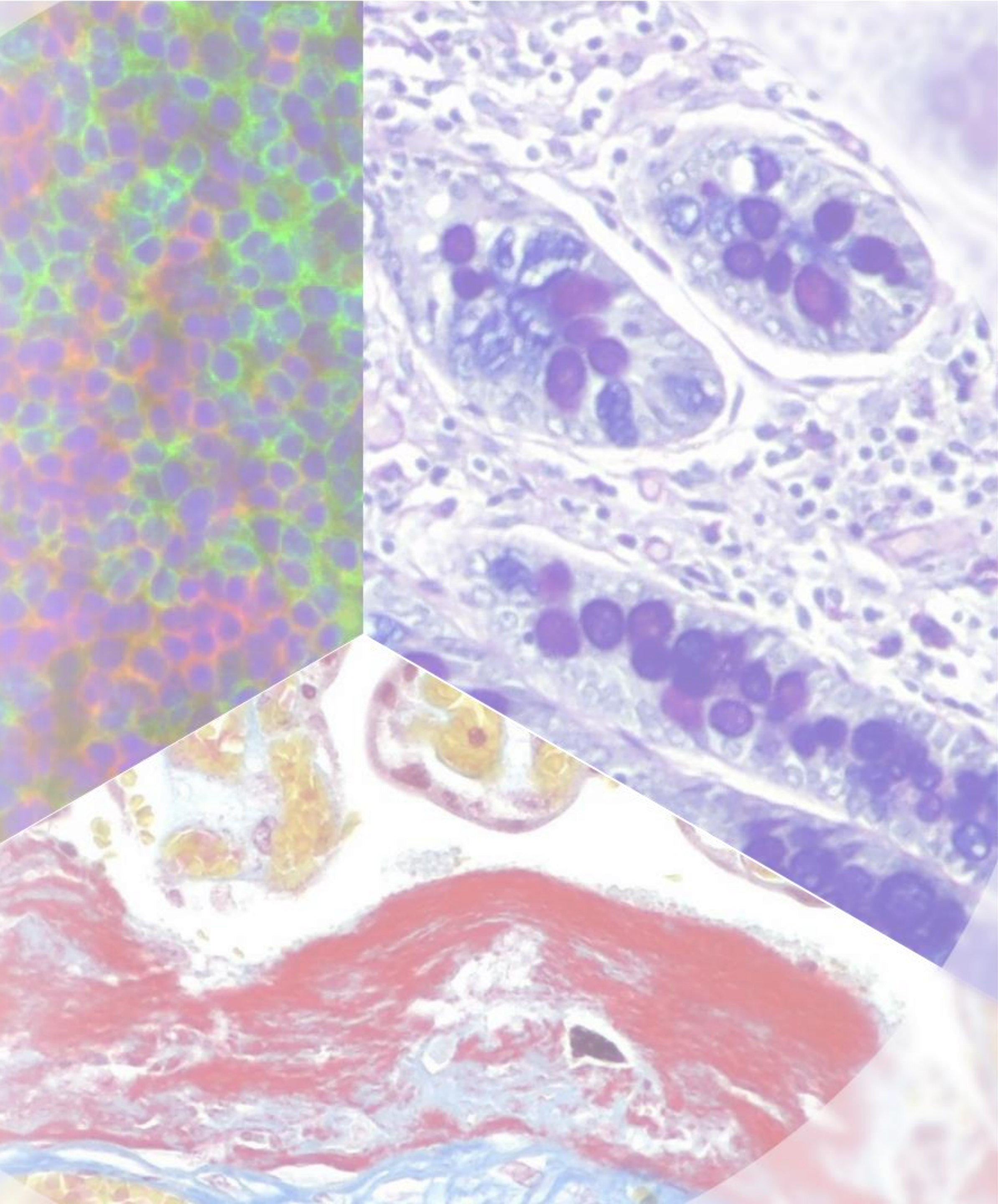
In the scope of trauma investigation, the microscope plays a key role in:

1. trauma lesions or postmortem phenomena & developmental defects
2. origin of trauma signs
3. nature of bone inclusions



Current limitations & future challenges

- ❑ Perceived **time-consuming** nature/ often associated with high **costs** $$$
- ❑ **Choice of method** depends on 1) research goals & 2) preservation status of bone samples, with more time-intensive techniques preferred for small or fragile specimens
- ❑ **Insufficient training**, particularly in the examination of paleopathological specimens & and mummified tissue



Current limitations & future challenges

- Studies emphasize the crucial role of **training and experience** in reducing bias and ensuring accurate analysis, underscoring the importance of developing a deep understanding of mosaic patterns in normal and pathological skeletal and tissue structures.
- Advancements in **less invasive techniques**, such as synchrotron radiation X-ray microtomography, circularly polarized light microscopy (CPLM), are overcoming traditional limitations
- These innovative methods provide detailed insights into bone structures and features, offering valuable **non-destructive alternatives**, although some challenges like potential color changes & equipment size complexity are acknowledged.