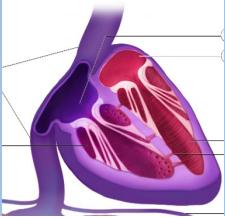


SunoikisisDC Spring 2022
Digital Approaches to Cultural Heritage, session 5

3D Modelling and Reconstruction

Orly Lewis, Hebrew University of Jerusalem
Tosca Lynch, Oxford University
Gabriel Bodard, University of London



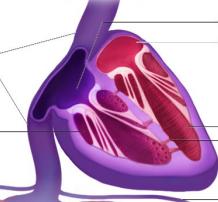
Session 5

3D modelling and reconstruction

3D Modelling “from scratch”

Introduction

Dr. Orly Lewis



What makes a 3D model scholarship?

- It is a visual interpretation of sources
(Textual, material, a combination)
- Modelling as a research process
- Modelling as a research output (others will use it !)

What makes a 3D model scholarship?

Accompanying information

- Commentary (explaining the model)
- Transparency of interpretive and production
 - Interpretive decisions and their sources
 - Software and modelling tools
 - References and sources (for different parts of the model)
- Enabling discussion, criticism, recreation, improvements

Challenges

- Practical (*how do we model?*)
- Scholarly (*how do we create a reliable and useful model?*)
- Dissemination (*how do we publish it as scholarship?*)



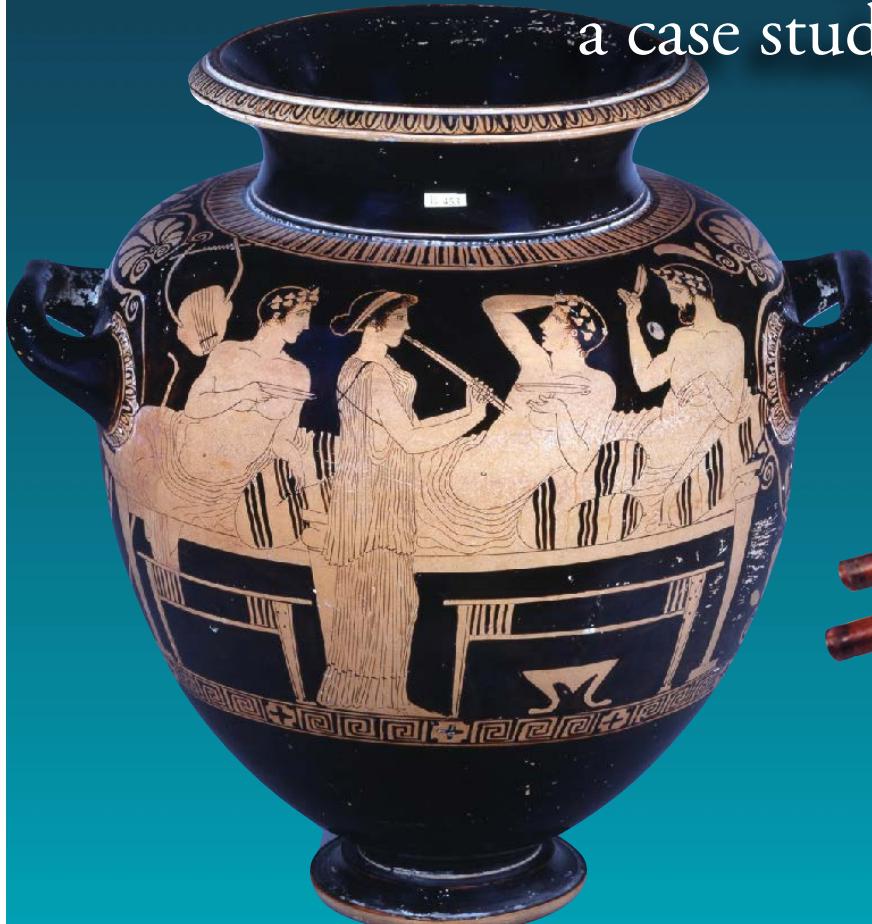
ICS London, Sunoikisis Digital Approaches to Cultural Heritage



UNIVERSITY OF
OXFORD

3D modelling and reconstruction as research processes: the Louvre aulos, a case study in Ancient Greek *Music*

Dr Tosca A.C. Lynch



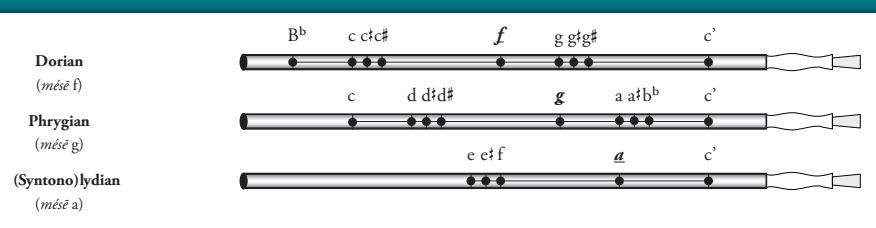
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-NoDerivatives 4.0 International License.



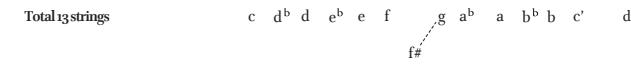
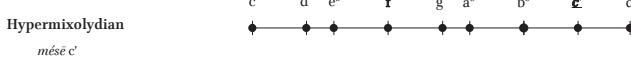
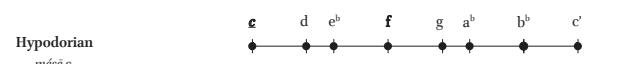
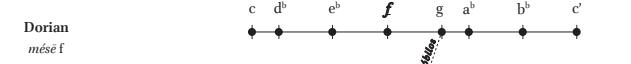
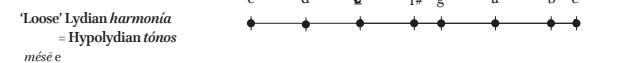
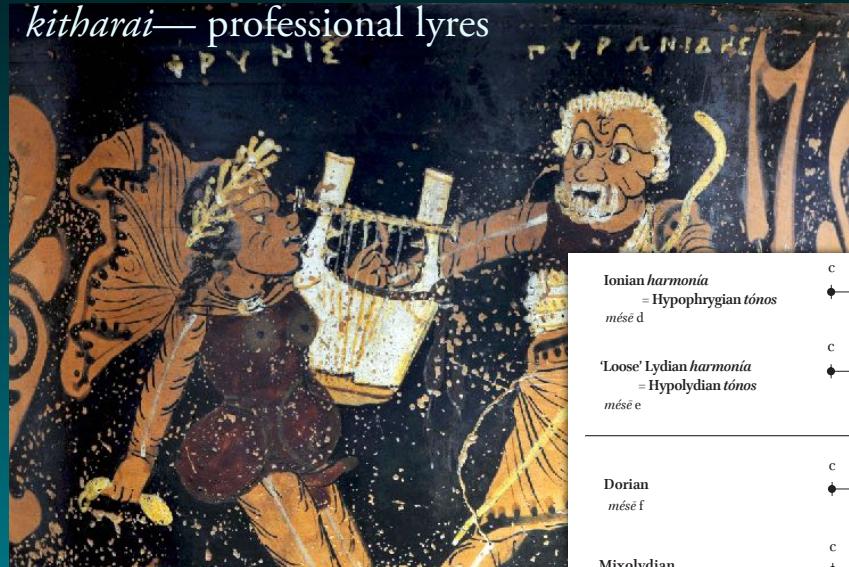
* A new, multi-faceted approach to Ancient Greek music that combines technical and theoretical sources with literary and philosophical insights

- The nature of the Classical modes (*harmoníai*) and their cultural significance (book in preparation on *Plato's musical ethos*)
- Reconstruction of the modulation system of the 'New Music' and its relationship to the two main families of Greek instruments (Lynch 2018 and 2020)

auloi— double pipes



kitharai— professional lyres



f#

Lynch 2022a and 2022b:
this reconstruction is
supported by the Greek
Musical Documents
(*dDAGM* database)

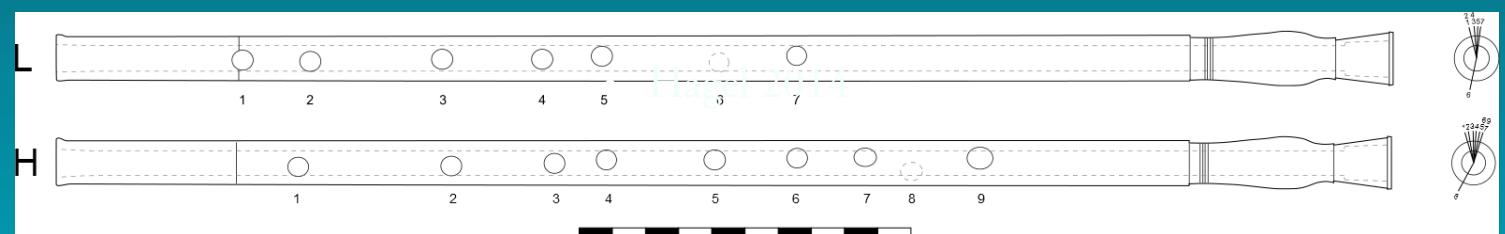
* Recently expanded this approach to include archaeological finds, essential source of independent evidence that is strikingly convergent with technical, theoretical and cultural models

3D model of the Louvre Aulos (inv. nr. E10962)

- very famous — plenty of reliable documentation, photos and detailed measurements (Hagel 2014)
- harmonic model firmly established in the 4th century BC; on Classical wooden instruments, cf. Elgin aulos, ‘Lybian *lōtos*’ (Eur. *Tr.* 544, *Hel.* 170, *IA* 1036, with Theophr. *Hist. Plant.* IV.iii.13–14)
- but this particular pair of pipes is likely be late Hellenistic or Imperial (no radiocarbon dating)



Hagel 2014



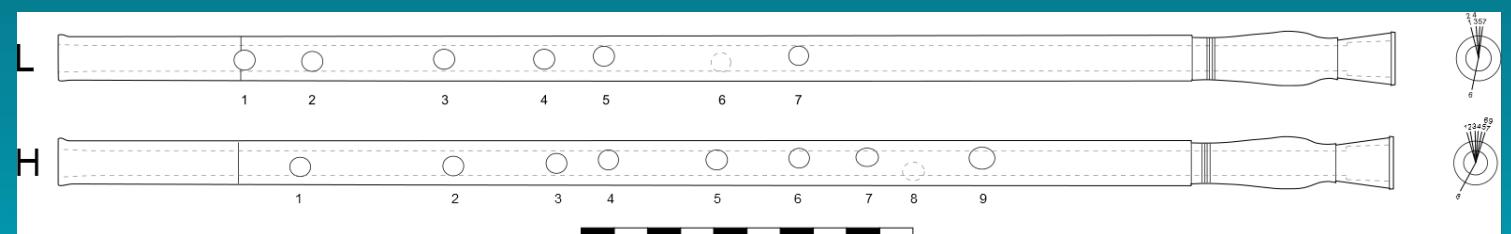
* Recently expanded this approach to include archaeological finds, essential source of independent evidence that is strikingly convergent with technical, theoretical and cultural models

3D model of the Louvre Aulos (inv. nr. E10962)

- Technical challenges: curved surfaces, variable bore diameters, round holes in cylindrical pipes set at different angles
- Many computer softwares could not handle this complexity, others were too demanding for my purposes
- Change of setup: iPad with Pencil, and Shapr3D app (free edu licence; also available for Mac and Windows)

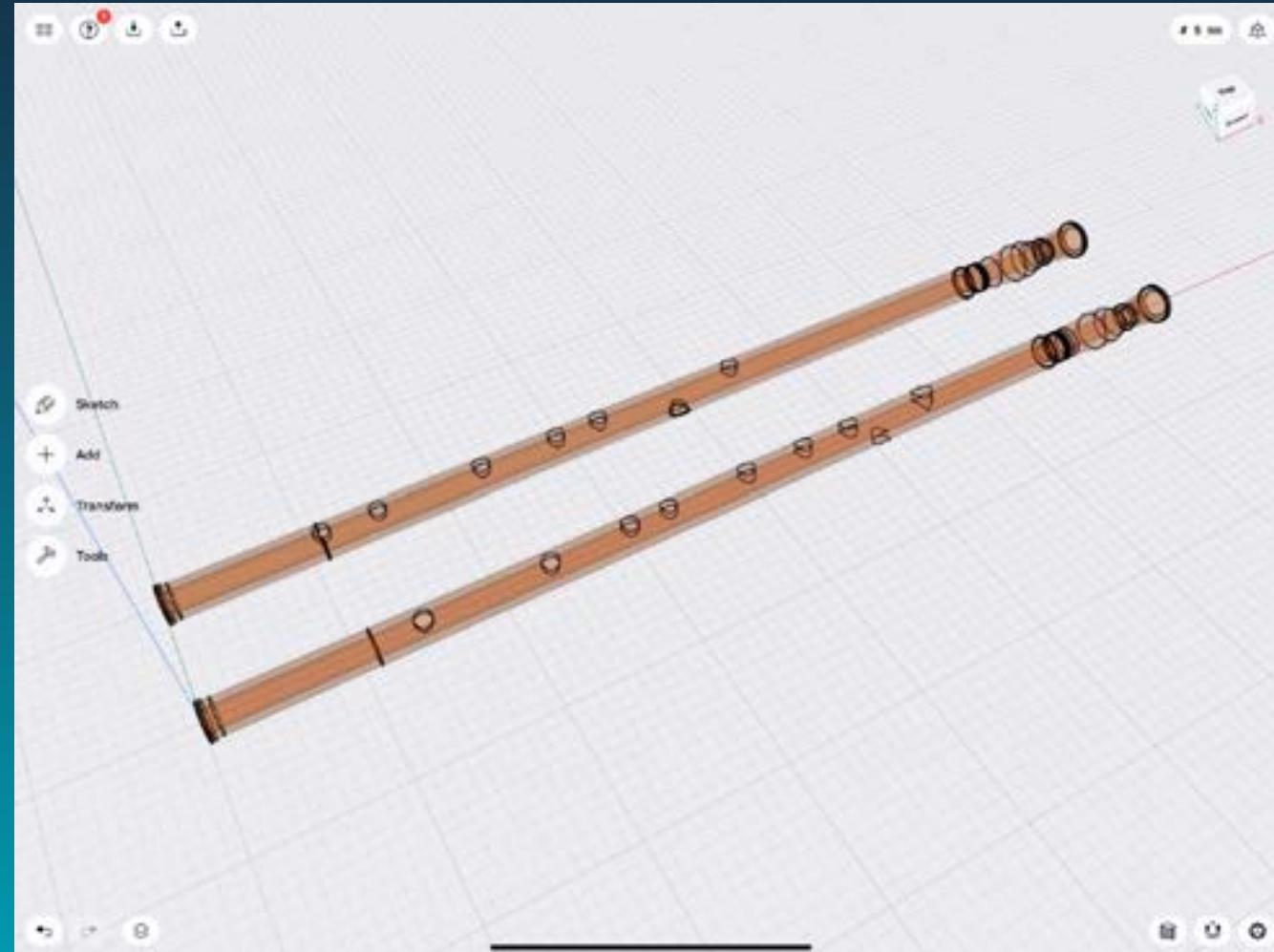


Hagel 2014



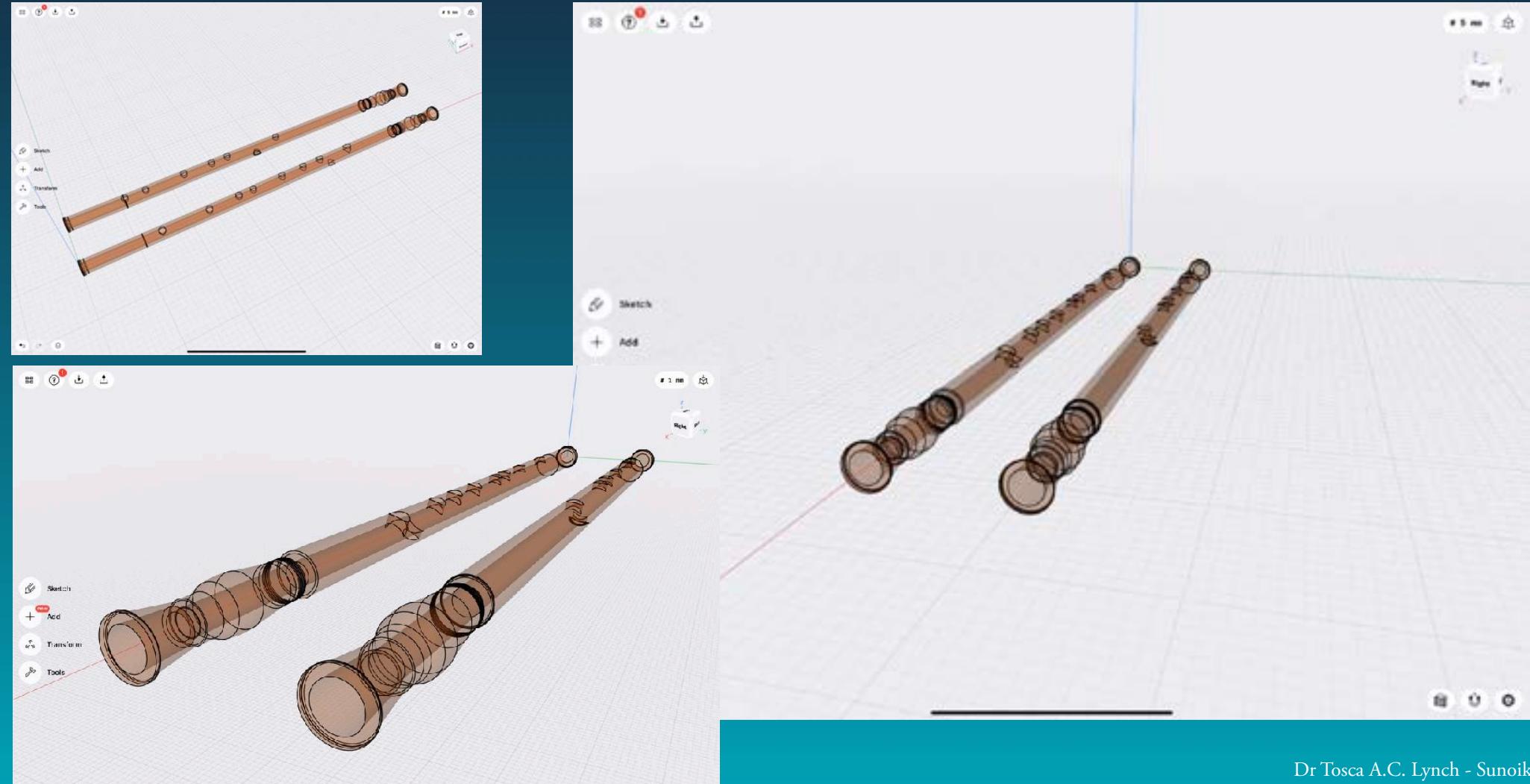
3D model of the **Louvre Aulos** (inv. nr. E10962) – iPad and Pencil, Shapr3D app

- A bit of experimenting...



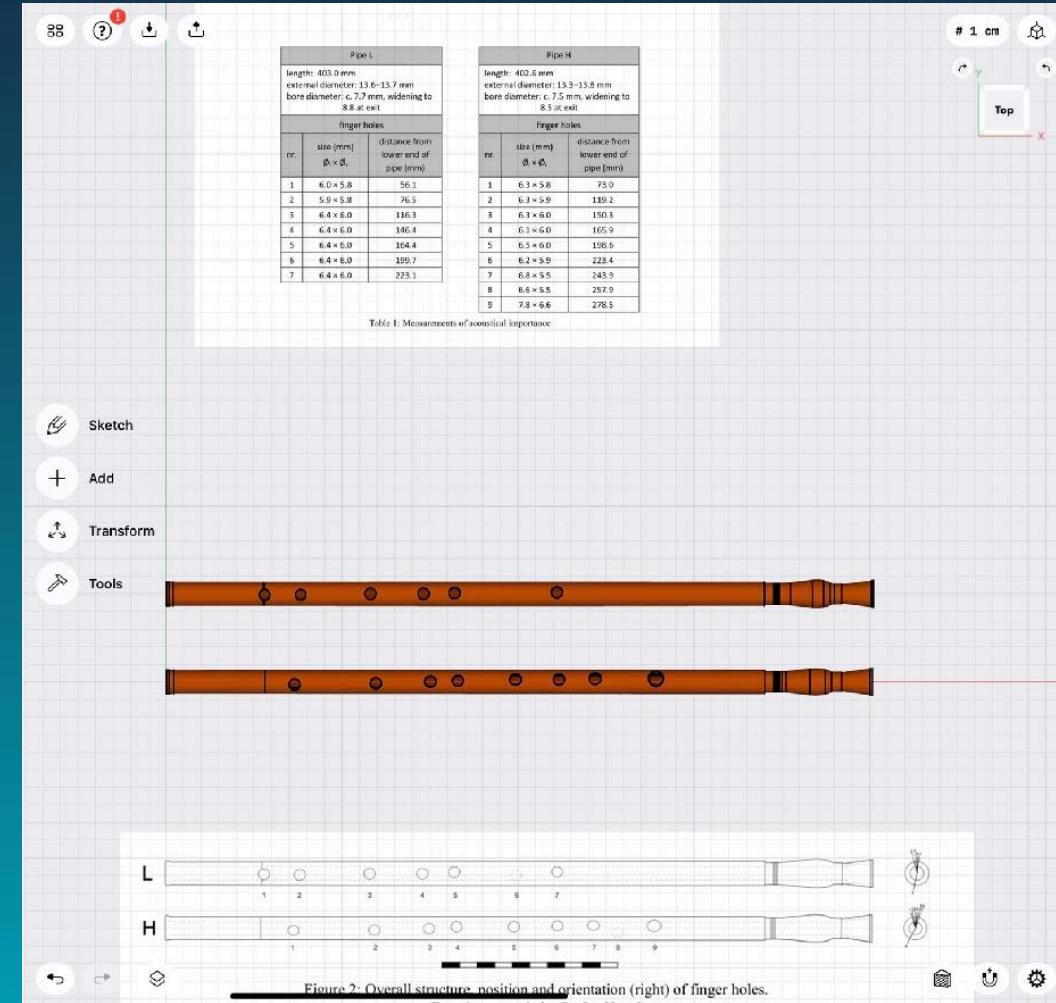
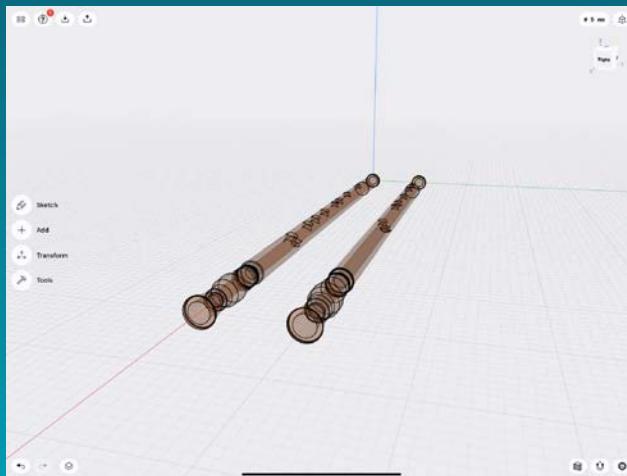
3D model of the Louvre Aulos (inv. nr. E10962) – iPad and Pencil, Shapr3D app

- A bit of experimenting...



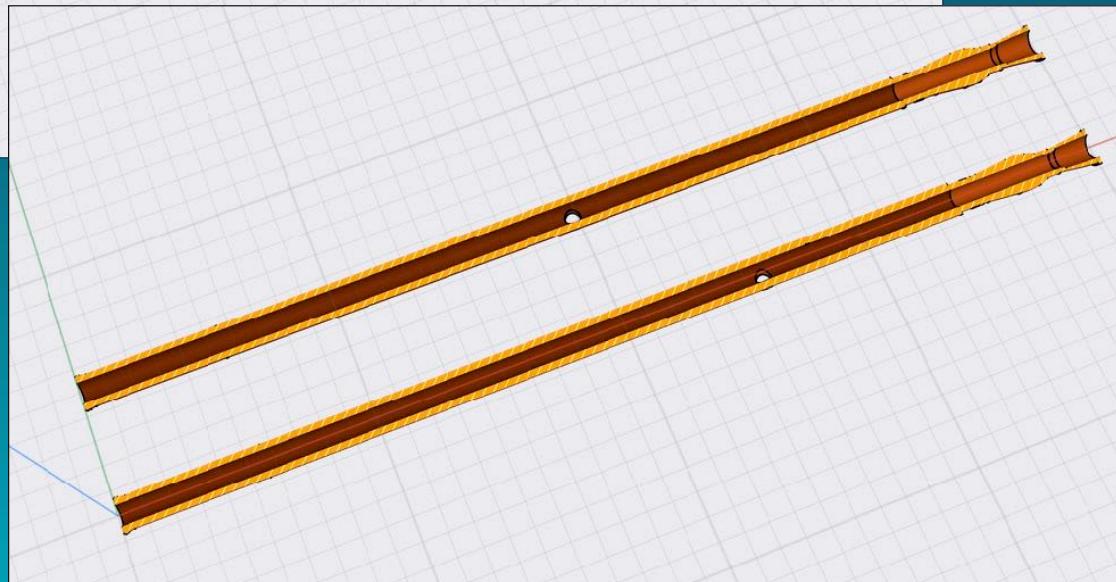
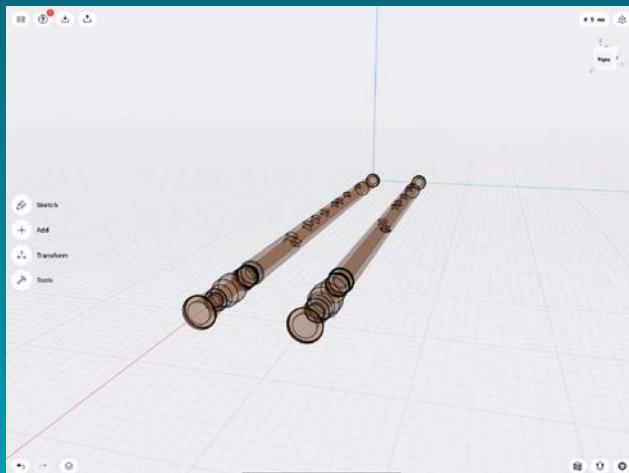
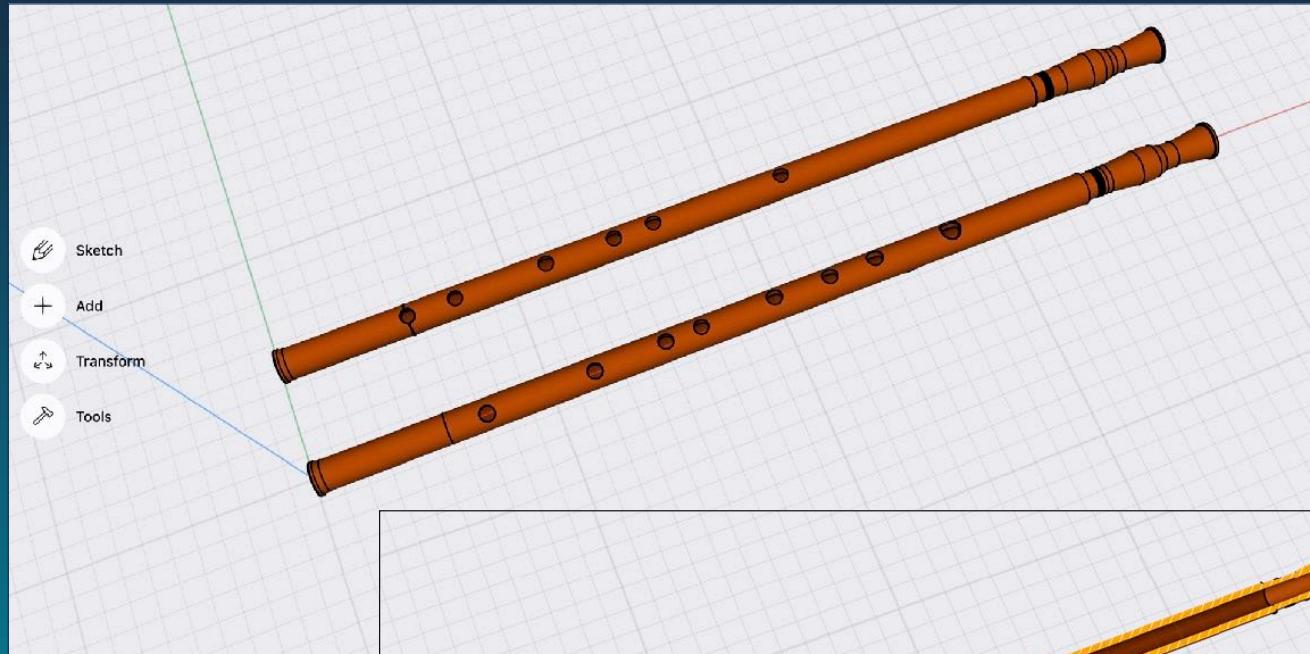
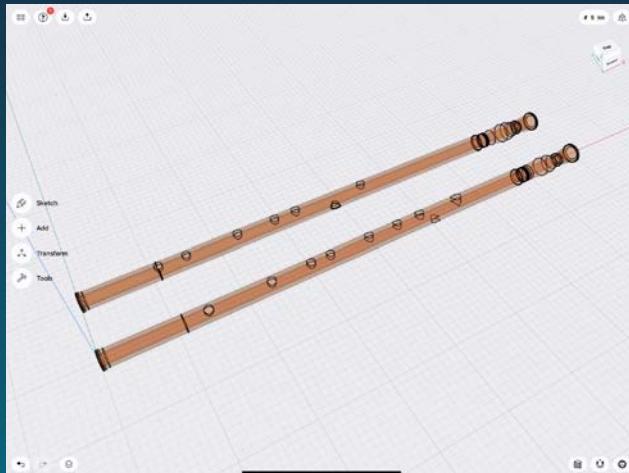
3D model of the Louvre Aulos (inv. nr. E10962) – iPad and Pencil, Shapr3D app

- A bit of experimenting...



3D model of the Louvre Aulos (inv. nr. E10962) – iPad and Pencil, Shapr3D app

- Ready!



3D model of the **Louvre Aulos** (inv. nr. E10962) – missing parts = **Double Reeds**

Ancient Greek auloi employed **double reeds** (such as those used on modern oboes),
and not single reeds (as in modern clarinets)

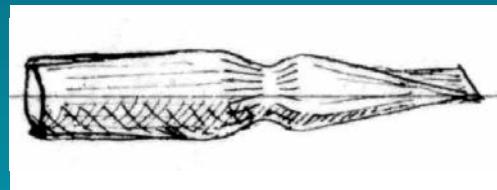
- No ancient reeds survive intact to this day, but we can confidently reconstruct them by combining different sources, including:

1. Broken remains of a reed from Ptolemaic Egypt (ca 323 to 31 BC)



MIM inv. 3396, Brussels
(Photo: ©Katia Novoa, 2018,
doublepipes.info)

2. Sketch of a double reed that was still fitted in the low pipe of the Berlin aulos in 1894, when the Egyptian Museum acquired the instrument



This sketch is particularly important,
as the Berlin aulos is very similar to the Louvre pipes

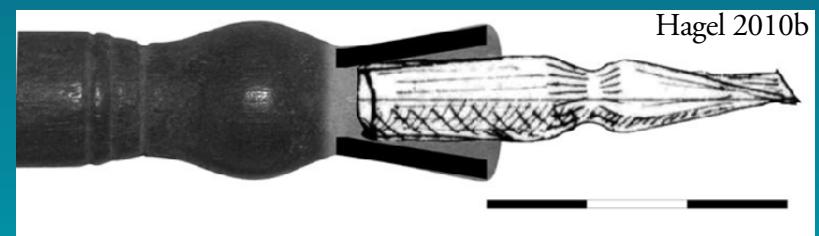


Fig. 27 Approximate scaling of the reed of Berlin Egyptian Museum inv. 12461

3D model of the Louvre Aulos (inv. nr. E10962) – missing parts = Double Reeds

3. Iconography, which confirms that auloi had double reeds; their length is not always relevant for the Louvre aulos (appropriate for different types of auloi)



- Aristoxenus fr. 101 Wehrli mentions **five different classes of auloi**, ranging from small, high-pitched pipes for ‘girls’ (*parhenioi*) and ‘boys’ (*paidikoi*) to auloi suitable for men, including ‘kitharodic’ pipes as well as longer pipes known as ‘complete’ and ‘hyper complete’ ones
- Considerable **differences in register and size (and therefore reed length)**: ‘the interval produced by the highest note of the “girl” aulos and the lowest note of the “hyper-complete” aulos is greater than three octaves’ (Aristox. *El. harm.* 26.8-11 DR)



Double Reeds → auloi were closed pipes, not flutes!

*Mistaken & misleading translation
that is still used in literature,
museum catalogues etc...*

The Greeks obviously had flutes too, called *plagiauloi*,
but flutes had a completely different design and iconography

Koilē *plagiaulos*

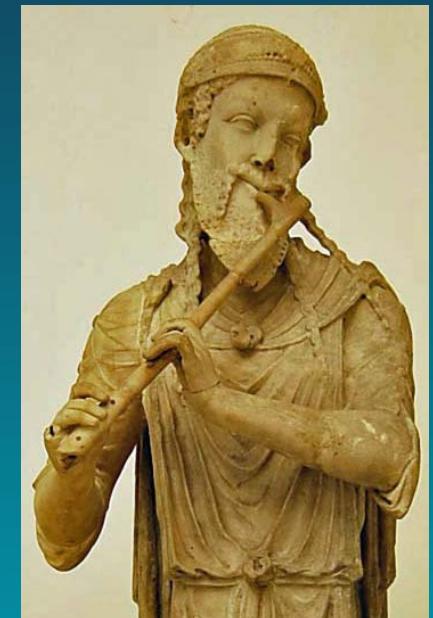


Terzēs 2020, 223, Figures 16.5 a and b

Corinth mosaic, A610 MOS



Herm, BM 1805,0703.26



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3D model of the **Louvre Aulos** (inv. nr. E10962)

missing Double Reeds → Closed Pipes

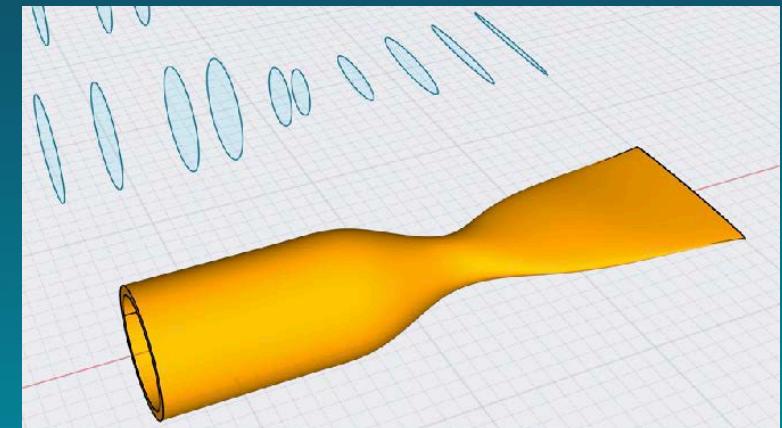
4. **Simple mathematical model** = Ideal **closed pipe** with **cylindrical bore** + **open-hole end correction** (Benade 1990)

- It calculates the basic pitch of the notes produced by different finger-holes, adjusted on the basis of different reed lengths;
- Pitches are automatically identified with modern notes, +/- microtonal variations in cents (1 semitone = 100 cents);
- This identification can be based on different chamber pitches → relationship to other tunings.

As I will show in a publication currently in preparation,
the **scale produced by the Louvre aulos corresponds to well-established tunings described in theoretical sources.**

But **this model can offer only basic guidance** —

reeds are very temperamental and the pitches produced by a pair of reeds can change significantly over time!



The same was true for ancient Greek reeds, as noted by Plato and Aristoxenus

→ finger-hole patterns were a blueprint that aulos players adapted to produce different tuning shades (variations in embouchure, half-covering etc.)



3D model of the **Louvre Aulos** (inv. nr. E10962) – missing parts = **Double Reeds**

5. Theophrastus' description of the kinds of cane used to produce aulos reeds, and of key steps in the process of reed production (*Hist. Plant.* IV.2–11)



... and practical experiments on working replicas



Photos © Callum Armstrong, doublepipes.info



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3D model of the Louvre Aulos (inv. nr. E10962) – Complete



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3D model of the Louvre Aulos (inv. nr. E10962) – Complete



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3D model of the Louvre Aulos (inv. nr. E10962) – Complete



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3D model of the **Louvre Aulos** (inv. nr. E10962) – Complete

This model produces a **scale that corresponds to well-established tunings** (Lynch in prep),
and also matches iconography very closely!

Stamnos, Peleus Painter (450-440BC),
BM E453, 1843,1103.99



3D model of the **Louvre Aulos** (inv. nr. E10962) – Complete

This model produces a **scale that corresponds to well-established tunings** (Lynch in prep),
and also matches iconography very closely!

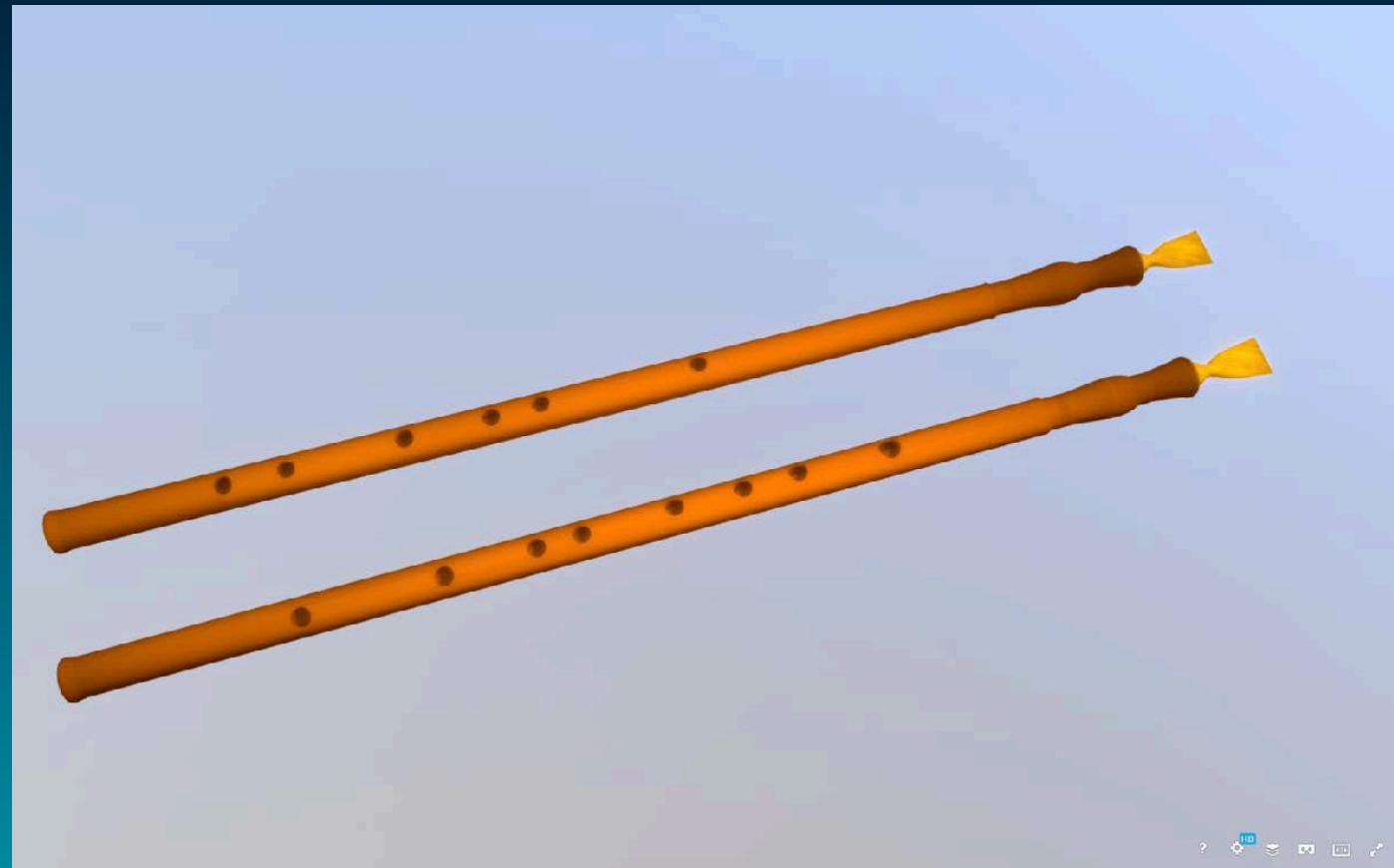
Stamnos, Peleus Painter (450-440BC),
BM E453, 1843,1103.99



Amphora, Peleus Painter (ca 440BC),
BM E271. 1847,0909.7

You can explore the 3D model
on SketchFab!

<https://skfb.ly/o7oUB>



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- West, M.L. (1992) *Ancient Greek Music*. Oxford.

Relevant Websites

The Workshop of Dionysus: doublepipes.info

European Music Archaeology Project (Emap): <http://www.emaproject.eu>

A live performance on the Louvre Auloi: <https://youtu.be/6JFa8BZt2B0?t=120>



Dr. Orly Lewis

Modelling Greco-Roman Anatomy

www.atlomy.com

Content

- 1 – Anatomy in Ancient Greece and Rome
- 2 – 3D Modelling of Ancient Anatomy
- 3 – Research Platform (3D atlas)
- 4 – Confidence / Source Indication

1 — *anatomē* (ἀνατομή)

Field of knowledge
and Practical method

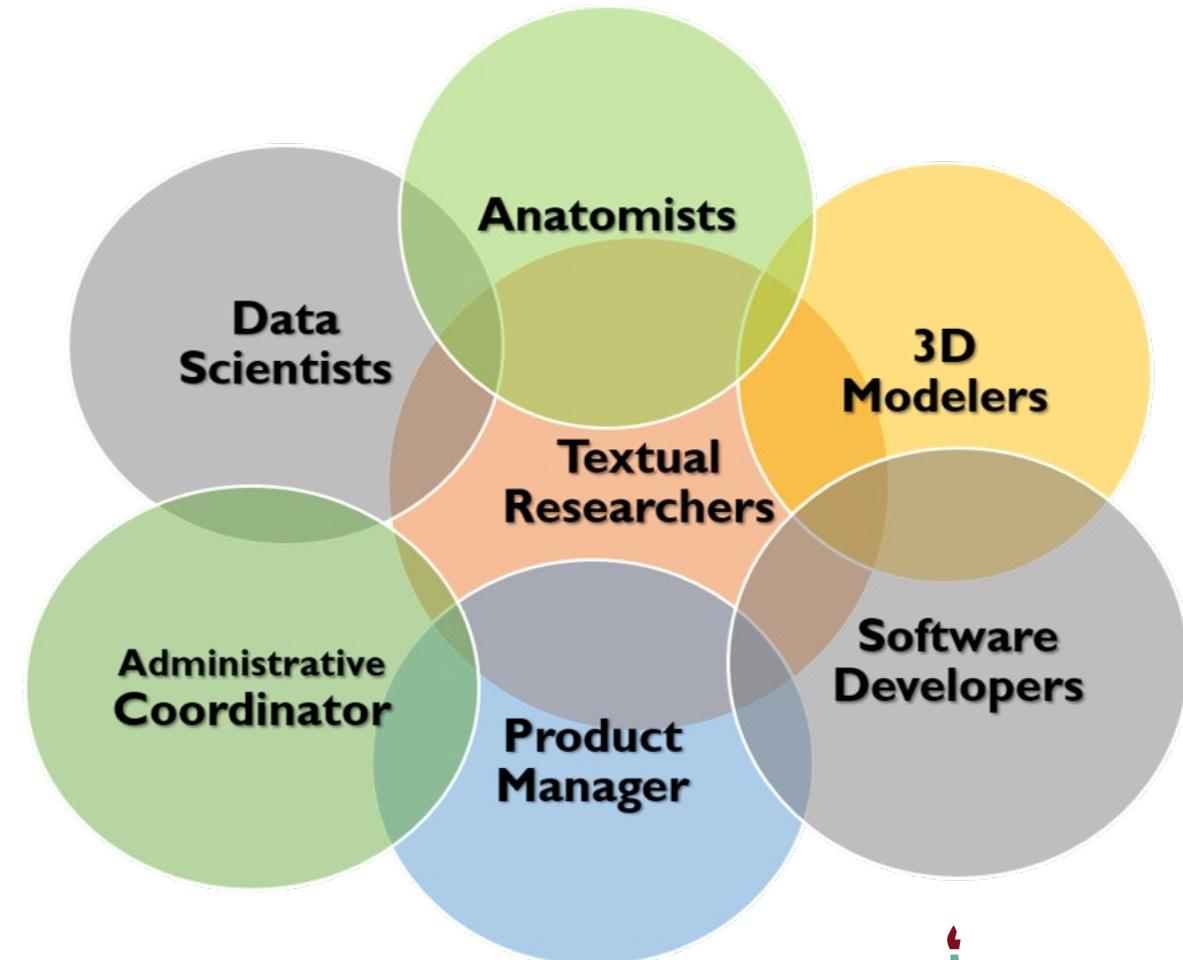
Ancient *anatomē*

- **Many anatomies**
- Ambiguous terminologies
- Textual sources (almost exclusively)
 - Descriptions of ideas and research
- Research mostly performed on animals

2 – 3D Modelling

From text to Model

Multidisciplinary Team



**ATLOMY: An Interactive Visual and Textual
Atlas of Greco-Roman Anatomy**

Pipeline



Translate and Interpret

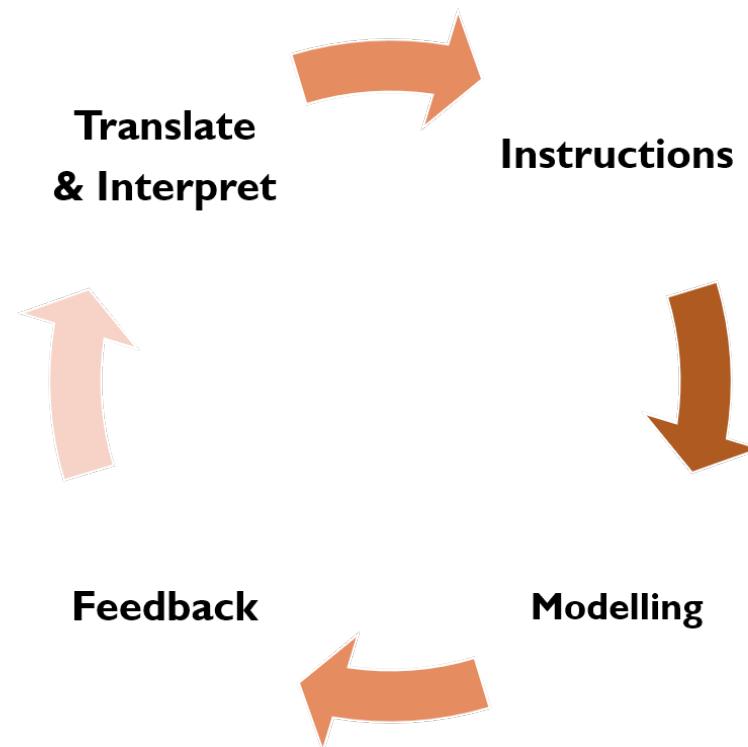
- Greek to English
- Anatomical discussion and deciphering

Instructions

- List of items
- Properties, connections

Modelling (professional modelers)

Feedback (return to text?)



Interpretive Decisions: Examples from *Sacred Disease*

- 5th century BCE
- Hippocratic Corpus
- Causes and Treatment of the “Sacred Disease”
- Describes related anatomy
- Brain and vascular systems as key

Thin Membrane in the Brain

“The brain of humans is double (...) A thin membrane separates it in the middle [lit. separate its middle].”

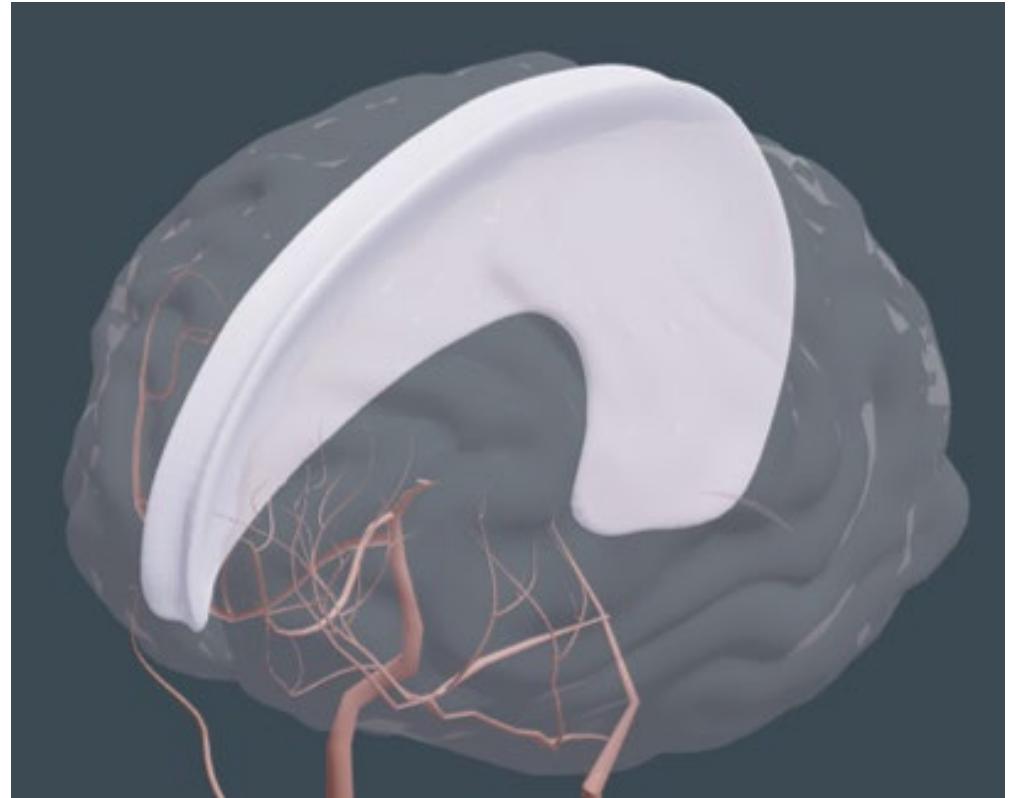
ὁ ἔγκεφαλος ἔστι τοῦ ἀνθρώπου διπλός (...). τὸ δὲ μέσον αὐτοῦ διείργει μῆνιγξ λεπτή.

(*Sacred Disease 3*)

Brain and Membrane in *Sacred Disease*



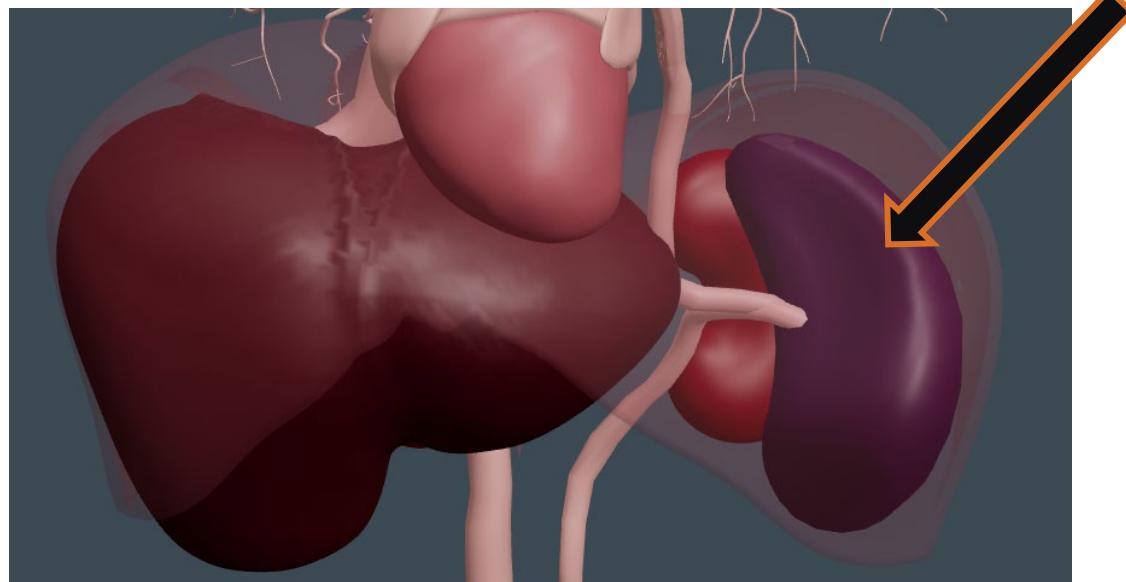
Brain hemispheres (“is double”) and the “thin membrane” in its middle (anterior view) ©ATLOMY



Brain (faded) and the “thin membrane” in its middle (view from left side) ©ATLOMY

<https://www.atlomy.com/three-d-model/AtlomyModel%20-%20clavcles%20only.glb/%CF%86%CE%BB%E1%BD%B3%CF%88/18/vein>

Spleen in *Sacred Disease*



Spleen with surrounding viscera
Diaphragm faded

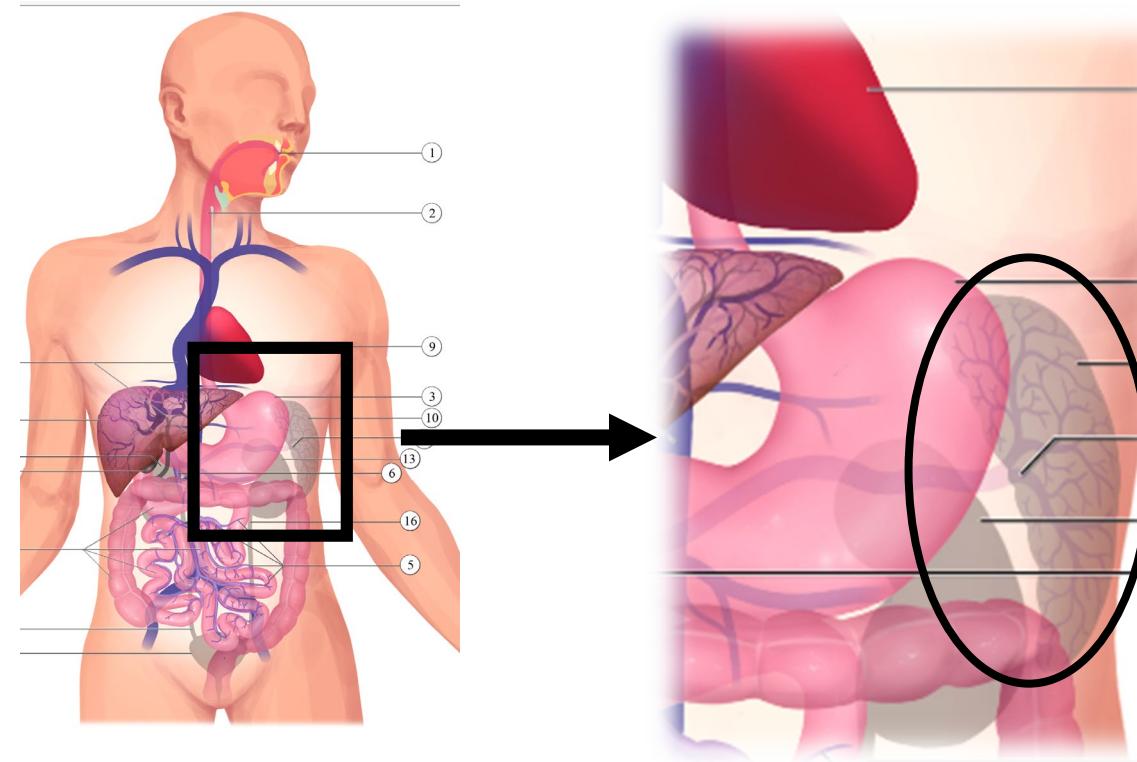
©ATLOMY



Spleen isolated

©ATLOMY

(But not so for Galen)



©ATLOMY

3 – Research Platform (Atlas)

Dedicated platform - Meeting scholars' needs

- Moving smoothly between text and model
 - References, citations, lexical information on the models
- More than a viewing platform
 - Interpretive insights; anatomical and lexical explanations
- Research and production transparency
- Open access
- User-oriented and Text-oriented design

Features

- Open access web-based software
- 3D models of particular parts or entire body
- Search and browse by author, term, reference
- Visual and textual commentary
- Interactive modular viewing and study options

4 – Confidence / Source indication

Confidence / Source indication

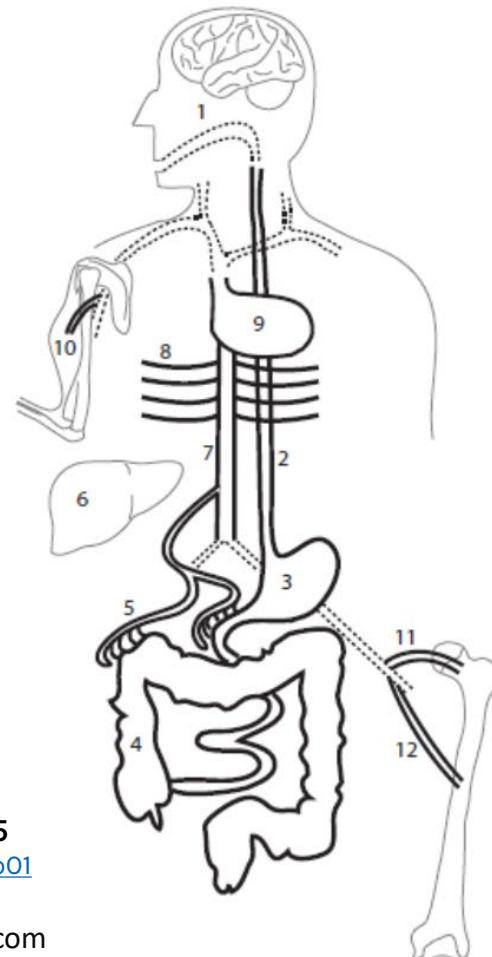
(*Working categories)

- **Text**
- **Inference**
 - based on observation / “logic” / other texts
- **Unclear structure**
- **Unclear trajectory**
- **Textual problem**
- **Meaning unclear**

Confidence indication in practice

(Ps.-Aristotle, *On Pneuma*)

- 1= mouth and oropharynx
- 2= esophagus
- 3= stomach
- 4= intestines
- 5= blood-ducts from the *megalē phleps* to the stomach and the intestines
- 6= liver
- 7= *megalē phleps* (vena cava)
- 8= blood-ducts extending along the ribs (intercostal veins)
- 9= heart
- 10= (example of) a blood-duct leading to the muscle
- 11= (example of) a blood-duct leading to the head of a bone
- 12= (example of) a blood-duct leading to the middle of a bone



Schematic representation of System 2. Full black lines represent parts of System 2 for which there is explicit textual evidence. Dotted black lines represent presumed passages which connect parts of System 2. Thin grey lines represent salient organs that facilitate understanding of the diagram, some of which are explicitly mentioned in connection with System 2. The diagram represents bodily parts out of their relative sizes and positions for the sake of intelligibility.

From: Gregoric, Lewis, Kuhar 2015
<https://doi.org/10.1163/15733823-00202p01>



Thank you

www.atlomy.com