Affiliation

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Institute for Mummy Studies
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Key-research interests

Ancient DNA analysis of mummified and skeletal human remains, Paleomicrobiology (Pathogens/Commensals), Bacterial/Human population genetics, Molecular reconstruction of ancient human diets

Research sites and research topic

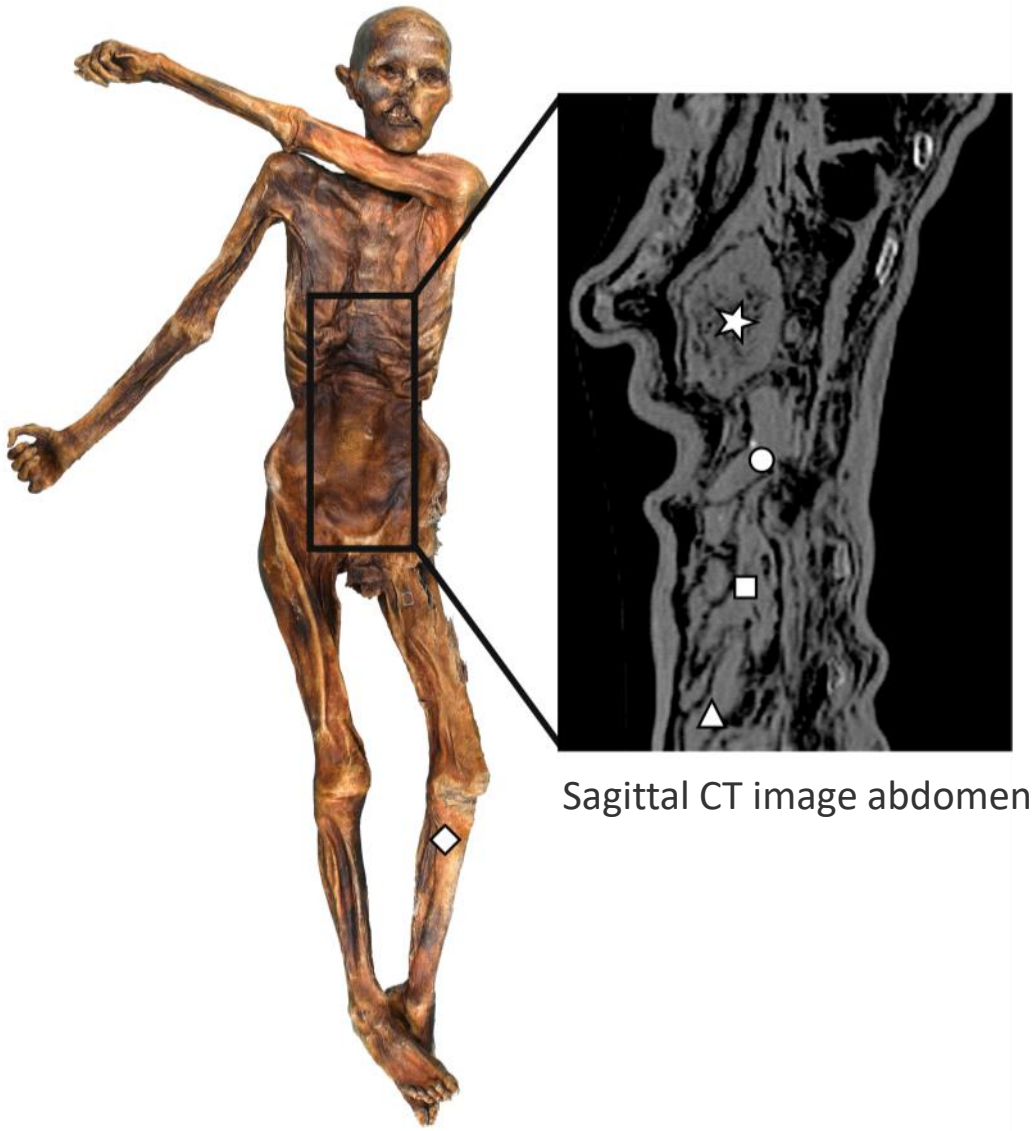
1) Molecular analysis of intestinal contents and of the Iceman (Poster No. and various other mummies (e.g. Egyptian, South American mummies)
2) Molecular analysis of human coprolites from the Hallstatt salt mine (in cooperation with Klaus Oeggl, Alexander Schoenaffinger and Hans Reschreiter) and from a Mexican cave (in cooperation with Karl Reinhard)

Samples are subjected to next generation shotgun sequencing and innovative bioinformatics tools aiming to reconstruct ancient meals and gut microbiome composition (in cooperation with Nicola Segata)

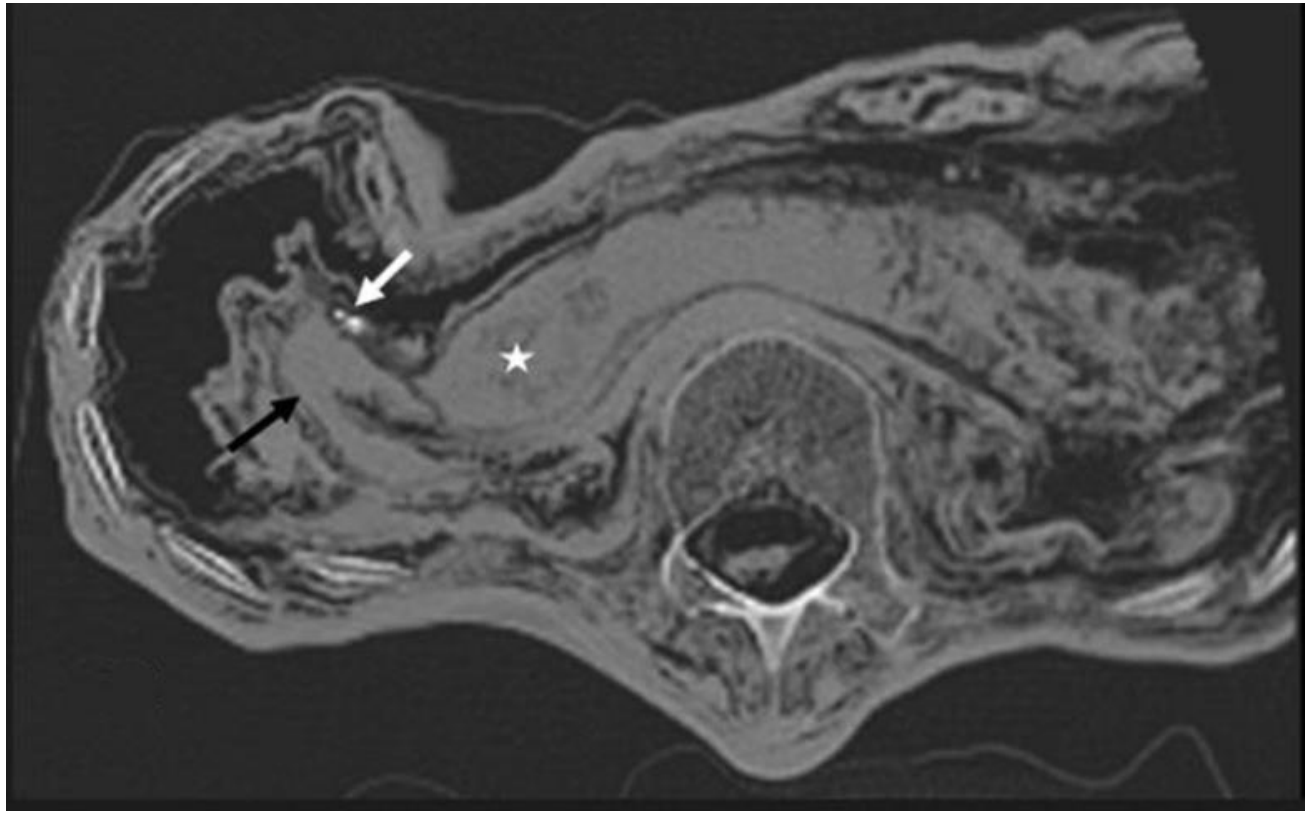
Motivation /potential input to the workshop

Research area of interest; time period of interest; interdisciplinary approach (Euregio); molecular analysis of ancient human remains can provide additional important information in the growing field of bioarchaeology

The Iceman
Radiological Re-evaluation: the stomach is completely filled



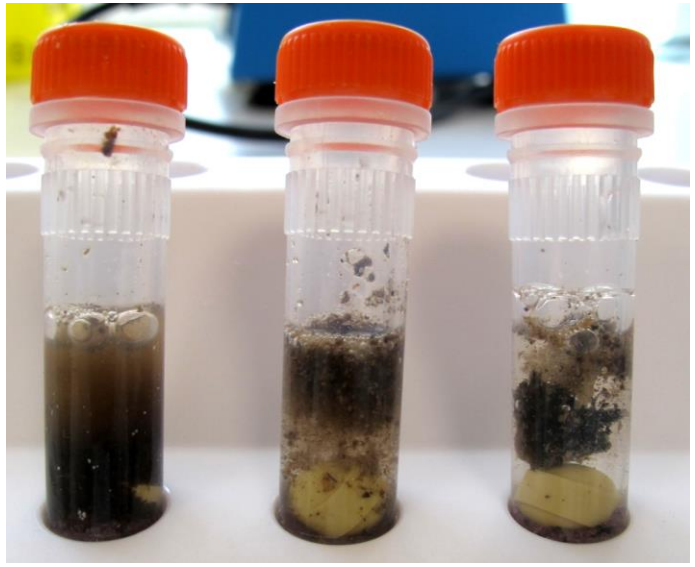
Sagittal CT image abdomen



Axial CT image abdomen

Paul Gostner, J. of Archaeological Science 38, 2011

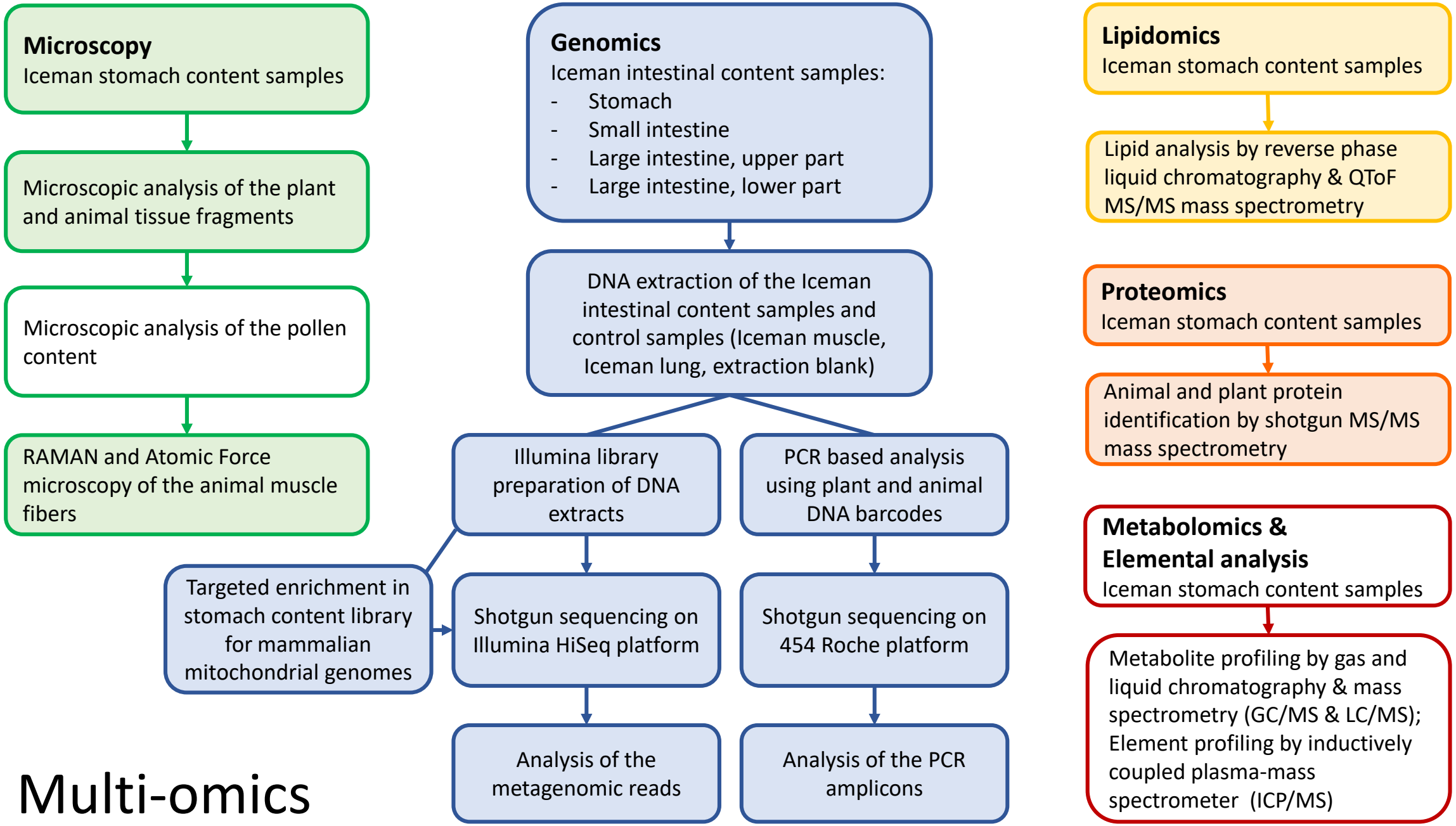
Sampling Iceman´s stomach (November, 2010)



Colon Duodenum Stomach

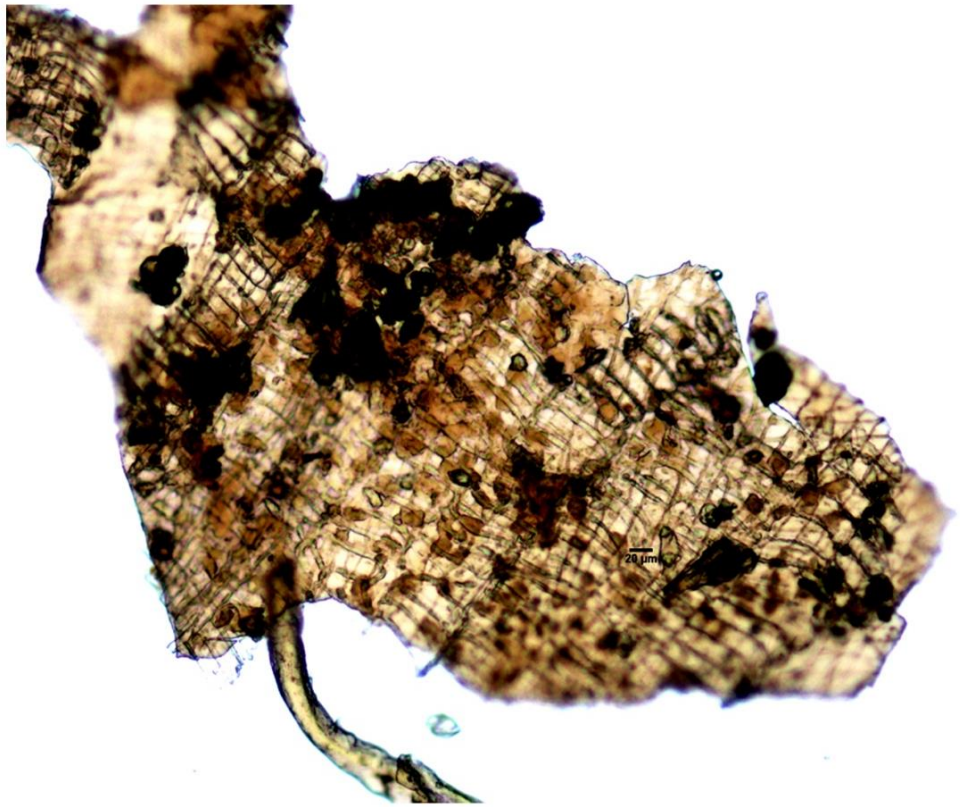
- Dietary reconstruction

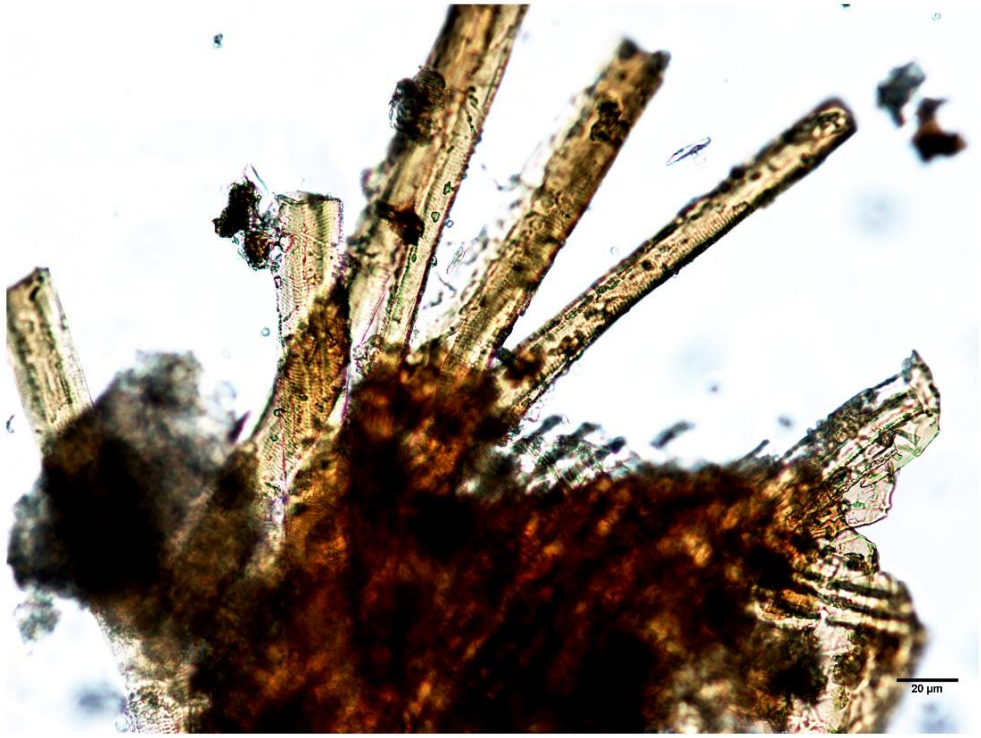
Maixner *et al.*, 2018


Microscopy
Iceman stomach content samples
Microscopic analysis of the plant and animal tissue fragments
Microscopic analysis of the pollen content
RAMAN and Atomic Force microscopy of the animal muscle fibers
Genomics
Iceman intestinal content samples:
- Stomach
- Small intestine
- Large intestine, upper part
- Large intestine, lower part
DNA extraction of the Iceman intestinal content samples and control samples (Iceman muscle, Iceman lung, extraction blank)
Illumina library preparation of DNA extracts
PCR based analysis using plant and animal DNA barcodes
Targeted enrichment in stomach content library for mammalian mitochondrial genomes
Shotgun sequencing on Illumina HiSeq platform
Shotgun sequencing on 454 Roche platform
Analysis of the metagenomic reads
Analysis of the PCR amplicons
Lipidomics
Iceman stomach content samples
Lipid analysis by reverse phase liquid chromatography & QToF MS/MS mass spectrometry
Proteomics
Iceman stomach content samples
Animal and plant protein identification by shotgun MS/MS mass spectrometry
Metabolomics & Elemental analysis
Iceman stomach content samples
Metabolite profiling by gas and liquid chromatography & mass spectrometry (GC/MS & LC/MS); Element profiling by inductively coupled plasma-mass spectrometer (ICP/MS)

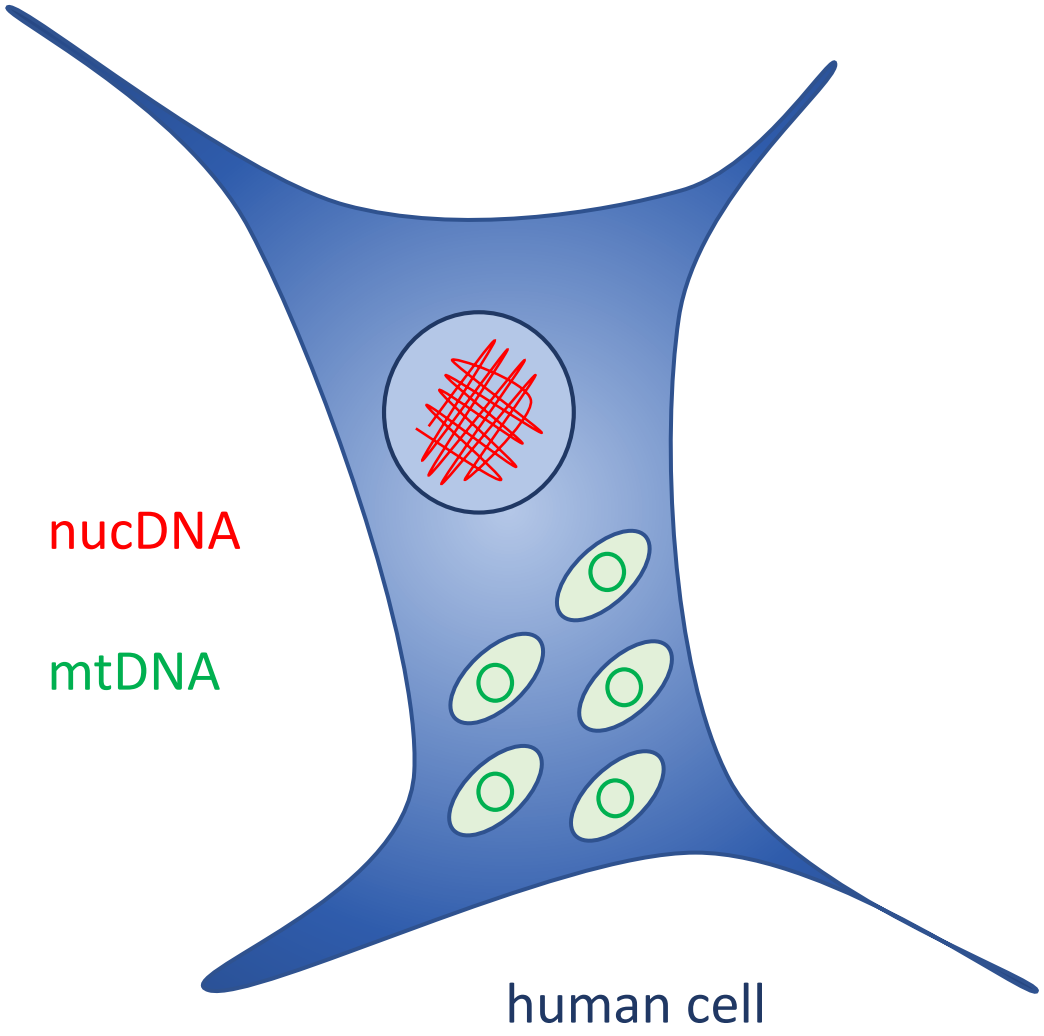
Multi-omics

Microscopy: Omnivorous diet



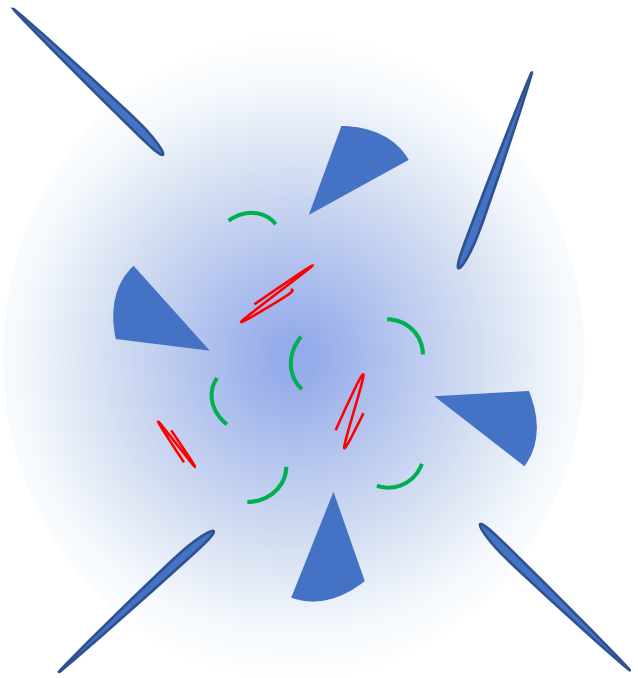


Ancient DNA: highly fragmented



Cell lysis
post mortem

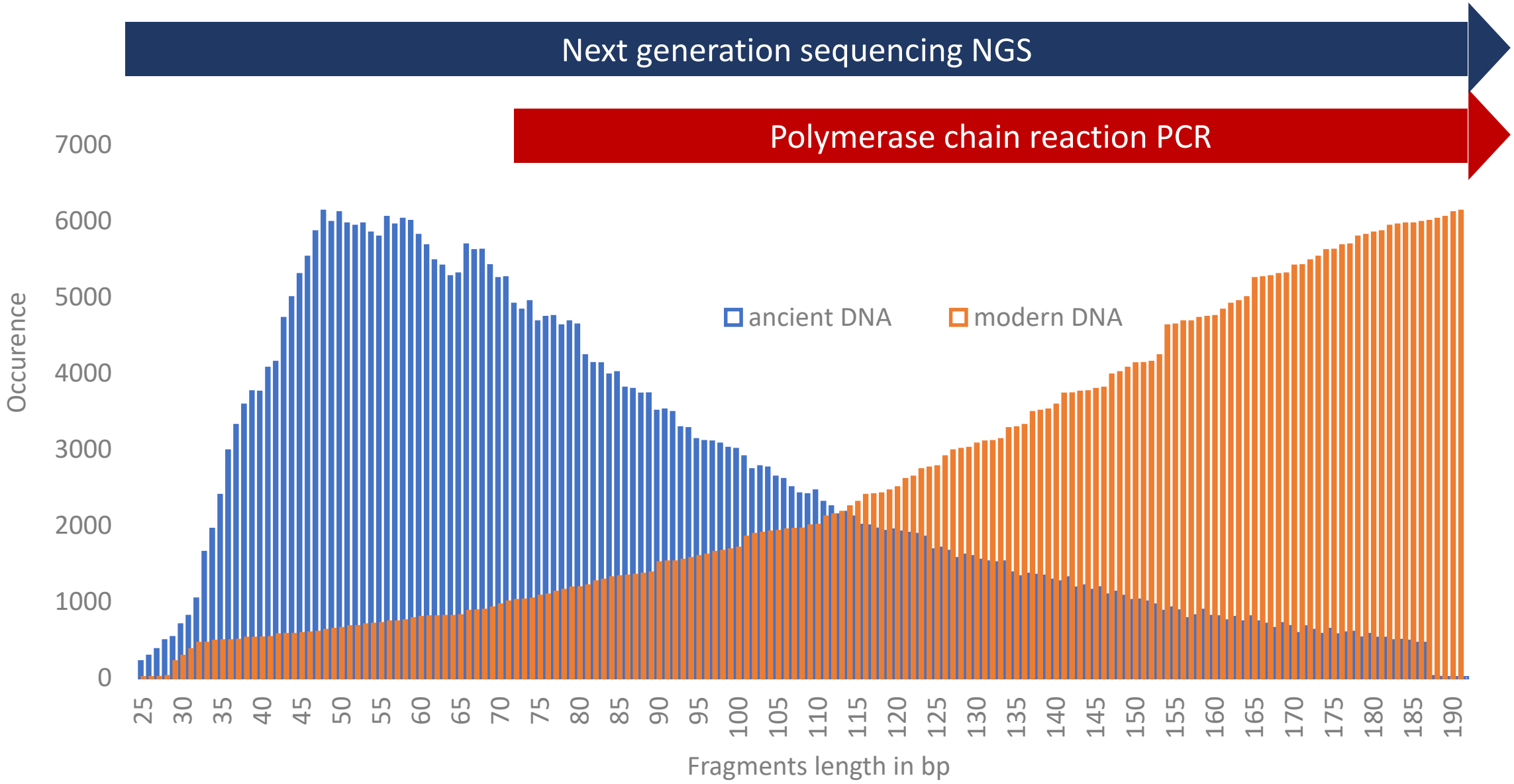
microorganisms
temperature
humidity
pH



- Highly fragmented biomolecules (DNA, proteins, lipids)
- Still detectable after 700.000 years

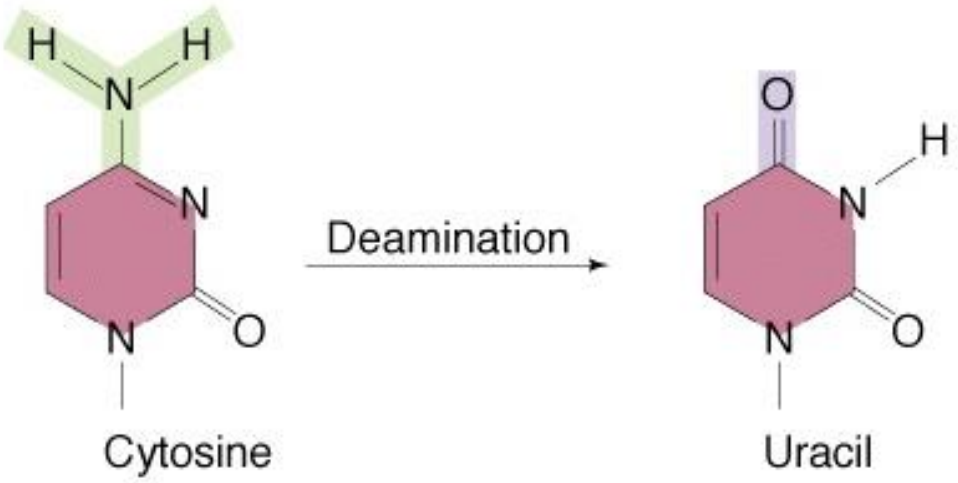
Orlando *et al.* 2013

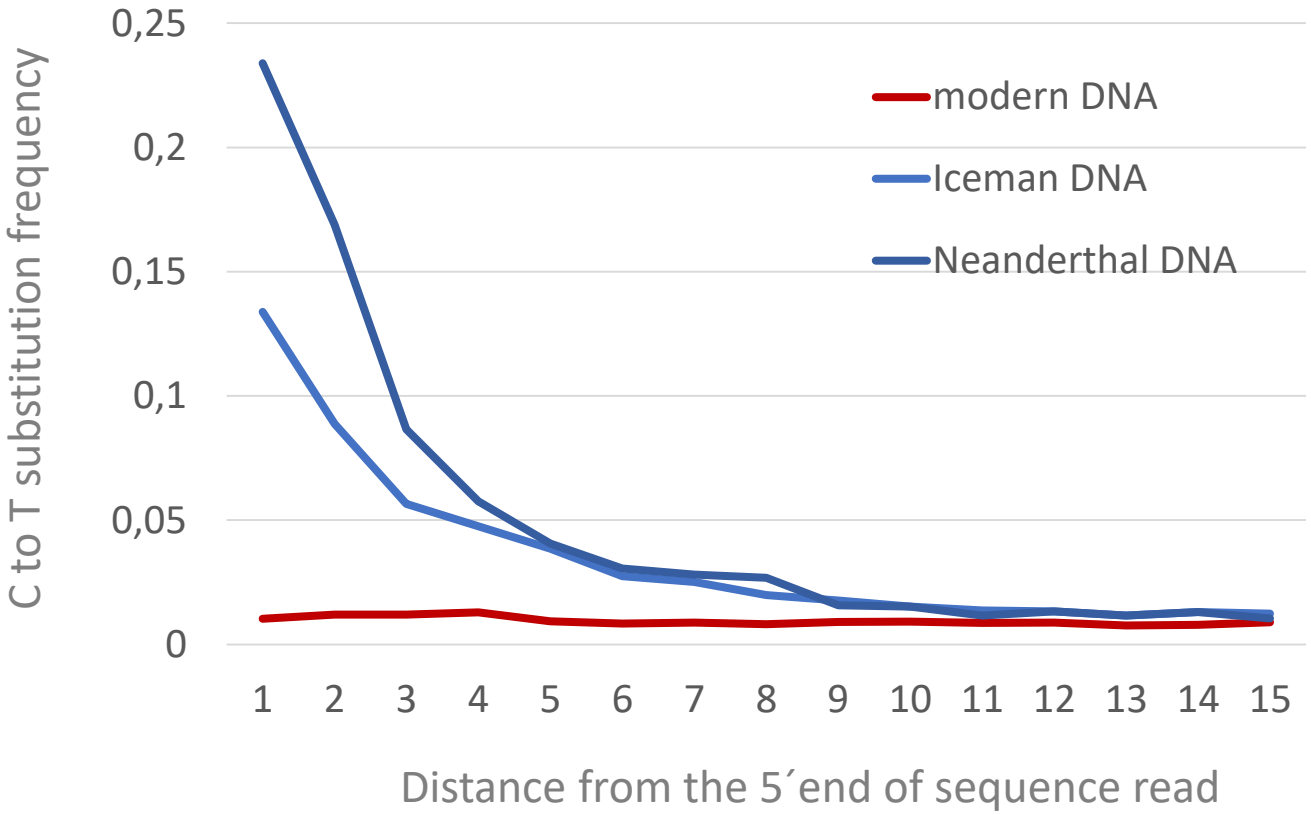
Ancient DNA: highly fragmented



Ancient DNA: damage patterns

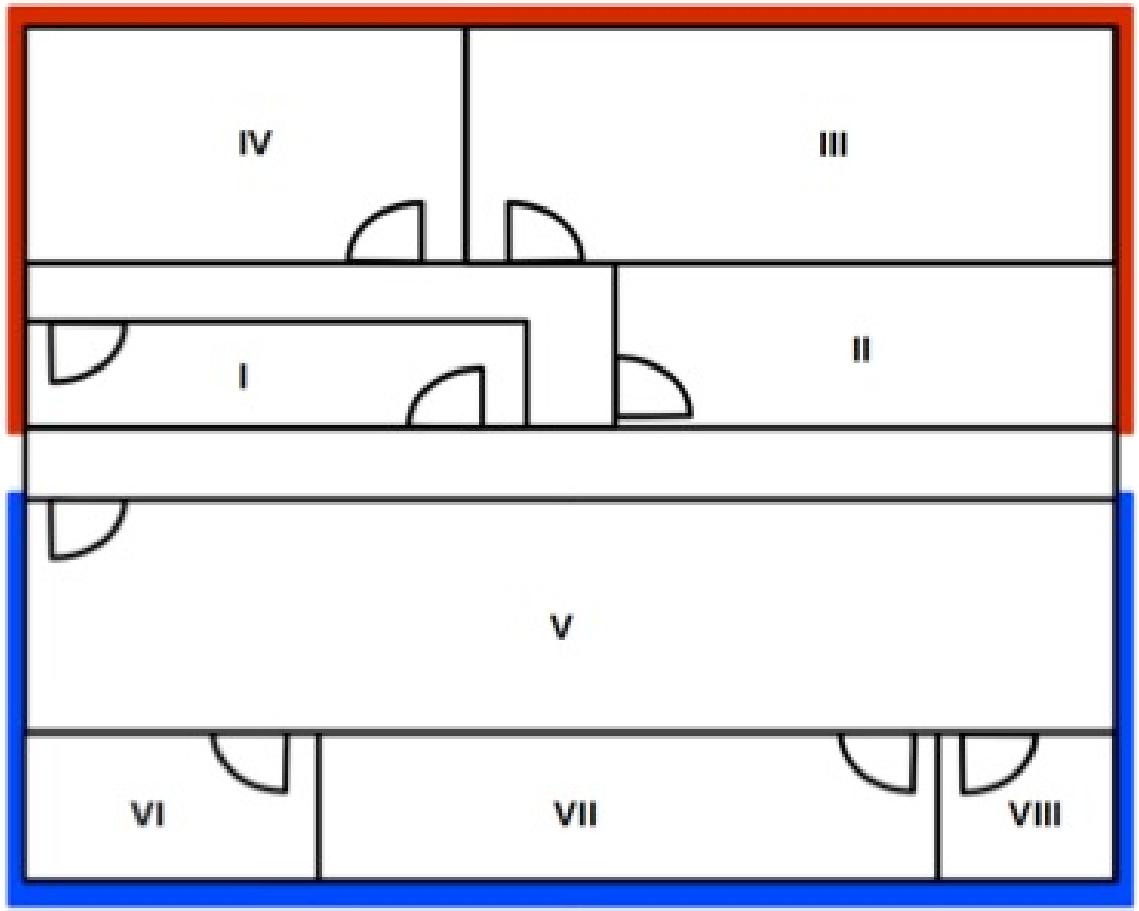
5´ CGTCATTGACCCTAGCTAGGCCAACGAA 3´
5´ TAACTGGGATCGATCCGGTTGCTTAGTCG 3´





Possibility to distinguish between ancient and modern DNA

2019: New ancient DNA laboratory

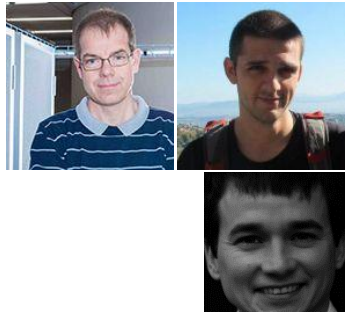


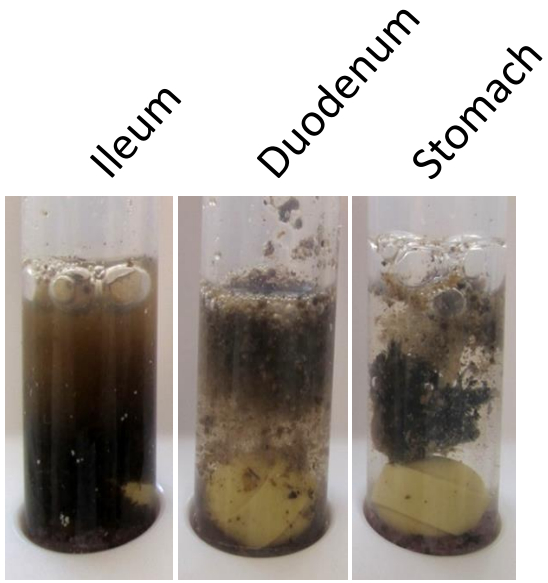
Pre-PCR

Post-PCR

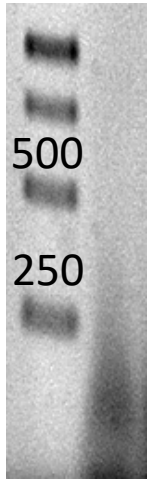
Institute for Mummy Studies, EURAC

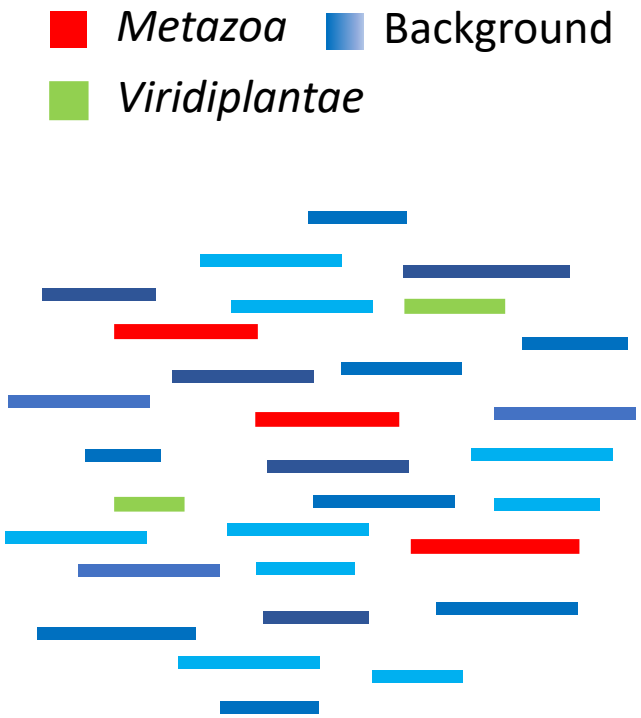
DNA-based analysis of the Iceman stomach content

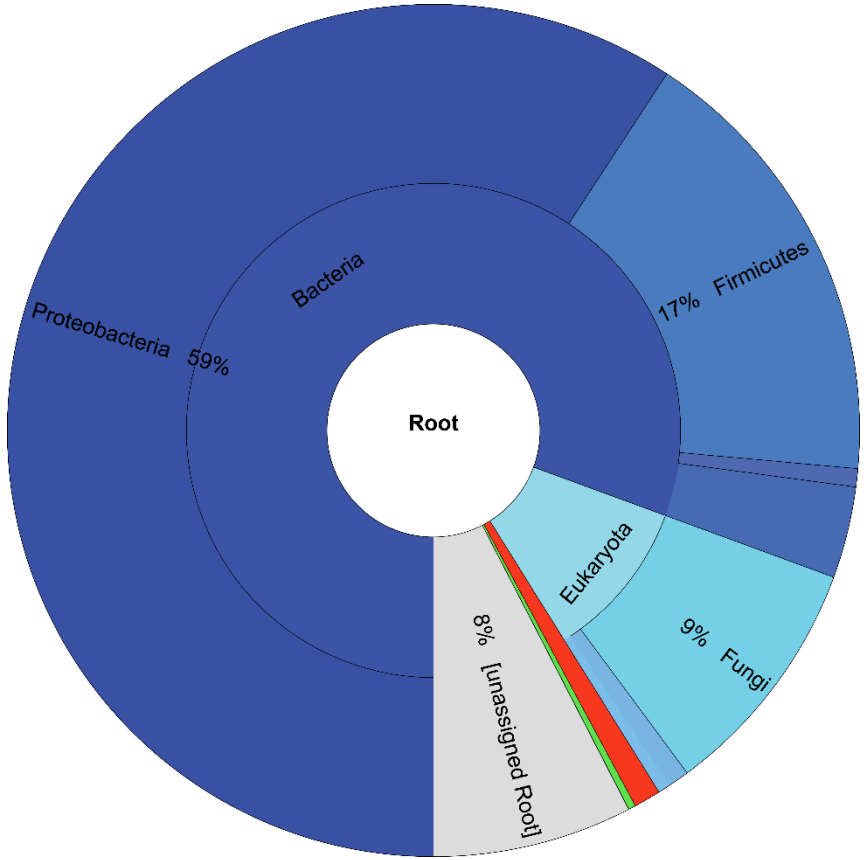




+ muscle tissue,
extraction blank





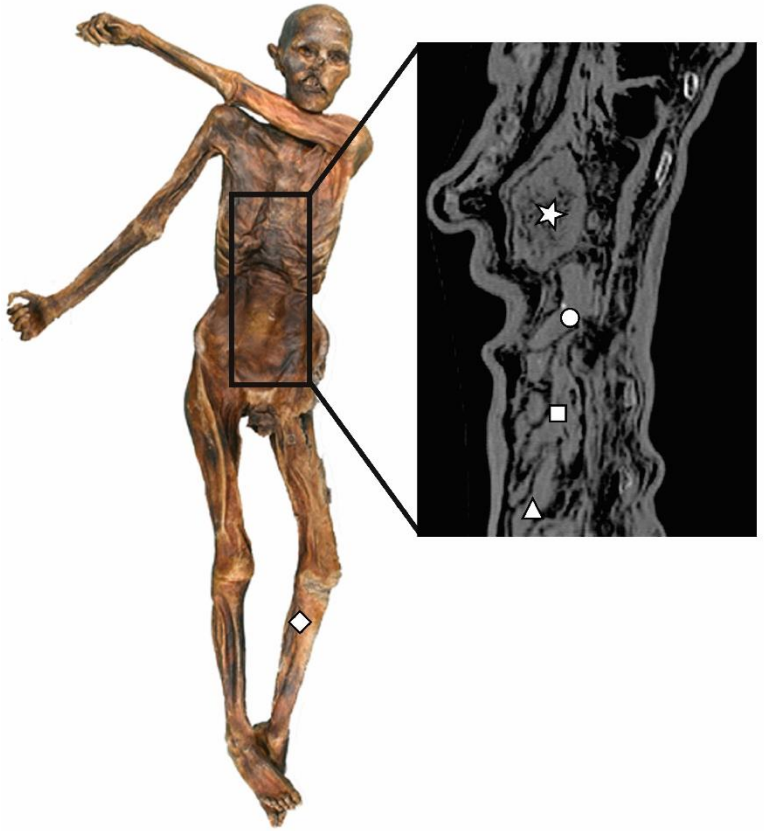


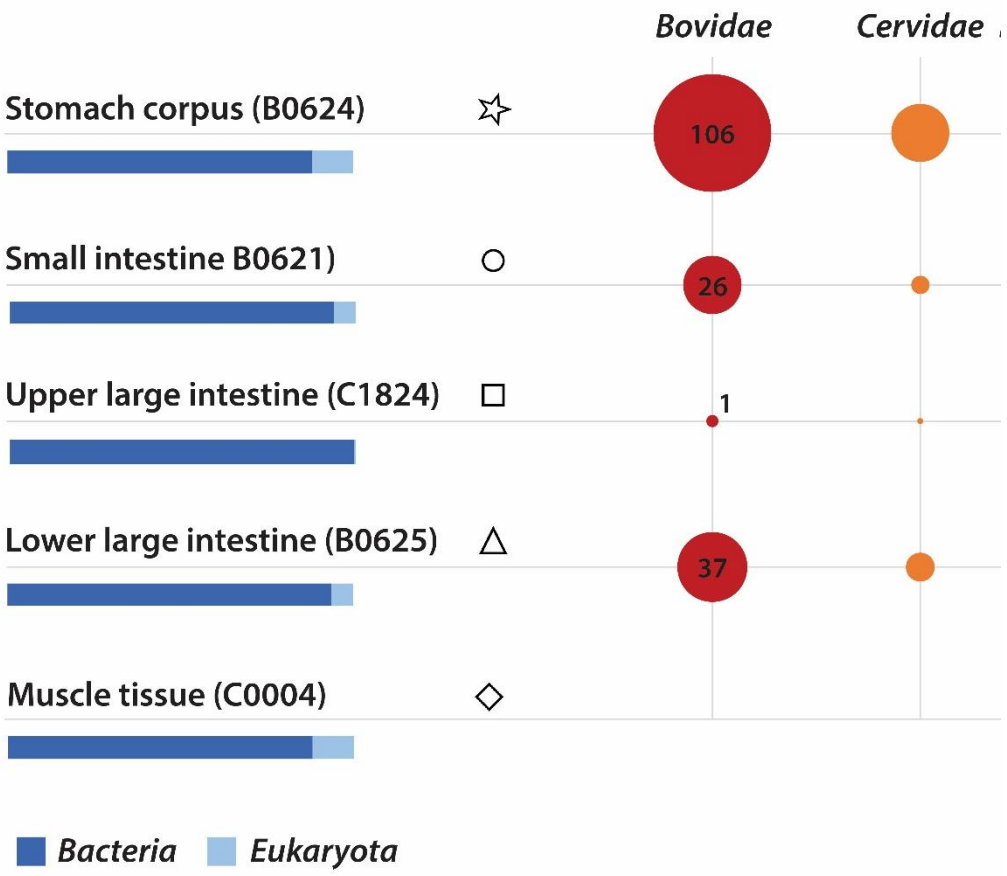
NCBI nr, RAPsearch2

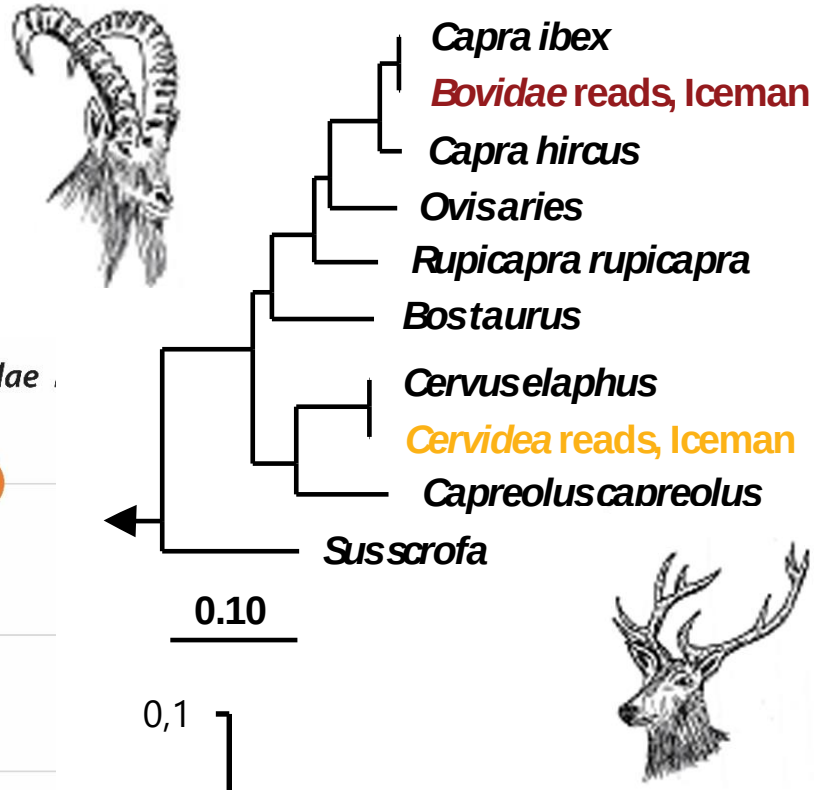
The *Metazoa* and *Virdiplantae* reads, important for the dietary reconstruction, comprise only 0.7% to 0.2% of all reads

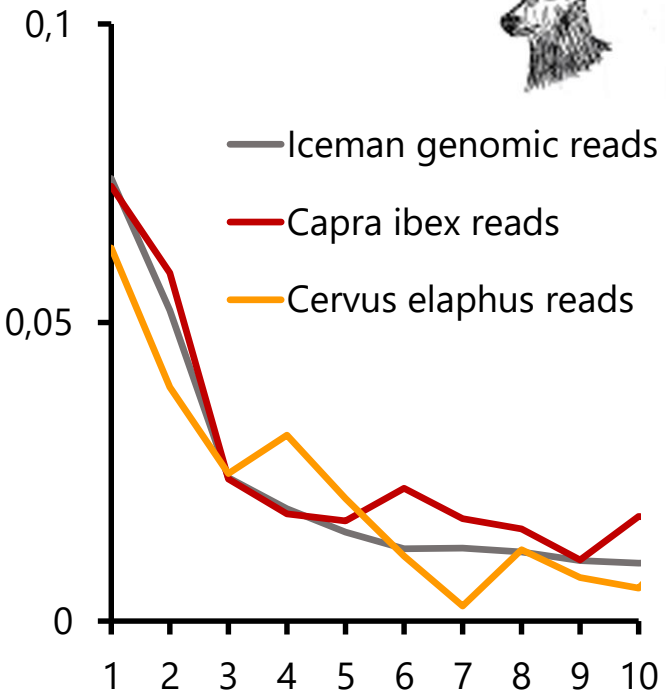
DNA-based analysis – Animal diet

Mitochondrial genomes, NCBI nt, bwa, blastn, LCA





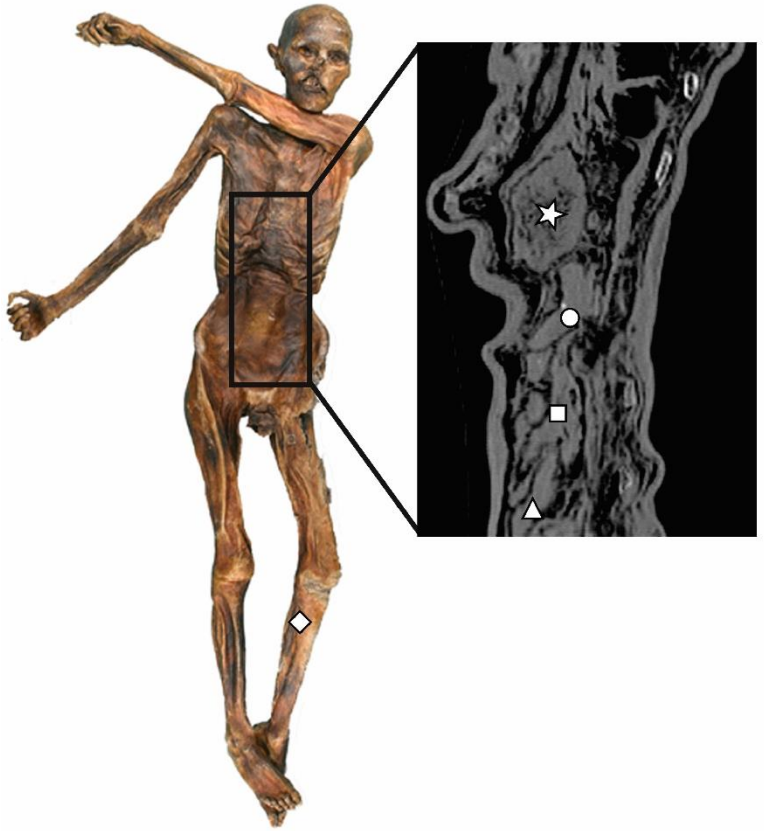


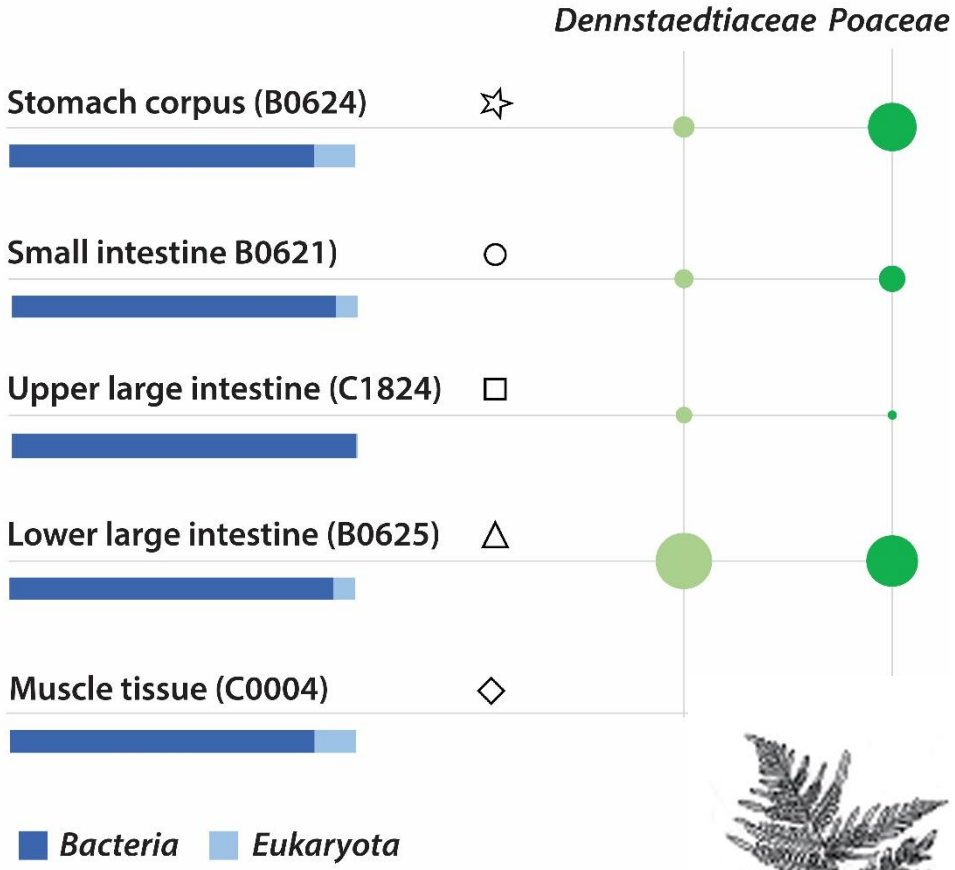


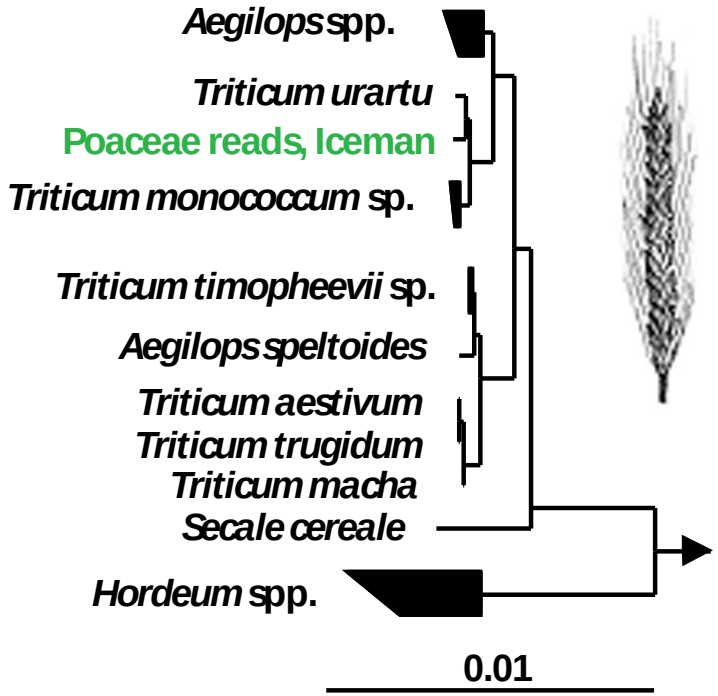
Trinity College Dublin: Independent replication

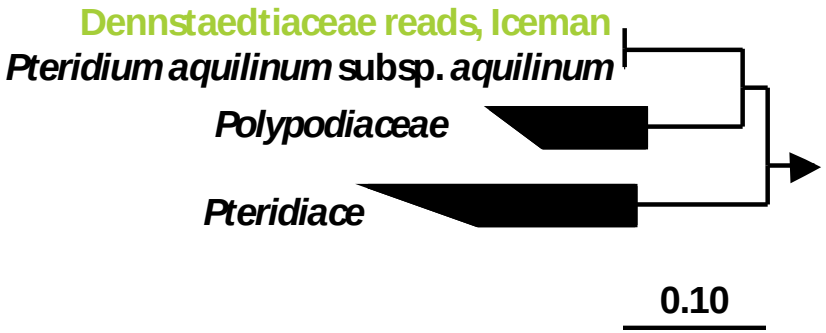
DNA-based analysis – Plant diet

Chloroplast genomes, NCBI nt, bwa, blastn, LCA

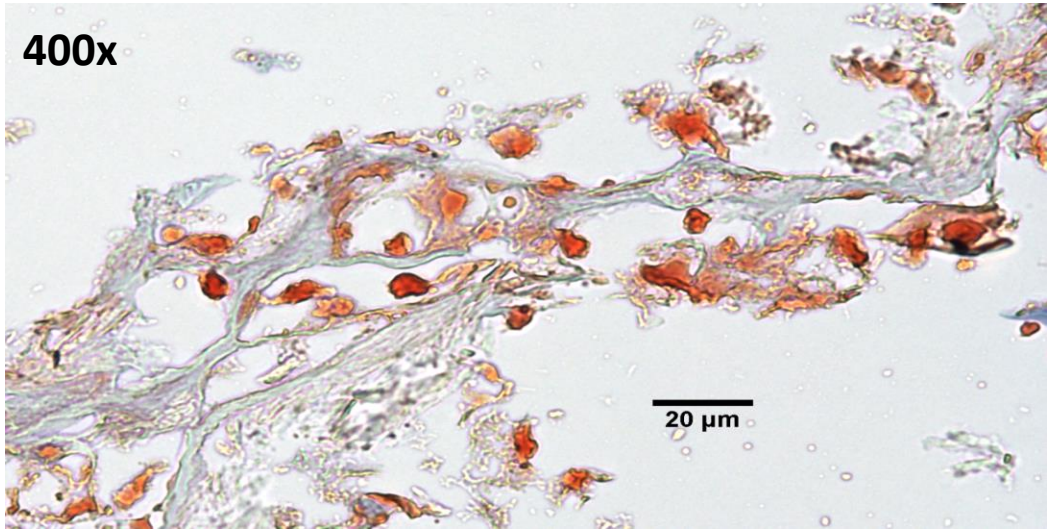


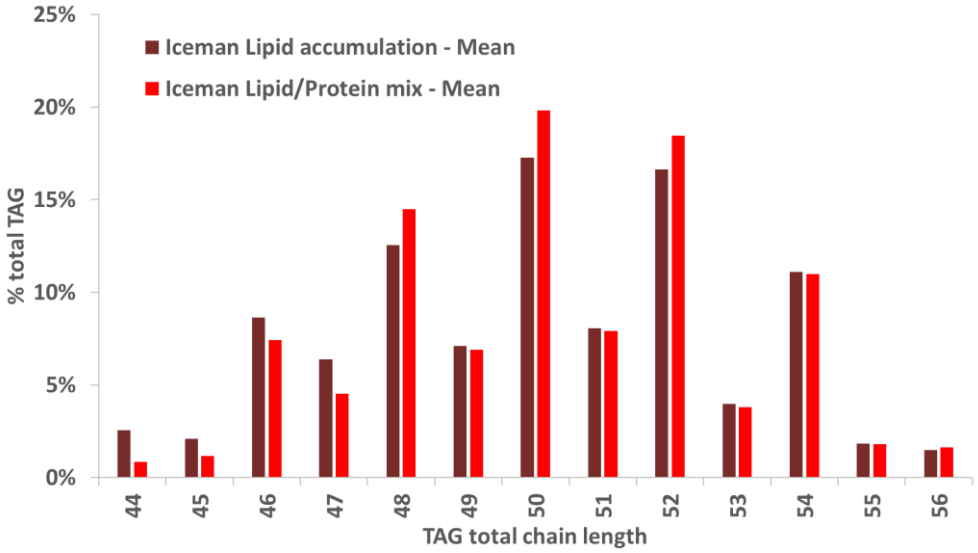


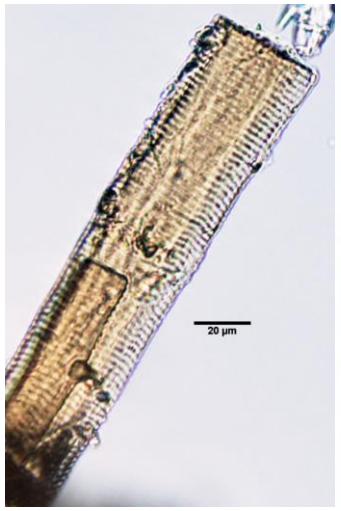


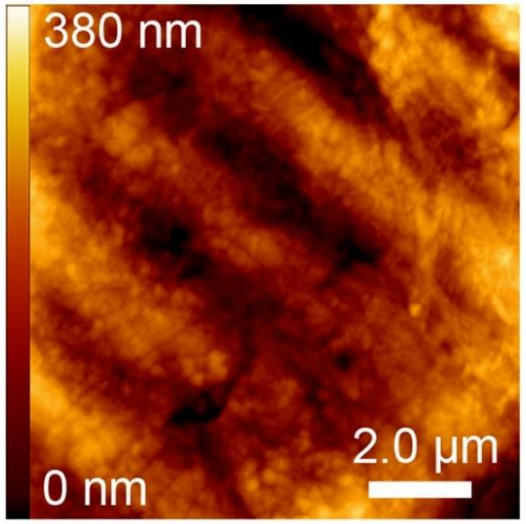


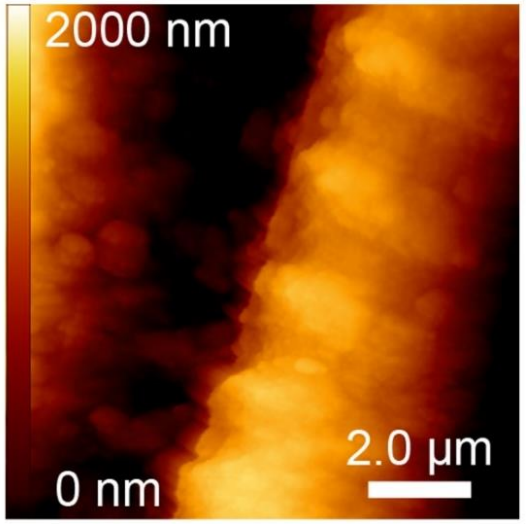
Animal or plant fat? Meat preparation? Poster 1595

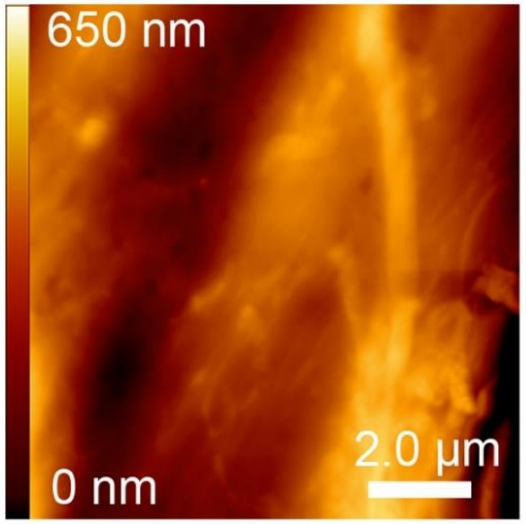


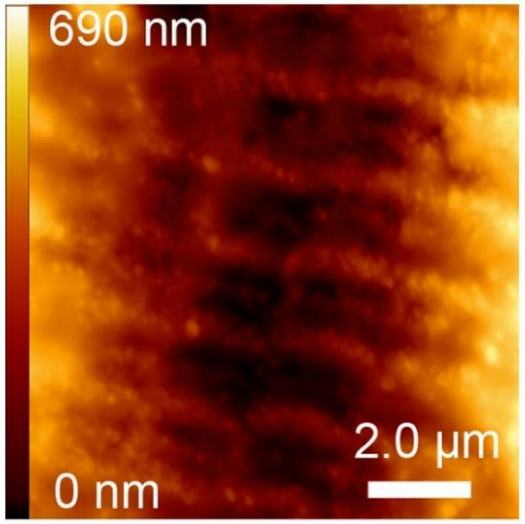












Stomach content

modern, raw

modern, fried

modern, air dried

Thank you!

eurac research

Institute for Mummy Studies

CIBIO

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universität innsbruck

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AUTONOME PROVINZ BOZEN SÜDTIROL
PROVINCIA AUTONOMA DI BOLZANO ALTO ADIGE

Thank you!

Albert Zink

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Niall O´Sullivan

Alice Paladin

Christina Wurst

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