Forensic Capability Network *Research and Development Festival. Thursday 9th September 2021*

Northumbria University NEWCASTLE

# Navigating the Cadaveric Island: integrating forensic taphonomy, archaeology and crime scene science in research and praxis

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This presentation contains images of decomposed human and animal remains slido

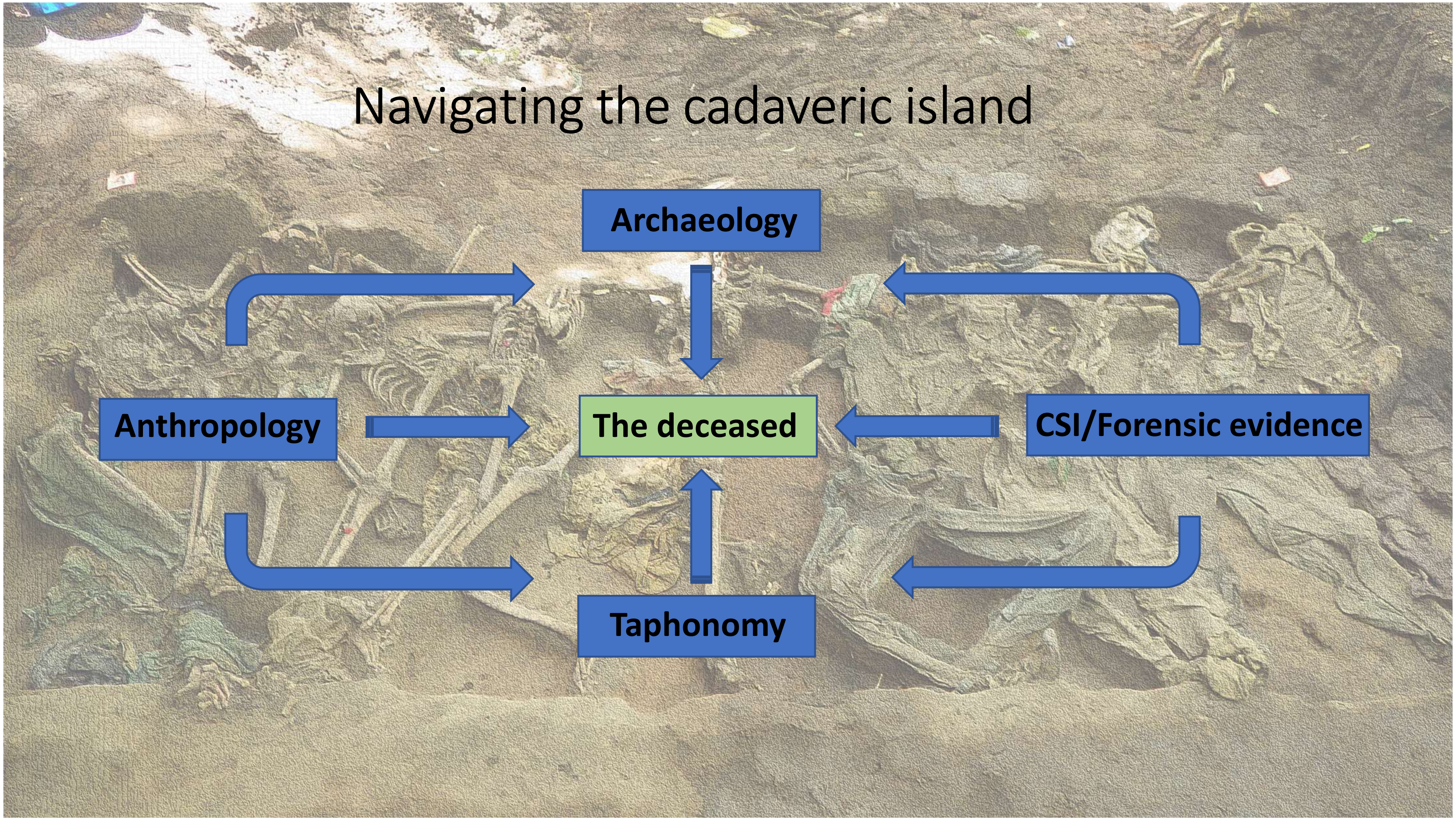
# What is your background?

ⓘ Start presenting to display the poll results on this slide.

slido

# Have you been involved in body recovery?

ⓘ Start presenting to display the poll results on this slide.

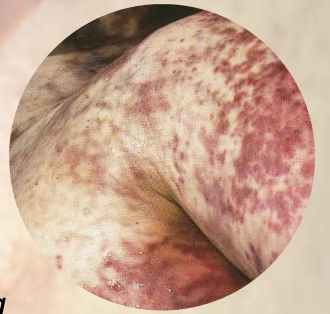

Navigating the cadaveric island
Archaeology
Anthropology
The deceased
CSI/Forensic evidence
Taphonomy

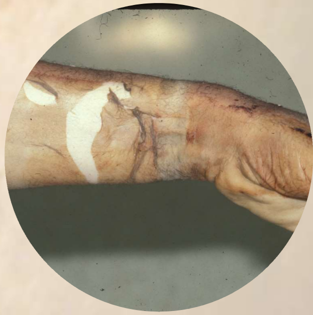
## Stages of decomposition

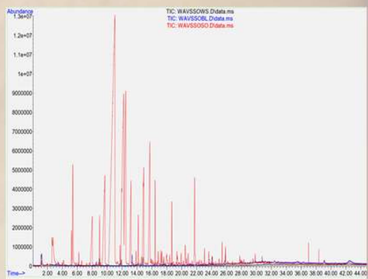
- Fresh
- Bloated
- Active decay
- Advanced decay
- Dry remains

## Early decomposition

- Mortem triad
  - *Rigor mortis – fluctuating rigidity*
  - *Livor mortis – gravitational staining*
  - *Algor mortis – background cooling*
- Bloating
- Marbelling
- Purging
- Skin slippage
- Odour (VOC)
  - ***Putrescine** and **cadaverine***
- Leachates

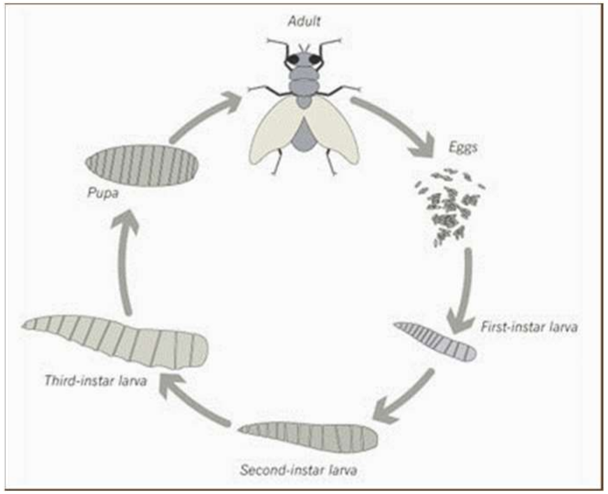






# Factors Affecting Decomposition

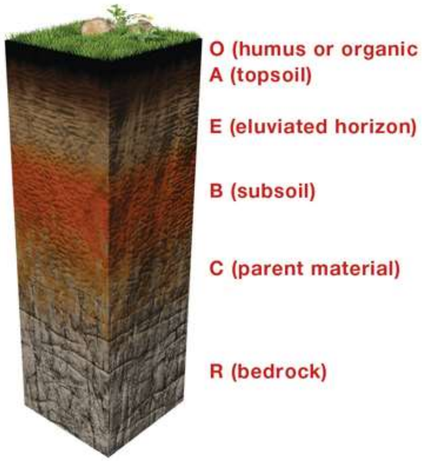
- Temperature and humidity affects insect activity (if accessible)
- Cold slows bacterial reproduction and chemical processes
- Heat and high humidity speeds process
- Low humidity can lead to mummification

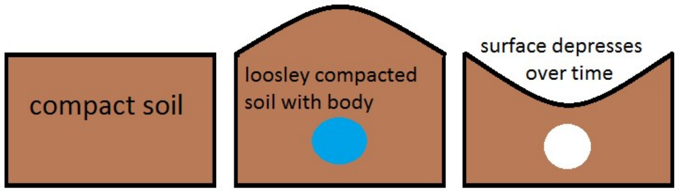



Source: PRQ

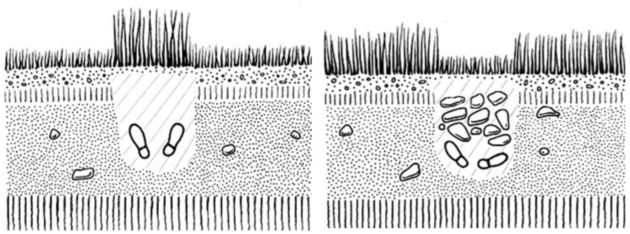
# Burial environments – the cadaveric island

- Preservation affected by:
  - Soil type
    - Parent material
    - Anthropogenic processes
  - pH
  - Burial depth
  - Humidity/water
  - Wrapping/clothing
  - Mortuary practices
  - Access by scavengers



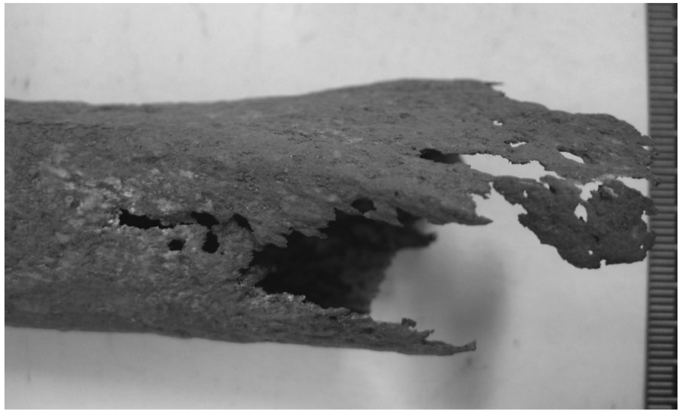

Change through time



Vegetational effects

Persistence

Acid corrosion



Mineral deposition

Soil matrix compression

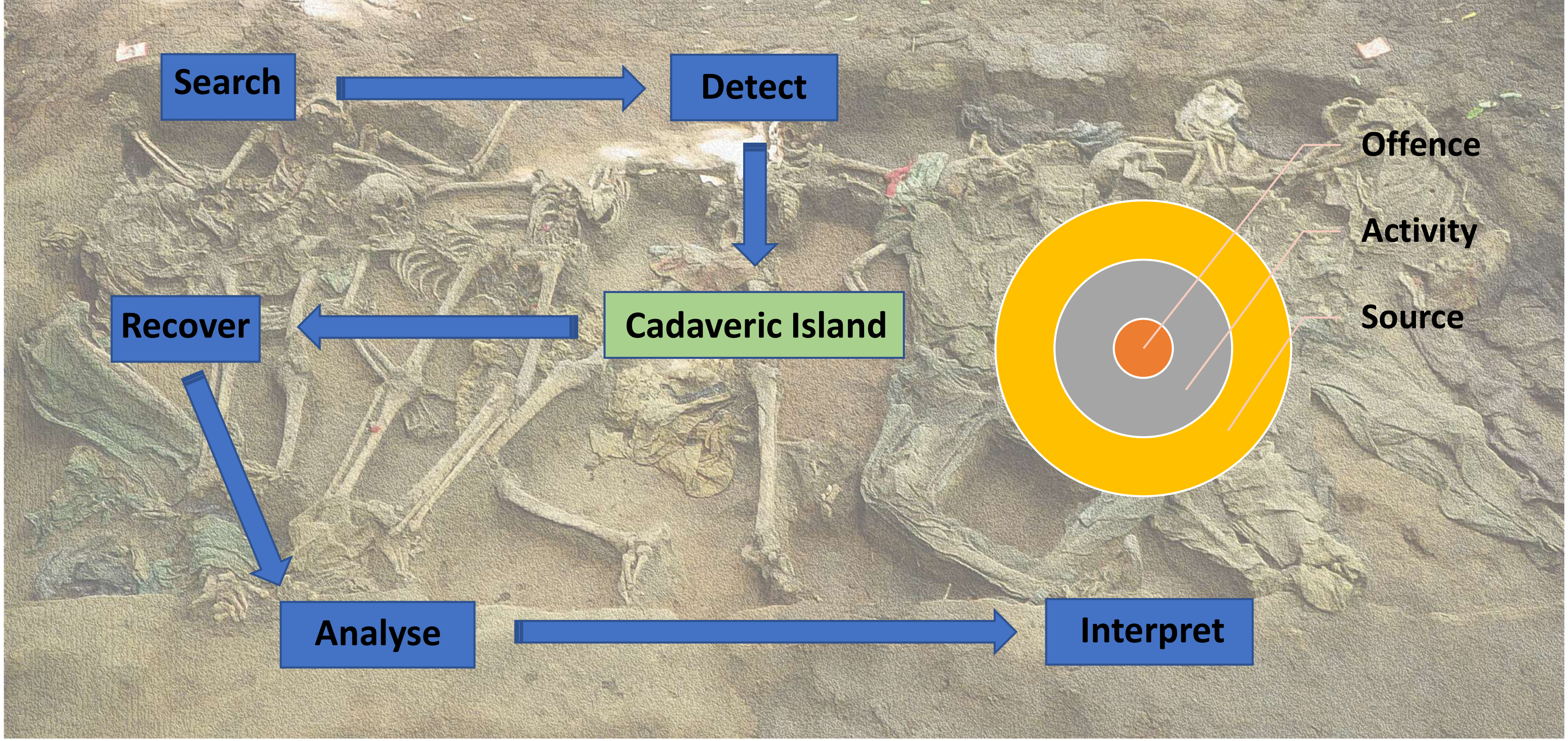
Source: PRQ

Root etching

Coffin wear

Source: Pokines and Symes (2014). *Manual of Forensic Taphonomy.* CRC Press.

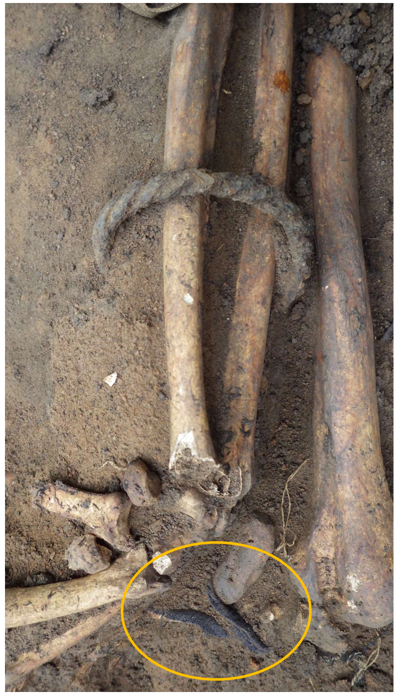
# Clandestine graves - key forensic needs




Source: PRQ


**Mission Chambres Africaines Extraordinaires (CAE)**

War crime investigations in case against Hissène Habré, Deli, Republic of Chad 2014



Sources: PRQ

*“The dead do not bury themselves”*

Parker Pearson, M. (2002). *The Archaeology of Death and Burial.* Sutton Publishing.

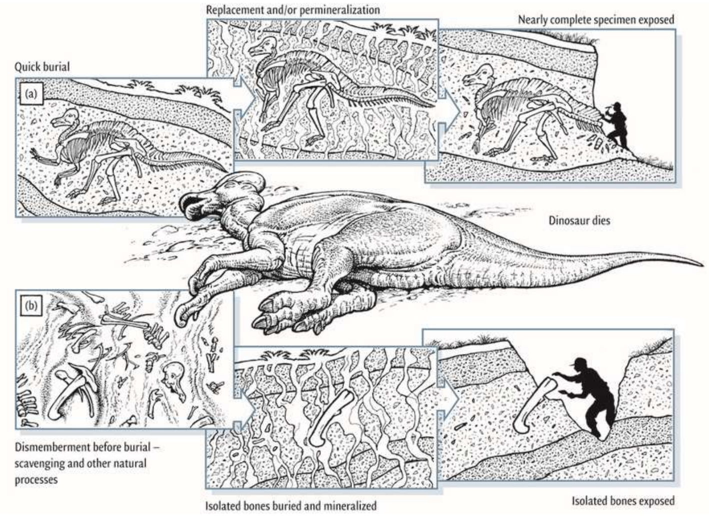
# Evidence recovery

- Anthropological
- Archaeological
- Forensic traces
  - Footwear impressions
  - Entomology
  - Tool marks
  - Ecology
  - Latent prints
  - Fibres
  - DNA
  - Toxicology
  - **Persistence, preservation, transfer**

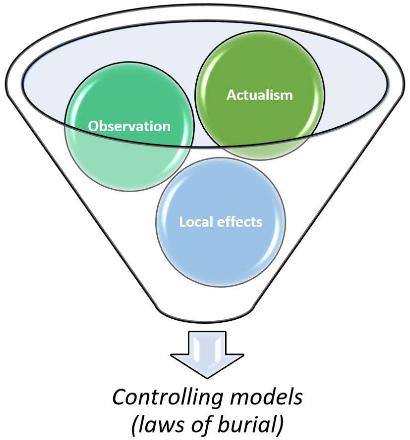

Sources: PRQ

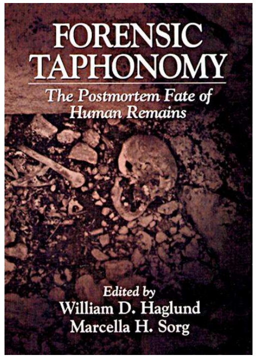
# Taphonomy (*taphos-nomos)*

- *"Transition of organic remains from the biosphere to the lithosphere"* Efremov, 1940
- Aims to construct *Laws of Burial*
- Forensic adoption of classical taphonomy - 1997
- Differs from most other areas of taphonomy through:
  - Lack of time averaging
  - Individual body as the unit of analysis
  - Interpretations may be ground-truthed through witness corroboration




Source: Kardong, K. (2001). *Vertebrates.* McGraw-Hill.




1997

# Approaches in taphonomy

## UNIFORMITARIANISM

### Classical taphonomy (inductive)

- Uses spatial patterning and part representation to develop a logical narrative

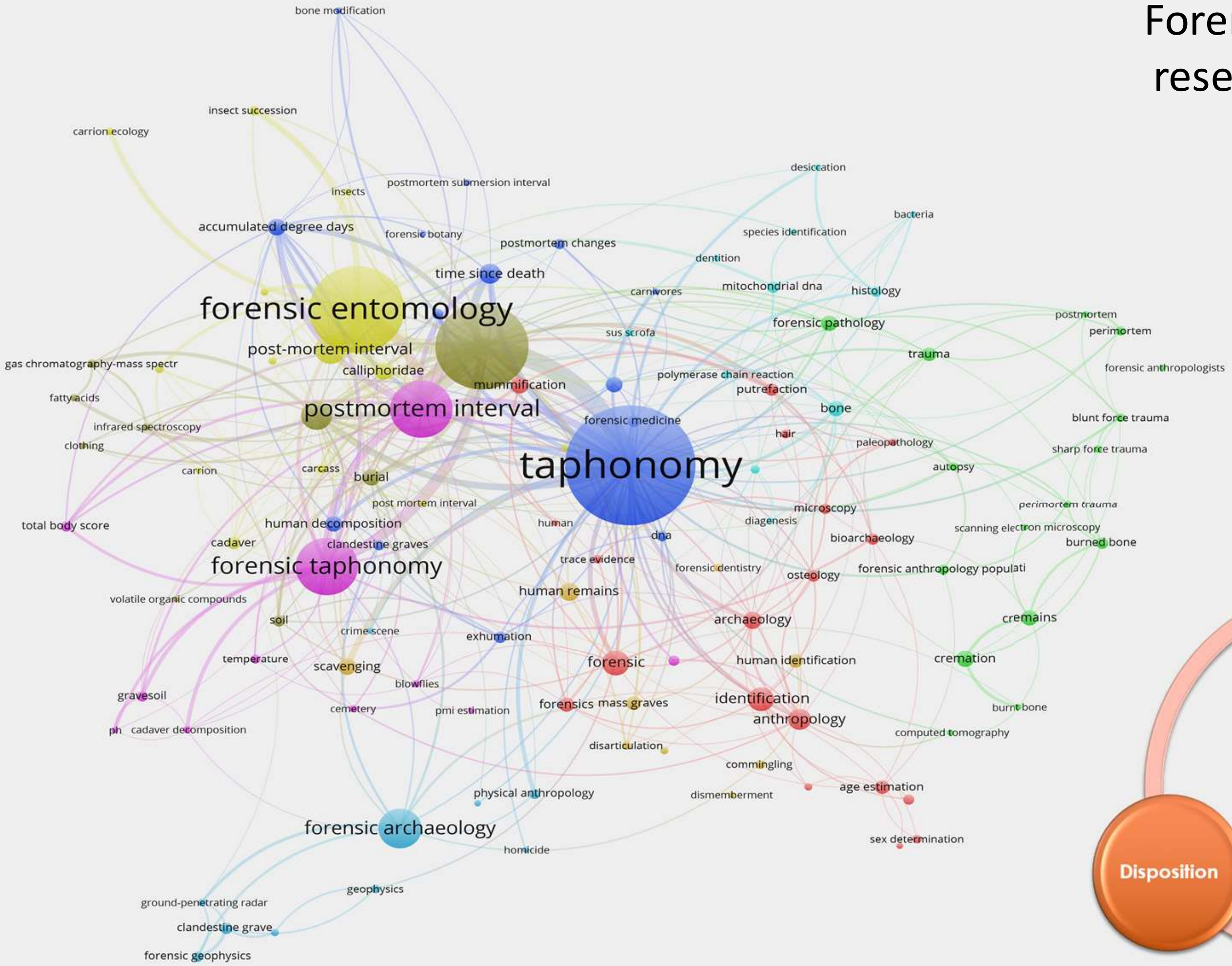
Source: PRQ

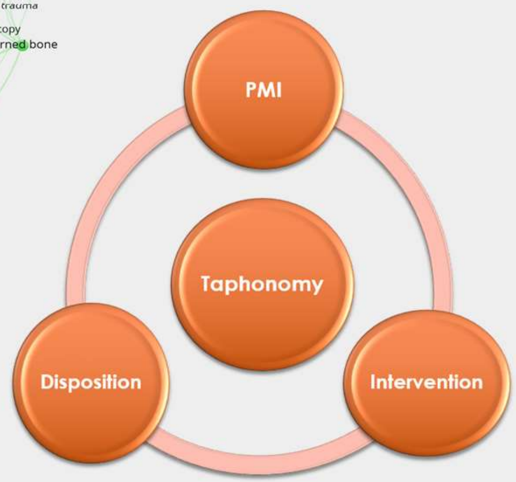
### Neo-taphonomy (deductive)

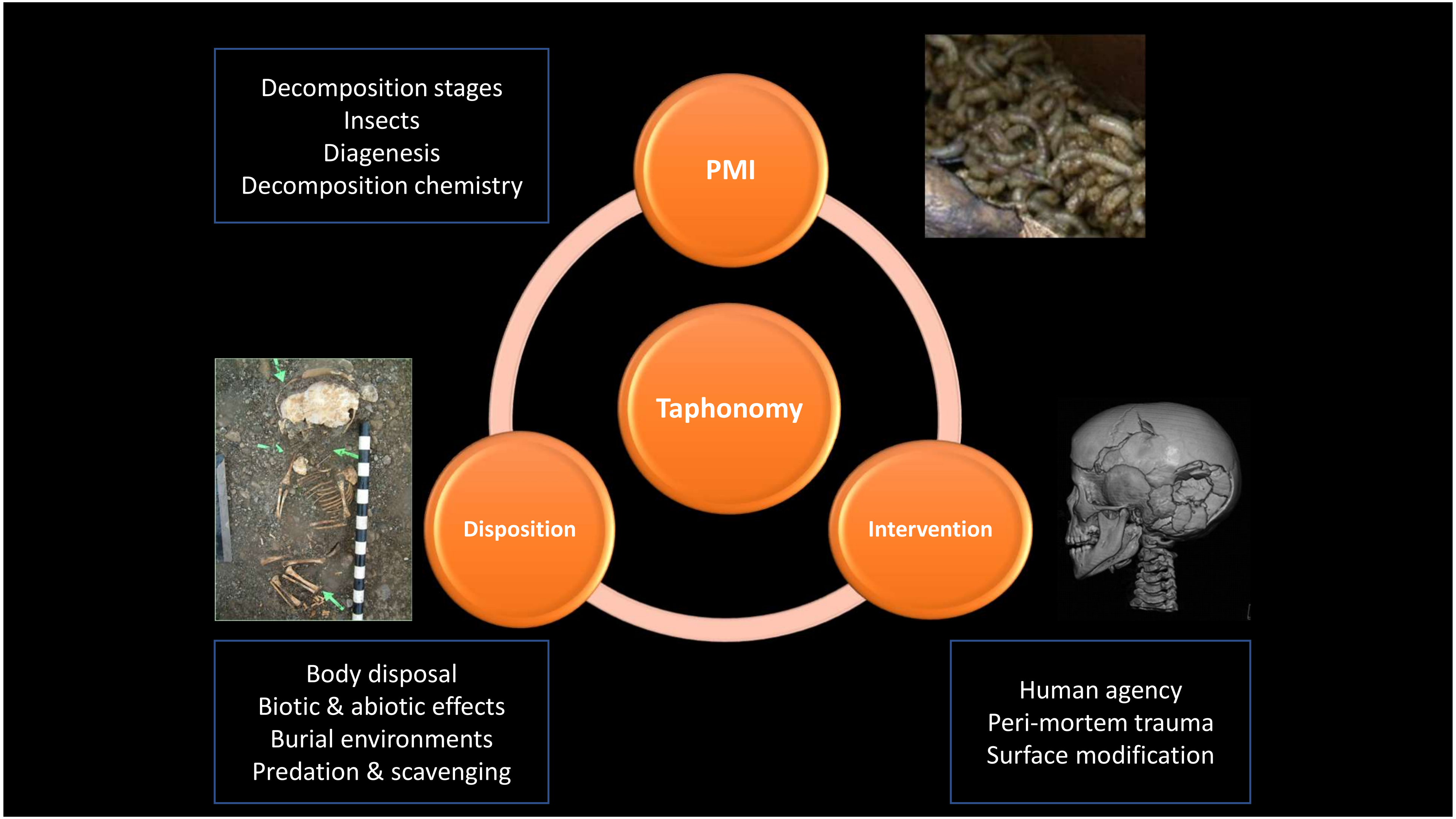
- Uses experimental actualism to produce analogues
- Allows for falsifiability of taphonomic patterns

Sources: Peter Cross, UCLan

# Forensic taphonomy research 2010-2020

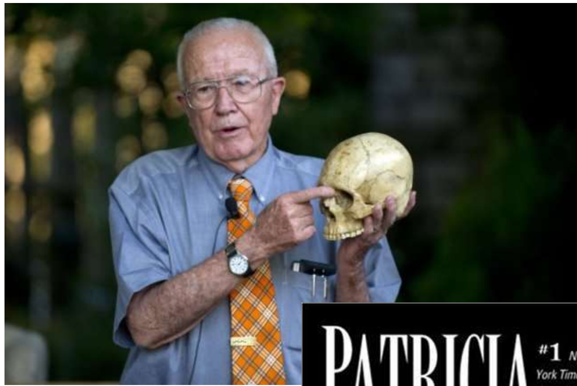


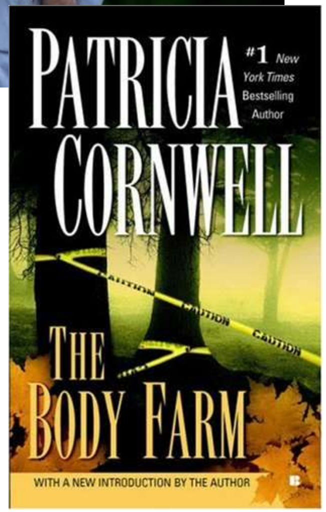




Decomposition stages
Insects
Diagenesis
Decomposition chemistry
PMI
Taphonomy
Disposition
Intervention
Body disposal
Biotic & abiotic effects
Burial environments
Predation & scavenging
Human agency
Peri-mortem trauma
Surface modification

# ‘Body Farms’ - Taphonomic Research Facilities

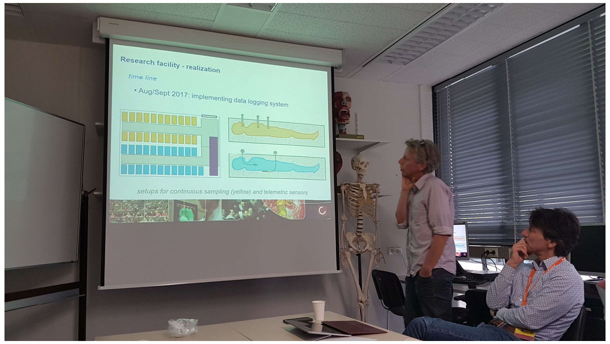
- University of Tennessee Forensic Anthropology Facility opened by William Bass in 1971
- Justification:
    1. Improve search and location skills
    2. Improves recovery skills (body and trace evidence)
    3. Builds resilience in first responders (training)
    4. Long scale time since death estimation
    5. Builds post-mortem narrative
- Human-based facilities:
    - 8 in United States
    - 1 in Canada
    - 1 In Netherlands
- Multiple animal-based facilities UK, US and South Africa





# TRF research frameworks

- Understand human decomposition
- Allow accurate and precise models of PMI
- Understand how fast a body becomes skeletonized
- Training law enforcement, search and rescue teams, and cadaver dogs to find remains



UNIVERSITY OF AMSTERDAM

University of Central Lancashire UCLan

UQTR Université du Québec à Trois-Rivières

- Analysis of Volatile Organic Compounds (VOCs)
- Analysis of VOC's, lipids and biomarkers
- Aiming to improve detection methods, 'electronic nose' development, and cadaver dog training

- Targeted geophysical and remote sensing approach to detecting buried forensic targets
- Tied to longitudinal studies on cadaver dog reliability (error rate evaluation) and training

# Multi-scalar taphonomic research

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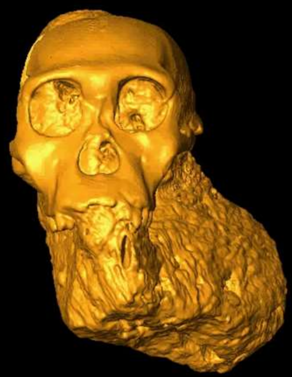
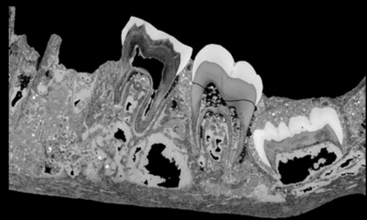
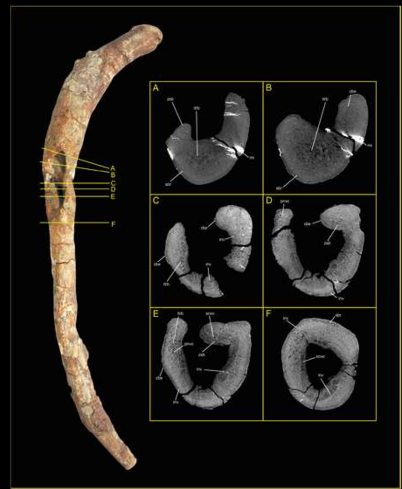
- Micro-computed and synchrotron tomography
- Histopathology
- Spatial taphonomy
- 4D decomposition modelling
- Proteomics and bioinformatics



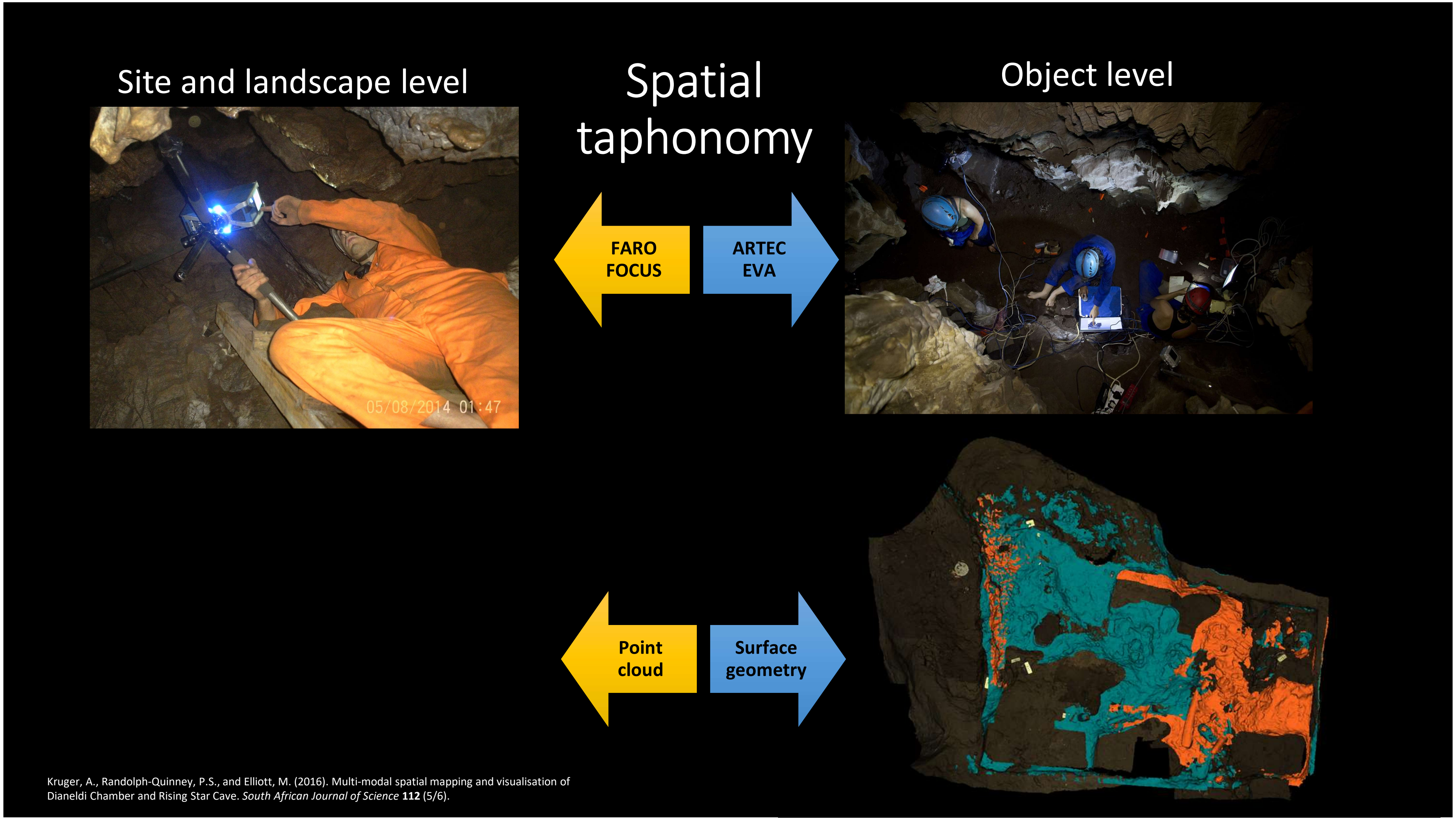


1. Mechanism of death in *Au. sediba*

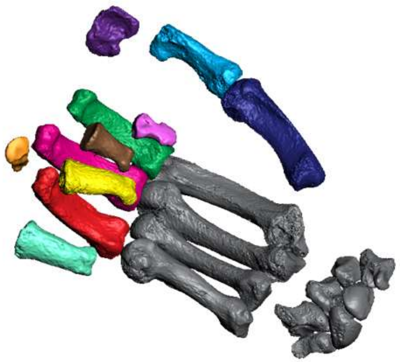


2. Bite induced osteomyelitis in *Lufengosaurus*


1. L'Abbe *et al.* (2015) *Scientific Reports* 5:15120
2. Xing *et al. (*2018) *Scientific Reports* 8:5045

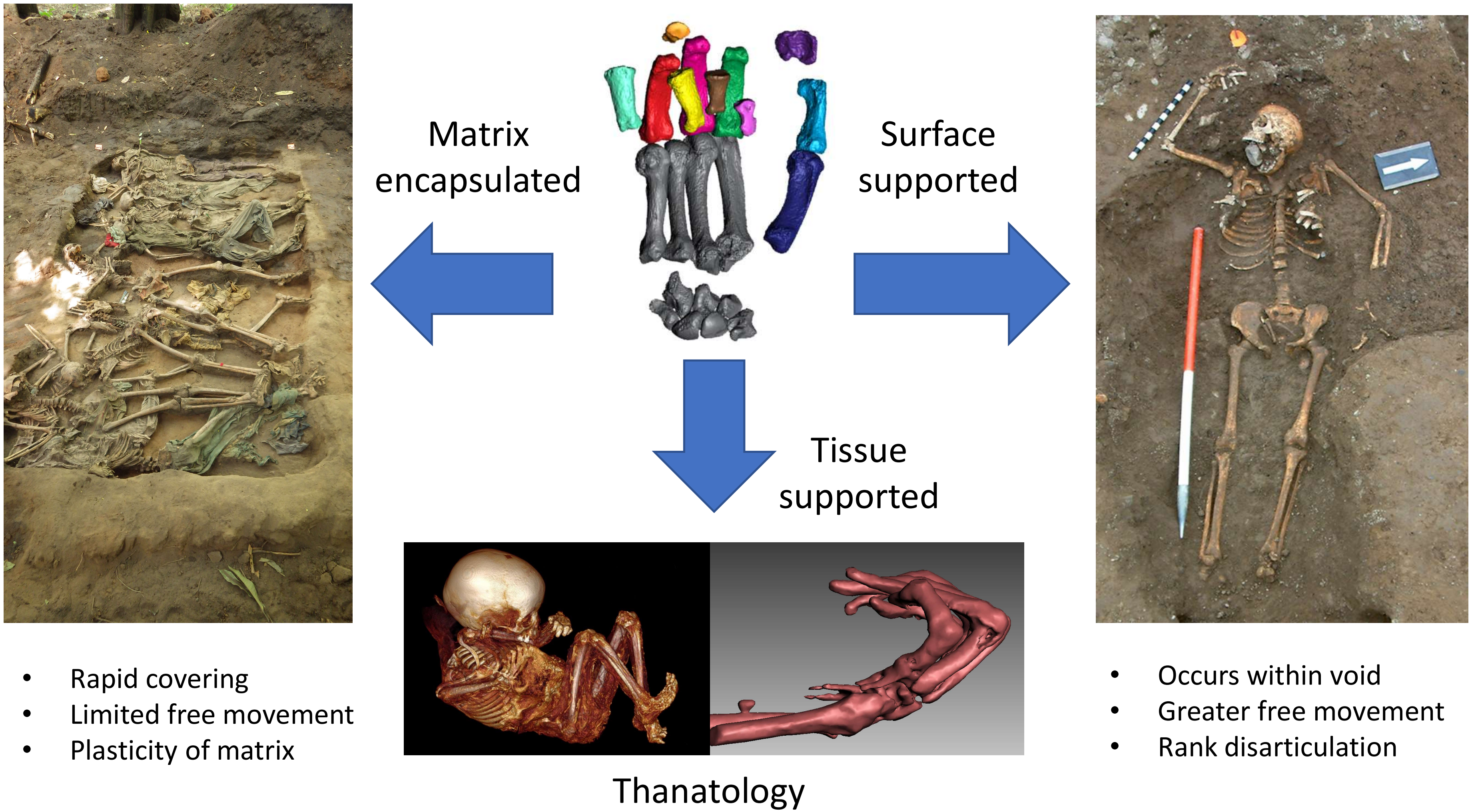

Site and landscape level
Spatial taphonomy
Object level
05/08/2014 01:47
FARO FOCUS
ARTEC EVA
Point cloud
Surface geometry
Kruger, A., Randolph-Quinney, P.S., and Elliott, M. (2016). Multi-modal spatial mapping and visualisation of Dianeldi Chamber and Rising Star Cave. *South African Journal of Science* **112** (5/6).

# Validating spatial decomposition: retrofitting of bones back into deposit site-space



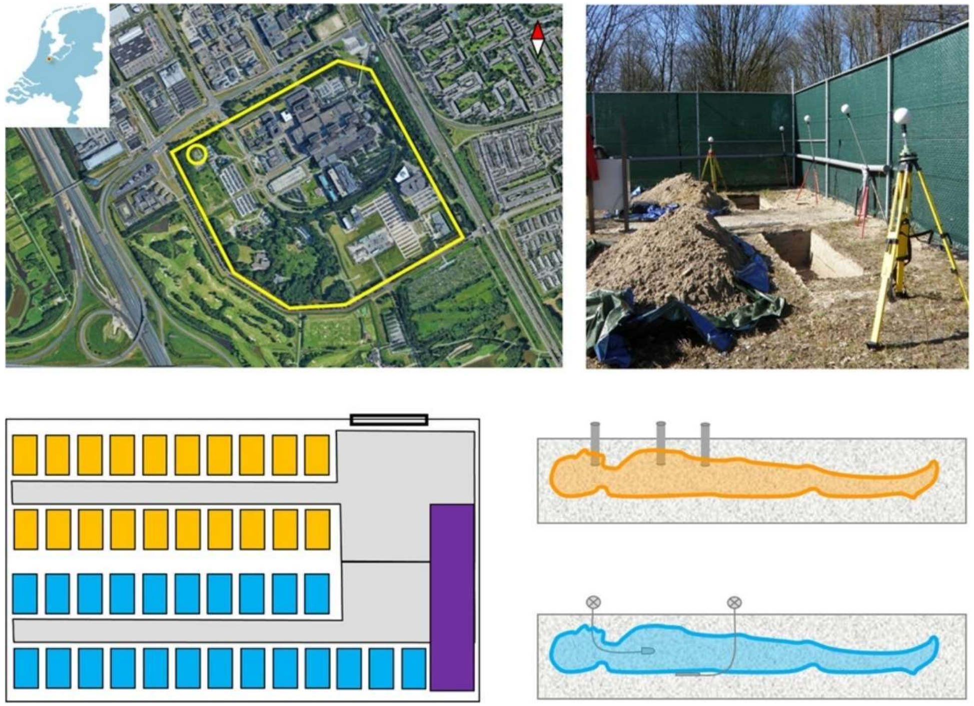
1. Uncover and highlight elements
2. Surface matrix scan with structured light scanner
3. Excavate and recover elements
4. Re-scan isolated elements post-excavation
5. Model construction of each element
6. Register isolated element models back into matrix position

Kruger, A. and Randolph-Quinney (in prep). *3D taphonomic modelling of differential decomposition signatures: a robust methodology for retrofitting of bones back into deposit site-space.*

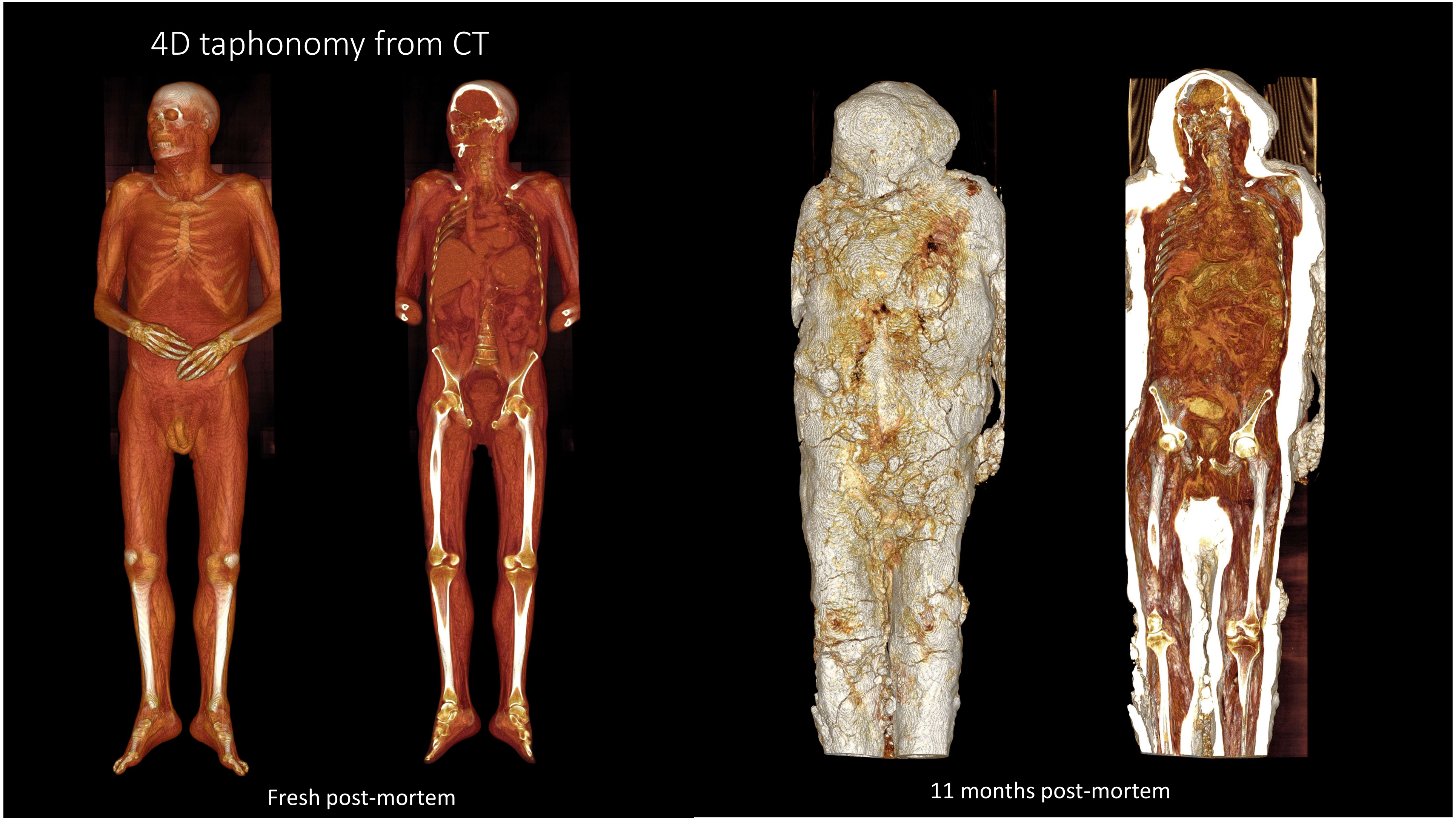

Matrix
encapsulated
Surface
supported
Tissue
supported
Rapid covering
Limited free movement
Plasticity of matrix
Thanatology
Occurs within void
Greater free movement
Rank disarticulation

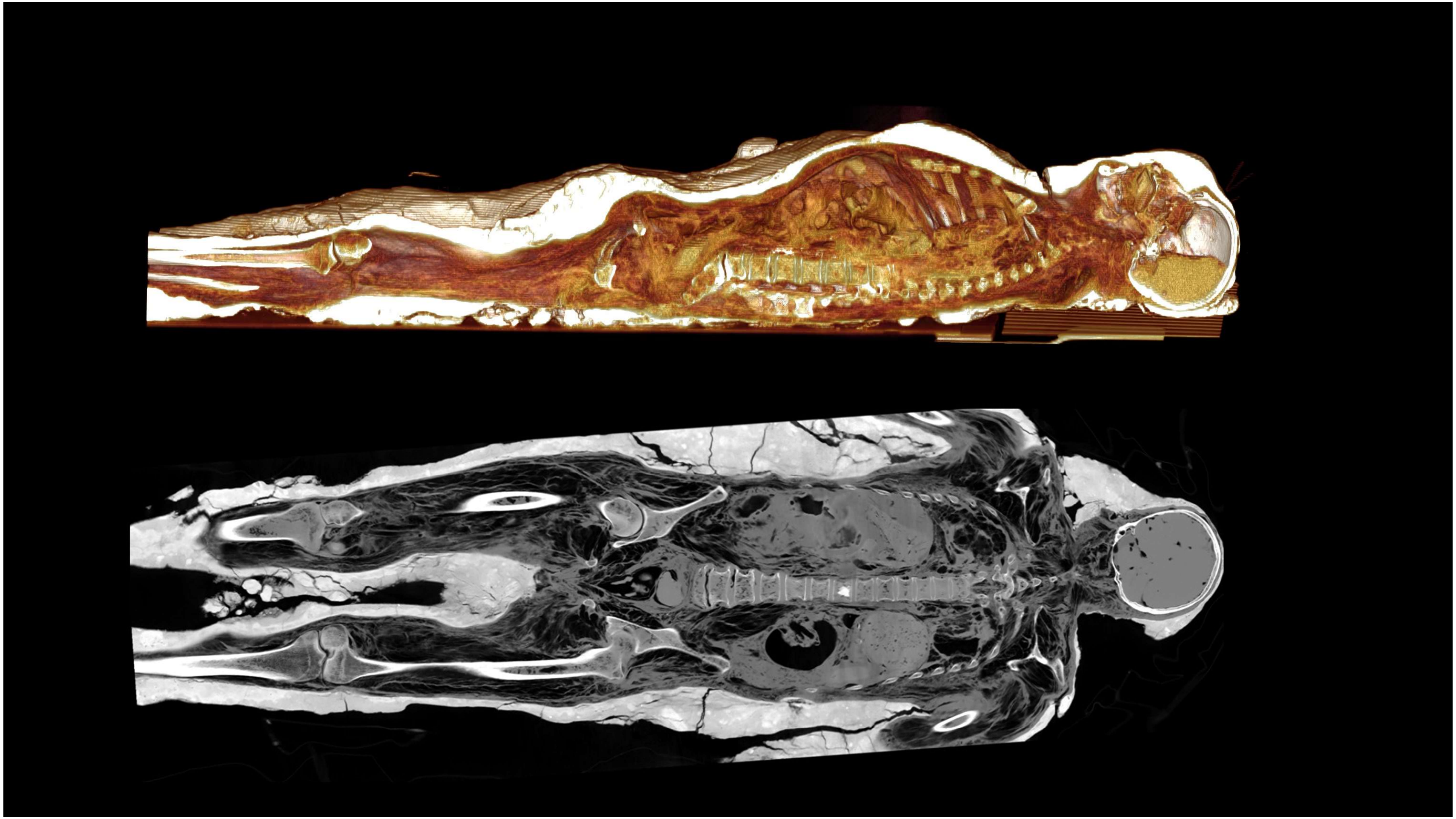
# UNDER Project at ARISTA

- Amsterdam University Medical Centre
- Coventry University – Chris Hiley
- Huddersfield University
- Keele University
- Linnaeus University
- Netherlands Forensic Institute
- Northumbria University
- Saxion University The Netherlands
- Staffordshire University
- University College London
- University of Central Lancashire
- University of Leicester
- University of Lincoln
- University of Portsmouth
- University of Salzburg
- Université du Quebec à Trois Rivières
- Vrije Universiteit Amsterdam
- Wolverhampton University



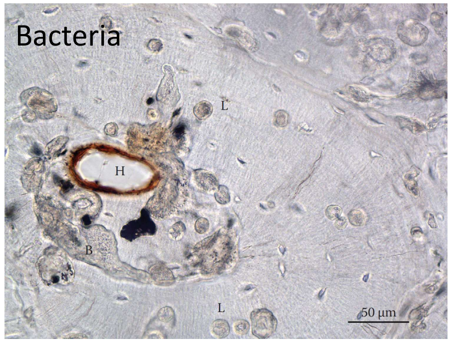
Oostra, R.-J *et al.* (2020). Amsterdam Research Initiative for Sub-surface Taphonomy and Anthropology (ARISTA) - A taphonomic research facility in the Netherlands for the study of human remains. *Forensic Science International, 317, 110483.*

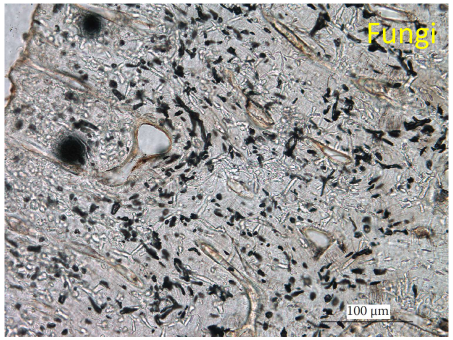

4D taphonomy from CT
Fresh post-mortem
11 months post-mortem



# Skeletal decomposition proteomics

- Bone components (collagen and mineral) initially offer each other mutual protection from degradation = preservation potential.
- Components are eventually affected by diagenetic processes.
- *Diagenesis* in bone = post-mortem alterations in physical, chemical, and microstructural composition of bone following deposition.



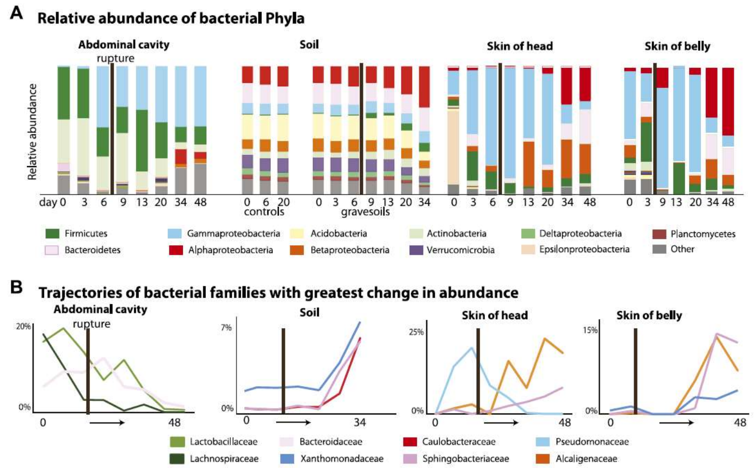




Source: Pokines and Symes (2014). *Manual of Forensic Taphonomy.* CRC Press.

eLIFE elife.elifesciences.org RESEARCH ARTICLE

**A microbial clock provides an accurate estimate of the postmortem interval in a mouse model system**

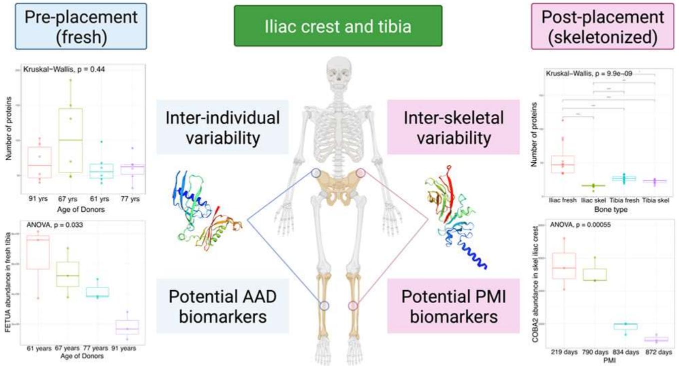
Jessica L Metcalf[1*], Laura Wegener Parfrey[1†], Antonio Gonzalez[1], Christian L Lauber[2], Dan Knights[3,4], Gail Ackermann[1], Gregory C Humphrey[1], Matthew J Gebert[1], Will Van Treuren[1], Donna Berg-Lyons[1], Kyle Keepers[1], Yan Guo[5], James Bullard[6], Noah Fierer[2,7], David O Carter[8], Rob Knight[1,9,10,11*]



# The "ForensOMICS" Project (UKRI FLF)

- Applying "omics" technologies (e.g., genomics, proteomics, metabolomics and lipidomics) to human bone samples to reveal forensically relevant information:
  - Age at death (AAD)
  - Post-mortem interval (PMI)
- Aim: developing objective mathematical methods to estimate PMI and AAD from skeletonised remains with high precision, accuracy and calculable error rates.
- Currently human bones from 120 donors at three HTFs (Tennessee University, Texas State University and Sam Houston State University) with PMI 0-35 years and AAD 18-107 years have been sampled.

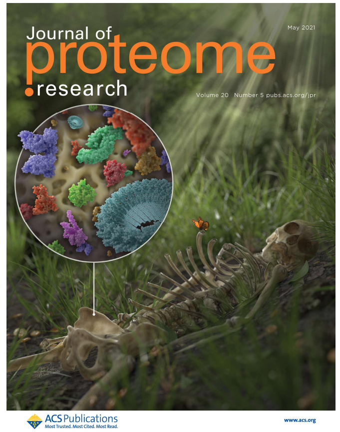
Human Bone Proteomes before and after Decomposition: Investigating the Effects of Biological Variation and Taphonomic Alteration on Bone Protein Profiles and the Implications for Forensic Proteomics. *J. Proteome Res.* 2021, 20, 5, 2533–2546




@ForensOMICS

# The Texas Mass Grave Project

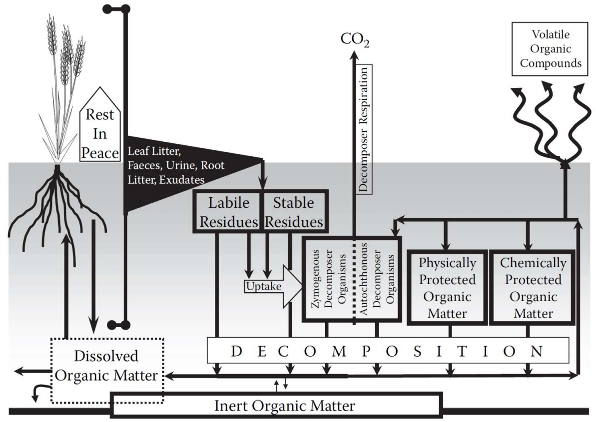
- The Mass Grave Project, led by Hayley Mickleburgh, aims at conducting multi-disciplinary research on an experimental mass grave composed of 6 donated individuals at Texas State HTF (FACTS).
- The ForensOMICS team is involved in the analysis of the microbiome that has been collected prior to burial of the individuals (both from the corpses and from the soil), during the decomposition (soil microbiome collected regularly) and after the recovery (corpse and soil microbiome).




Mickleburgh, H. L., & Wescott, D. J. (2018). Controlled experimental observations on joint disarticulation and bone displacement of a human body in an open pit: Implications for funerary archaeology. *Journal of Archaeological Science: Reports, 20, 158-167.*

# Natural Burials Project

- Research aims to understand the ecological benefits associated with natural decomposition of human cadavers in soil.
- Investigate the extent to which cadaver decomposition alters soil ecological processes and identify whether this shift forms a unique and stable microbial community composition.
- Systems-based approach to understand human burial as a soil ecological process:
  - Microbiology (bacteria, viruses, fungi)
  - Soil micro-morphology and ecology
  - Carbon turnover and sequestration
  - Soluble leachate chemistry
  - Persistence and environmental transfer
  - Anthropogenic effects
- Cranfield: Mark Pawlett, Nick Marquez-Grant
- Northumbria: Patrick Randolph-Quinney, Noemi Procopio, David Pearce
- Newcastle: Lisa Marie Shilito
- Quebec: Shari Forbes




Northumbria University NEWCASTLE

Cranfield Environment and Agrifood

Forensic Institute

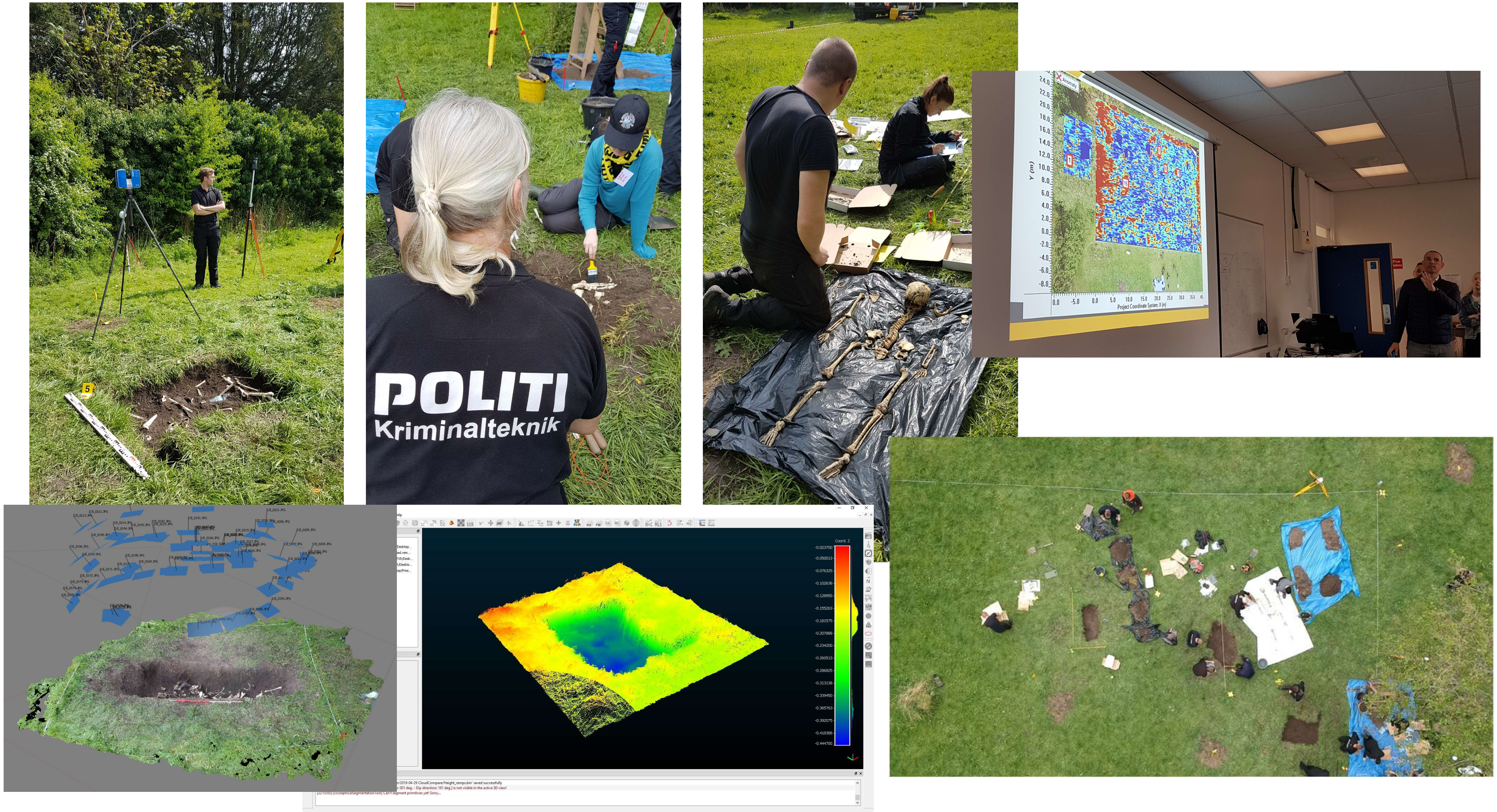
Newcastle University

UQTR Université du Québec à Trois-Rivières

# Training and practice

ENFSI
EUROPEAN NETWORK OF FORENSIC SCIENCE INSTITUTES

EMFA
European Meeting on Forensic Archaeology



POLITI
Kriminalteknik

# Standards development in human forensic taphonomy – Autumn 2022

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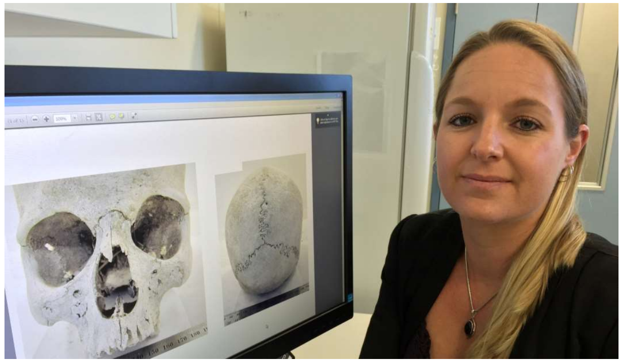
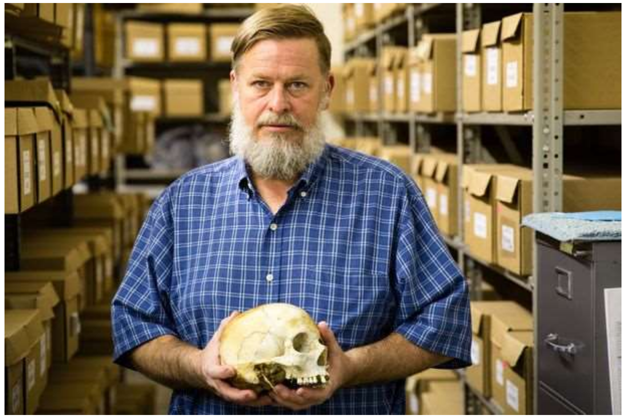
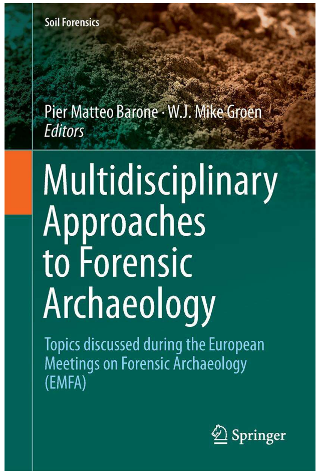
Netherlands Forensic Institute
Ministry of Justice and Security

UQTR
Université du Québec à Trois-Rivières








https://www.springer.com/series/11807

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UNIVERSITY OF AMSTERDAM

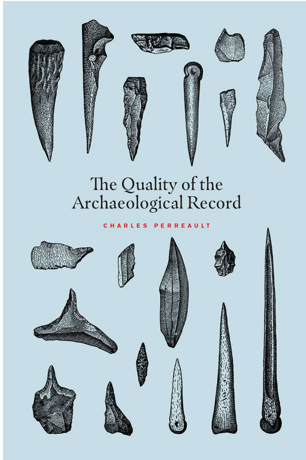
UTS UNIVERSITY OF TECHNOLOGY SYDNEY

TEXAS STATE UNIVERSITY

University of Cape Town · iYunivesithi yaseKapa · Universiteit van Kaapstad

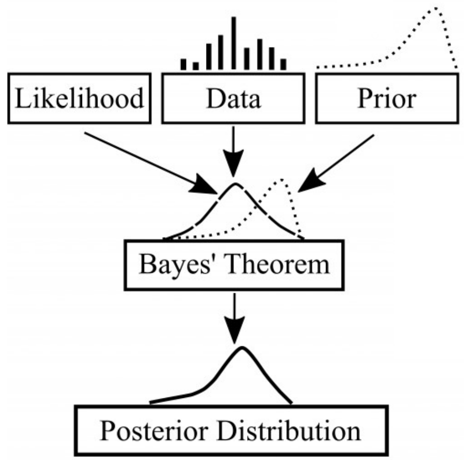
# Validation in forensic taphonomy

- Small sample sizes – anecdata
- Inappropriate analogues
- Lack of robust experimental design
- Lack of controls and/or monitoring (environmental baselines)
- Lack of standardized methodologies, terminology, and analyses
- Historically poor understanding of system complexity (ecological modelling, biodiversity, multi-scalar)




- Equifinality
- Underdetermination

$$\text{likelihood ratio} = \frac{p(D|H_1)}{p(D|H_2)}.$$




$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

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