

SunoikisisDC Spring 2024 Session 8

3D Modelling: Archaeological reconstruction and 3D printing

Gabriel Bodard (University of London)
Orly Lewis (Hebrew University Jerusalem)
Michael Donnay (University of London)

March 7, 2024

1. Definitions of 3D modelling and software
2. Modelling Greco-Roman Anatomical Ideas
3. Case studies
4. Modelling for 3D printing
5. Exercise

London 3D Summer School

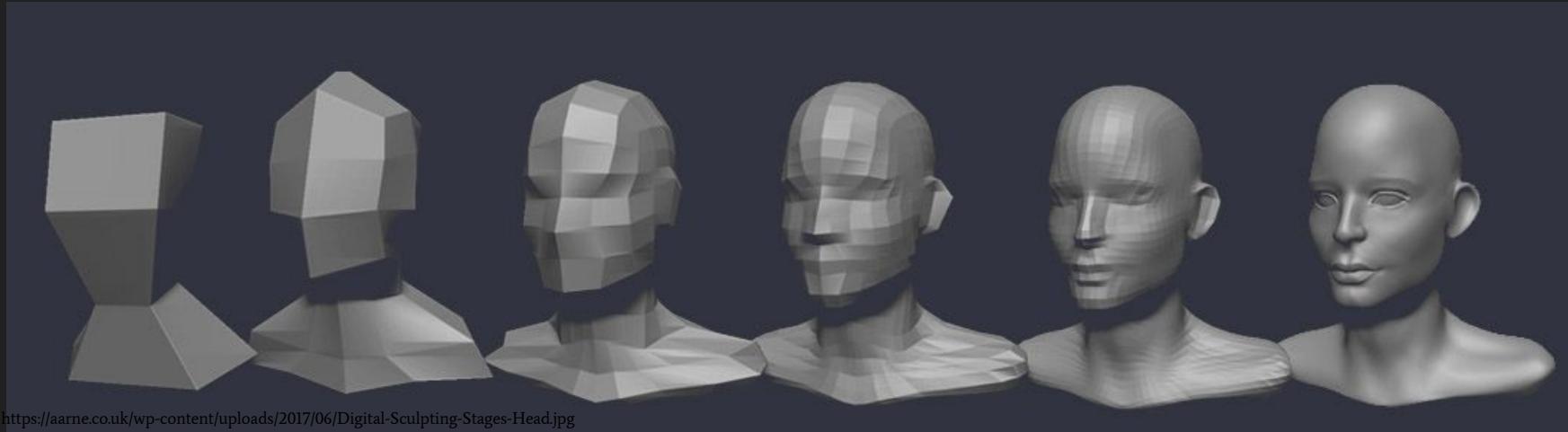
3D Modelling and Visualisation

Gabriel Bodard, University of London
Valeria Vitale, University of Sheffield
Alicia Walsh, Recollection Heritage

What is 3D Modelling?

The creation of a 3D digital representation of an object or landscape that may or may not exist in materiality.

- Computer-aided design (CAD)
- Digital Sculpting
- Procedural modelling
- Simulations and Virtual Worlds
 - Sims, Second Life, Minecraft, Metaverse
- Real Time Engines
 - Unreal, Unity3D

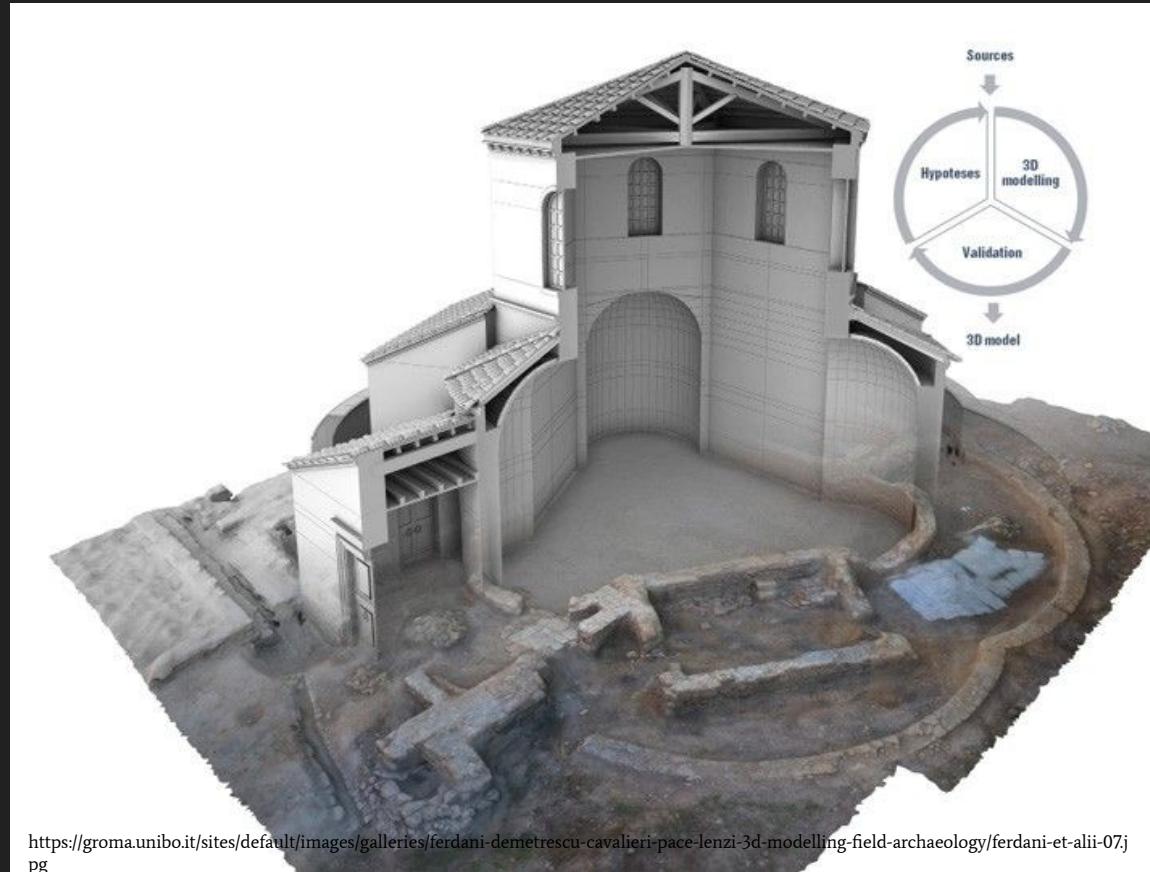


3D modelling for Cultural Heritage

Used for visualizing objects that do not exist (anymore), have changed over time, or are inaccessible.

Applications:

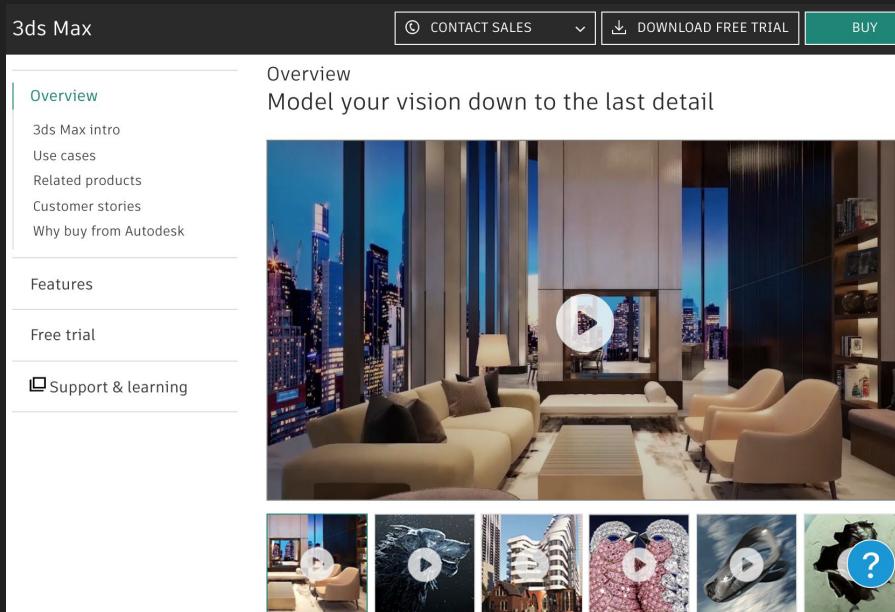
- Visualizing light and shadow
- Investigate lines of sight
- Simulate structural strength
- Communicate research findings (public outreach)



CAD and 3D software

- Autodesk 3DS Max
- Blender
- Maxon Cinema 4D
- Rhino 3D
- Sketchup Make/Pro
- Unity

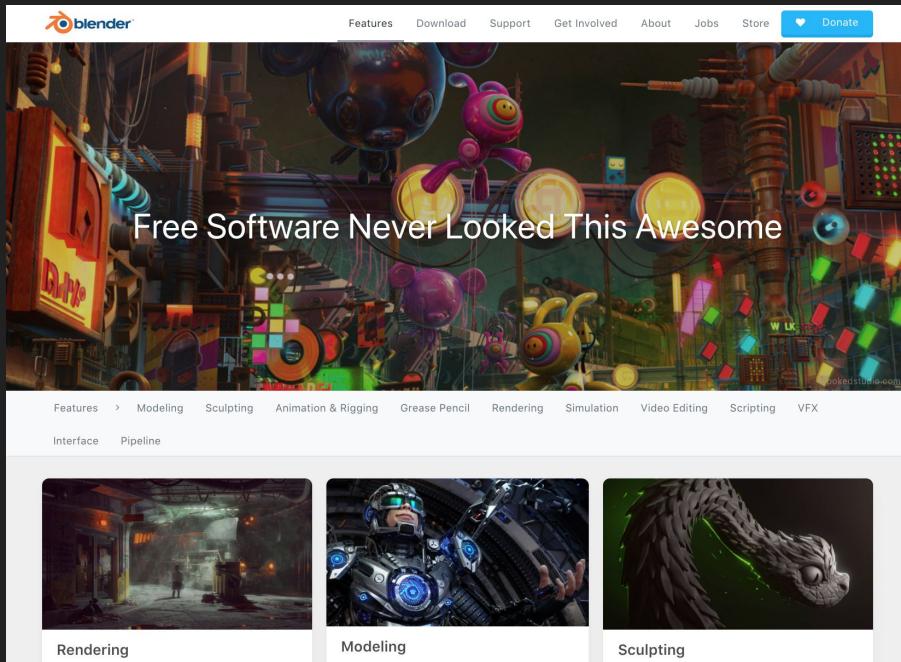
Autodesk 3DS Max



The screenshot shows the Autodesk 3ds Max product page. At the top, there are buttons for 'CONTACT SALES' and 'DOWNLOAD FREE TRIAL', and a large green 'BUY' button. Below this, the word 'Overview' is highlighted in green. A sub-headline reads 'Model your vision down to the last detail'. To the left, a sidebar lists navigation links: 'Overview' (highlighted), '3ds Max intro', 'Use cases', 'Related products', 'Customer stories', 'Why buy from Autodesk', 'Features', 'Free trial', and 'Support & learning'. The main content area features a large image of a modern living room overlooking a city skyline at night, with a play button icon overlaid. Below this are seven smaller thumbnail images showing various 3D models: a sofa, a lion's head, a building, two birds, a horse's head, and a cracked surface.

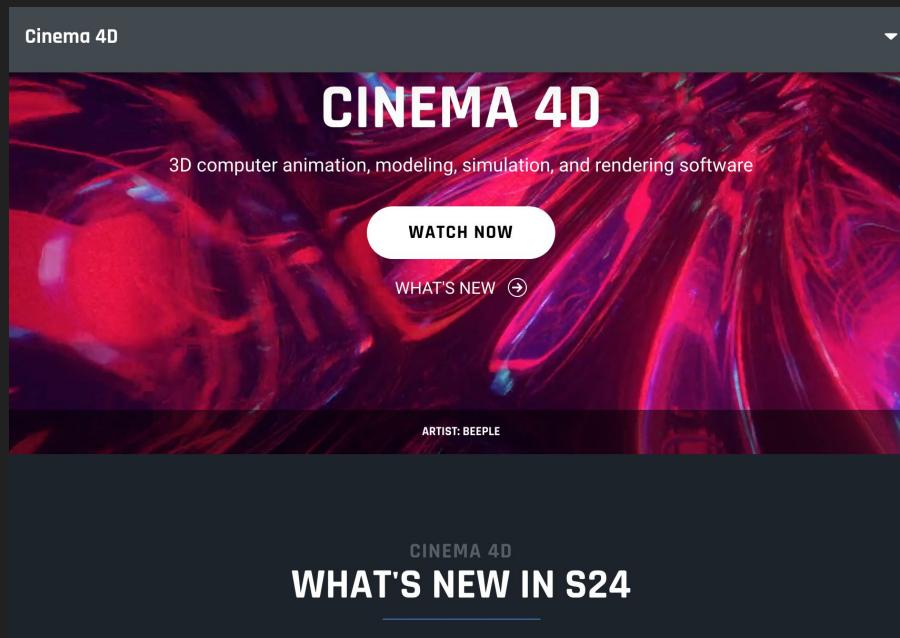
- Windows only
- Free education license
 - ◆ Full £2000/yr
- Pro architect tool
 - ◆ Compatible with suite
- Granular control of objects
- Export in all formats

Blender



- PC/Mac/Linux
- Open source software
- Redundant functionalities:
 - ◆ Extended keyboard
 - ◆ Keyboard shortcuts
 - ◆ Counterintuitive geometry
- Responsive dev community
- Export in several formats

Maxon Cinema 4D

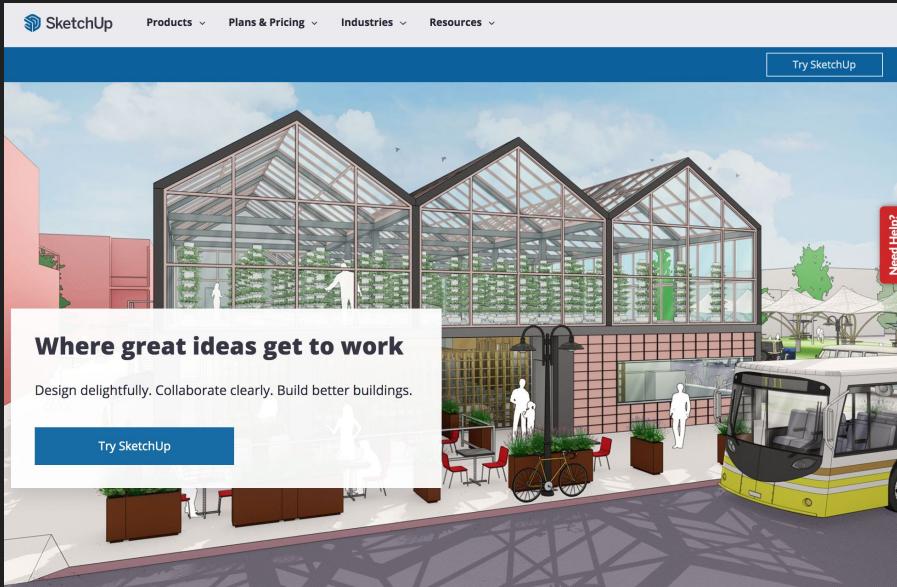


- Windows/Mac/Linux
- Education license £58/yr
 - ◆ Full £55/month
- Best tool for textures
 - ◆ Integrates Adobe CS
- Export in all formats

Maxon ZBrush

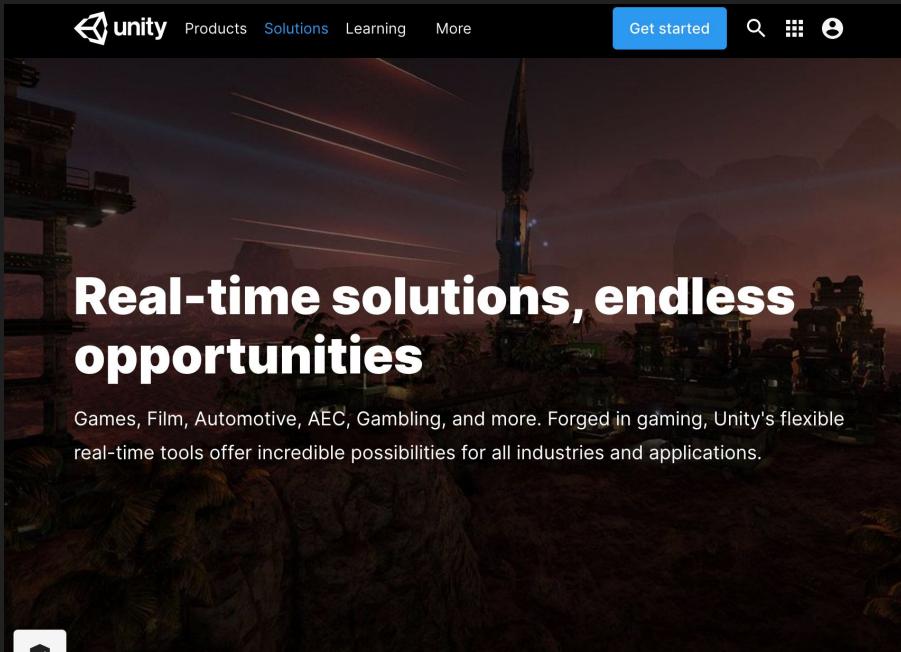
The website features a dark header with a red 'M' logo, a navigation bar with 'PRODUCTS' (highlighted in blue), 'NEWS', 'LEARN', 'SUPPORT', 'TRY', 'BUY', and user icons. Below the header is a secondary navigation bar with categories: 'ZBRUSH', 'SCULPTING', 'PAINTING & TEXTURING', 'RENDERING', 'PIPELINE', and 'INDUSTRY'. The main content area has a large, colorful collage of digital art including a man's face, a colorful figure, and a fish. Overlaid on the collage is a large white 'ZBRUSH' logo. Below the logo is the tagline 'The industry standard for digital sculpting and painting'. A white button labeled 'WATCH NOW' is positioned in the center of the collage. To the right of the button is a link 'WHAT'S NEW' with a small circular icon. In the bottom left corner of the collage, there is a small circular icon with the letters 'co'.

Sketchup



- Windows/Mac
- [Sketchup Make 2017: free]
- Sketchup Pro:
 - ◆ £245/year
 - ◆ Teacher/student: \$55/year
- Sketchup Web:
 - ◆ free
- Easy to learn
- Limited granularity
- A few export options

Unity



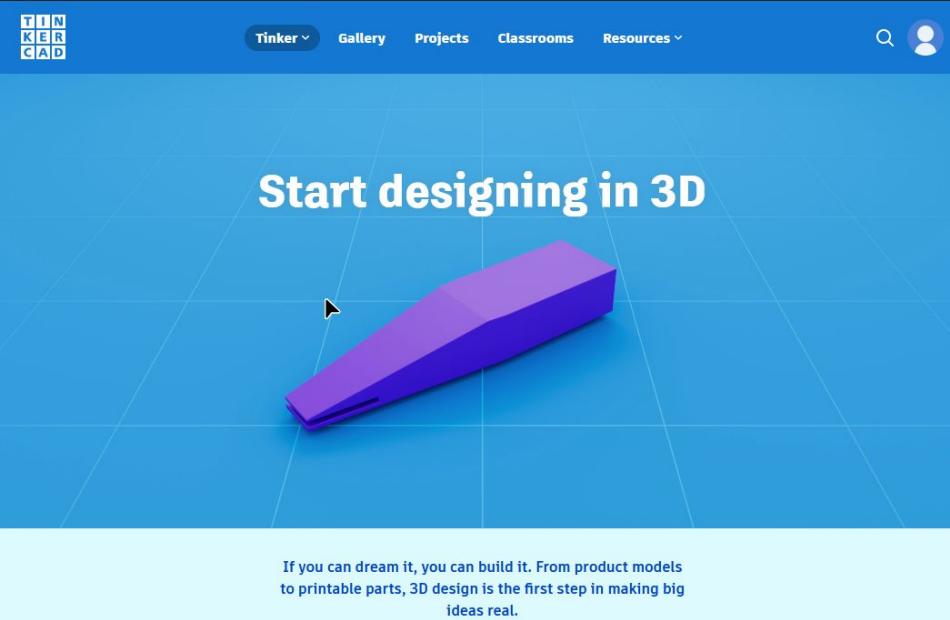
- Windows/Mac
- Real-Time Engine
- Personal/student free
- Pro €1900/year
- Not ideal for building
- Imports all formats

Rhino 3D



- Windows/Mac
- Cost: €1200/student €234
- Design tool
 - ◆ Free-form 3D sculpting
- Steep learning curve

AutoDesT TinkerCAD



- Free online app
- Basic functionality
 - ◆ Lots of presets
- Very easy to use
- Limited scale
- Good for knocking up an idea for printing

- Many even more expensive tools on market
 - Usually very specialist
 - Often steep learning curve, require training
 - Institutional licenses prohibitive
- Also many free apps with limited functionality
- Projects/institutions will have preferences



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ATLOMY
Greco-Roman
Anatomy Atlas

Dr. Orly Lewis



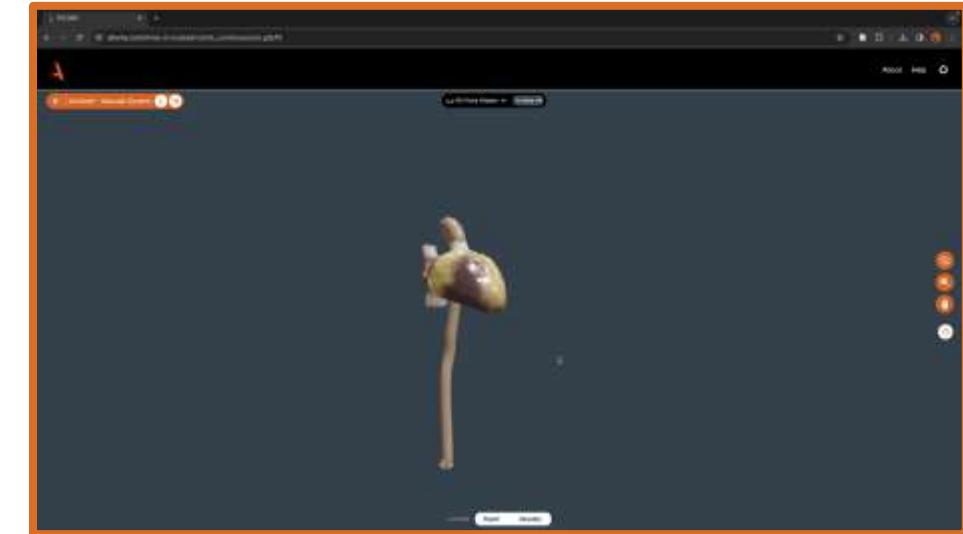
Modelling Greco-Roman Anatomical Ideas

Aristotle on the Cavities of the Heart

“The heart has three cavities (*koiliai*);
the largest on the right side, the
smallest on the left and a medium one
in the middle.”

“Inside the cavities of the heart there
are tendons (*neura*).”

Aristotle, *Research on Animals*, I.17, III.15



טלס אינטראקטיבי



Search for an anatomical part

Search

Learn how to use ATLOMY

Available Models



Aristotle - Respiratory System
by: Aristotle



Aristotle - Gastrointestinal System
by: Aristotle



Hippocratic Sacred Disease - Vascular System
by: Hippocratic Corpus



Hippocrates - De Corde
by: Hippocratic Corpus



Aristotle - Vascular System
by: Aristotle



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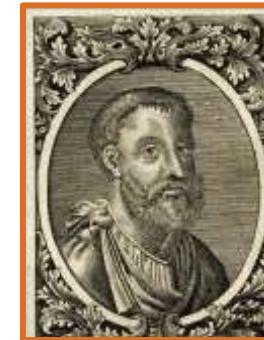


ATLOMY

Anatomy in Ancient Greece and Rome: An Interactive Visual and Textual Atlas

Ancient *anatomē* (ἀνατομή)

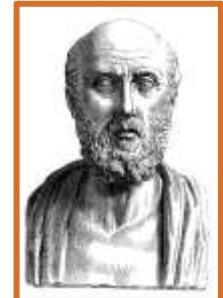
- Many anatomies
- Ambiguous terminologies
- Dozens of textual sources
- Research mostly performed on animals



Galen (2nd c. CE)



Hippocrates
(5th-4th c. BCE)



Aristotle
(4th c. BCE)



Praxagoras
(3rd c. BCE)



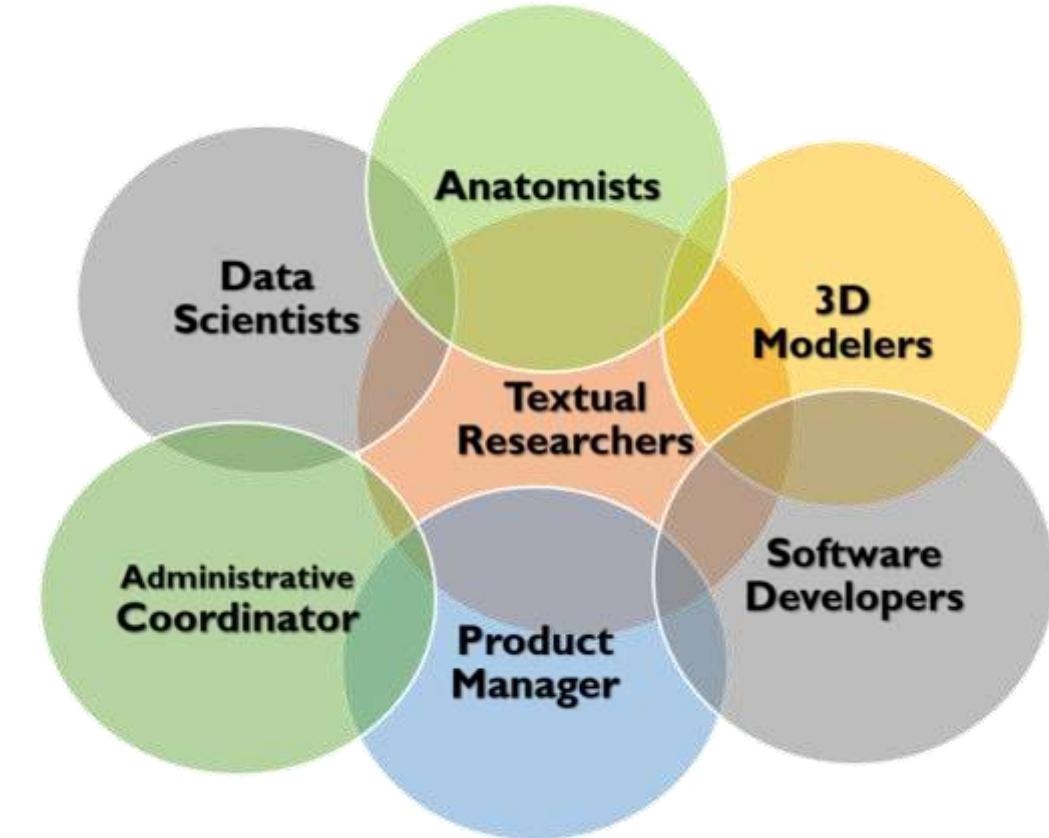
Archigenes
(1st-2nd c. CE)



Erasistratus
(3rd c. BCE)

Main Research Questions and Team

- How did Greeks and Romans investigate, understand and describe the structure of the body?
- How did anatomical ideas, research and terminology shape one another?
- What were the conventions of anatomical textual descriptions?





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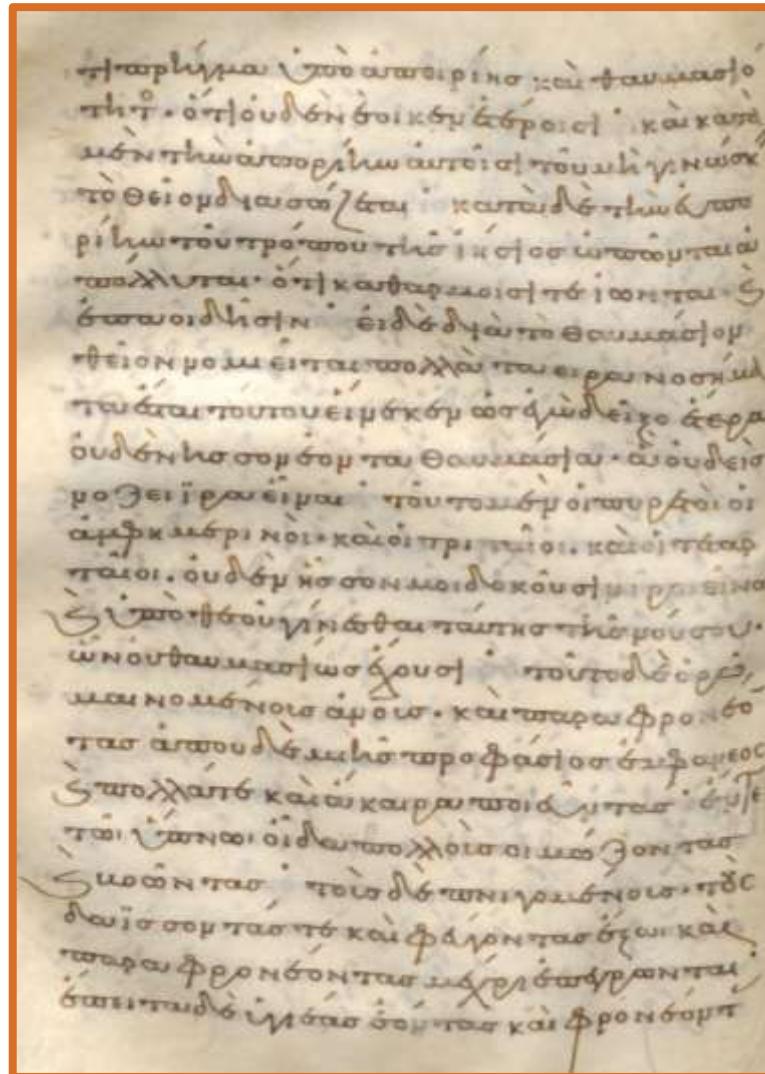


ATLOMY
Greco-Roman
Anatomy Atlas

Research Workflow

1. Textual Analysis and Translation
2. Anatomical Deciphering
3. 3D Modelling

1 – Textual Analysis and Translation



Sacred Disease, Ch. 3 [1] Certainly, the brain is responsible for this affliction, just as for the other gravest diseases as well. How it happens and from what cause, I will make clear. [2] The brain of humans is double, just as that of all other animals. A thin membrane separates it in the middle [lit. separate its middle]; therefore, it does not always hurt on the same [part] of the head, but sometimes on one of the two sides, sometimes in the entire head. [3] And vessels (phlebes) extend (teinousin) to it from all over the body, many thin ones and two thick ones – one [extending] from the liver and one from the spleen. [4] And the one from the liver is as follows: part of the vessel extends downwards through the parts on the right, along the kidney itself and the lower back into the inner part of the thigh and reaches down to the foot – and it is called the ‘hollow vein’. The other part [lit: the other part of the [vessel]] extends upwards through the diaphragm and the lungs on the right side, and splits also to the heart and the right arm; and the remaining part* carries upwards through the collar-bone to the right side* of the neck, to the skin itself, so that it is visible,¹ but along the ear itself it is hidden, and there it splits. And the thickest, largest and hollowest part ends at* the brain; whereas the other part ends at the right ear, another part at the right eye and another at the nostril.

Computational Textual Analysis

Sacred Disease, Ch. 3 [1] Certainly, the brain is responsible for this affliction, just as for the other gravest diseases as well. How it happens and from what cause, I will make clear. [2] The brain of humans is double, just as that of all other animals. A thin membrane separates it in the middle [lit. separate its middle]; therefore, it does not always hurt on the same [part] of the head, but sometimes on one of the two sides, sometimes in the entire head. [3] And vessels (phlebes) extend (teinousin) to it from all over the body, many thin ones and two thick ones – one [extending] from the liver and one from the spleen. [4] And the one from the liver is as follows: part of the vessel extends downwards through the parts on the right, along the kidney itself and the lower back into the inner part of the thigh and reaches down to the foot – and it is called the 'hollow vein'. The other part [lit: the other part of the vessel] extends upwards through the diaphragm and the lungs on the right side, and splits also to the heart and the right arm; and the remaining part carries upwards through the collar-bone to the right side* of the neck, to the skin itself, so that it is visible,² but along the ear itself it is hidden, and there it splits. And the thickest, largest and hollowest part ends at³ the brain; whereas the other part ends at the right ear, another part at the right eye and another at the nostril.*



2 – Anatomical Deciphering

Sacred Disease, Ch. 3 [1] Certainly, the brain is responsible for this affliction, just as for the other gravest diseases as well. How it happens and from what cause, I will make clear. [2] The brain of humans is double, just as that of all other animals. A thin membrane separates it in the middle [lit. separate its middle]; therefore, it does not always hurt on the same [part] of the head, but sometimes on one of the two sides, sometimes in the entire head. [3] And vessels (phlebes) extend (teinousin) to it from all over the body, many thin ones and two thick ones – one [extending] from the liver and one from the spleen. [4] And the one from the liver is as follows: part of the vessel extends downwards through the parts on the right, along the kidney itself and the lower back into the inner part of the thigh and reaches down to the foot – and it is called the 'hollow vein'. The other part [lit: the other part of the vessel] extends upwards through the diaphragm and the lungs on the right side, and splits also to the heart and the right arm; and the remaining part* carries upwards through the collar-bone to the right side* of the neck, to the skin itself, so that it is visible,* but along the ear itself it is hidden, and there it splits. And the thickest, largest and hollowest part ends at* the brain; whereas the other part ends at the right ear, another part at the right eye and another at the nostril.



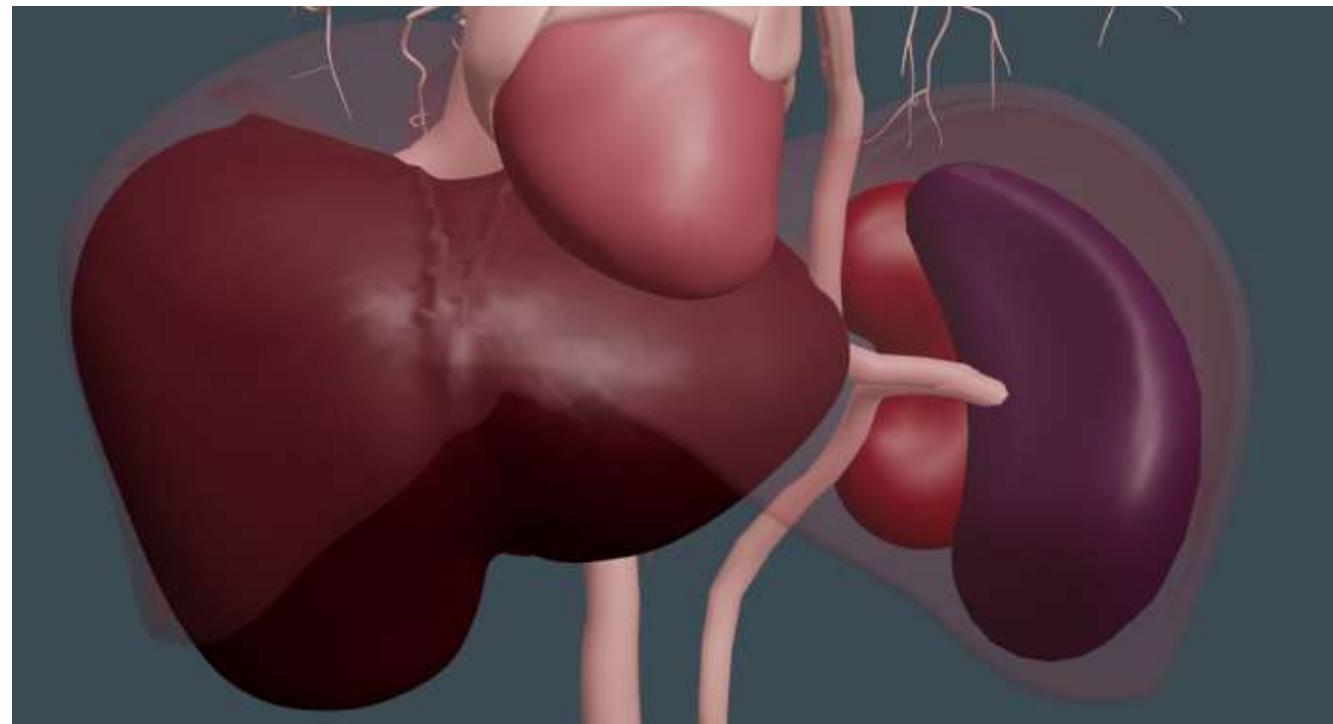
Workflow | Anatomical Deciphering

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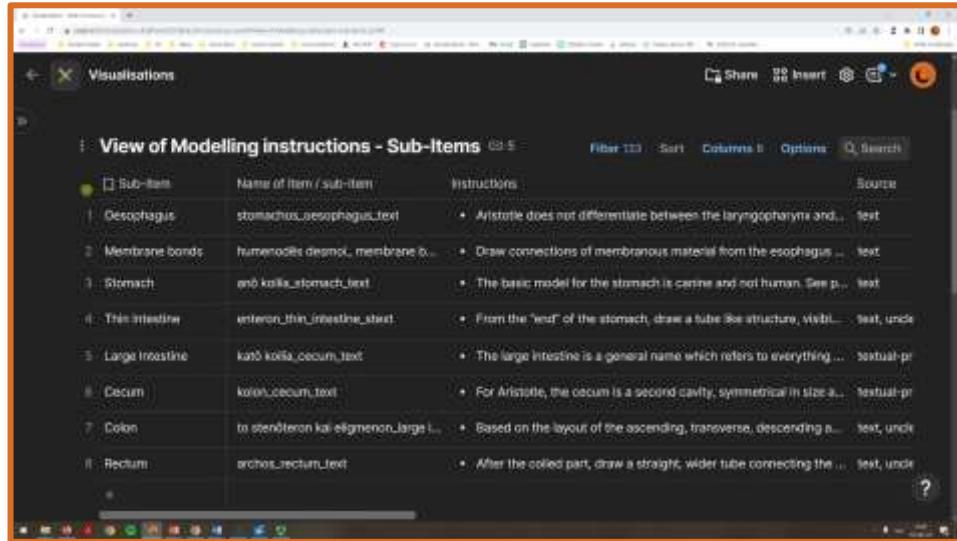
3 – 3D Modelling

Sacred Disease, Ch. 3 [1] Certainly, the brain is responsible for this affliction, just as for the other gravest diseases as well. How it happens and from what cause, I will make clear. [2] The brain of humans is double, just as that of all other animals. A thin membrane separates it in the middle [lit. separate its middle]; therefore, it does not always hurt on the same [part] of the head, but sometimes on one of the two sides, sometimes in the entire head. [3] And vessels (phlebes) extend (teinousin) to it from all over the body, many thin ones and two thick ones – one [extending] from the liver and one from the spleen. [4] And the one from the liver is as follows: part of the vessel extends downwards through the parts on the right, along the kidney itself and the lower back into the inner part of the thigh and reaches down to the foot – and it is called the 'hollow vein'. The other part [lit: the other part of the vessel] extends upwards through the diaphragm and the lungs on the right side, and splits also to the heart and the right arm; and the remaining part carries upwards through the collar-bone to the right side* of the neck, to the skin itself, so that it is visible,* but along the ear itself it is hidden, and there it splits. And the thickest, largest and hollowest part ends at* the brain; whereas the other part ends at the right ear, another part at the right eye and another at the nostril.



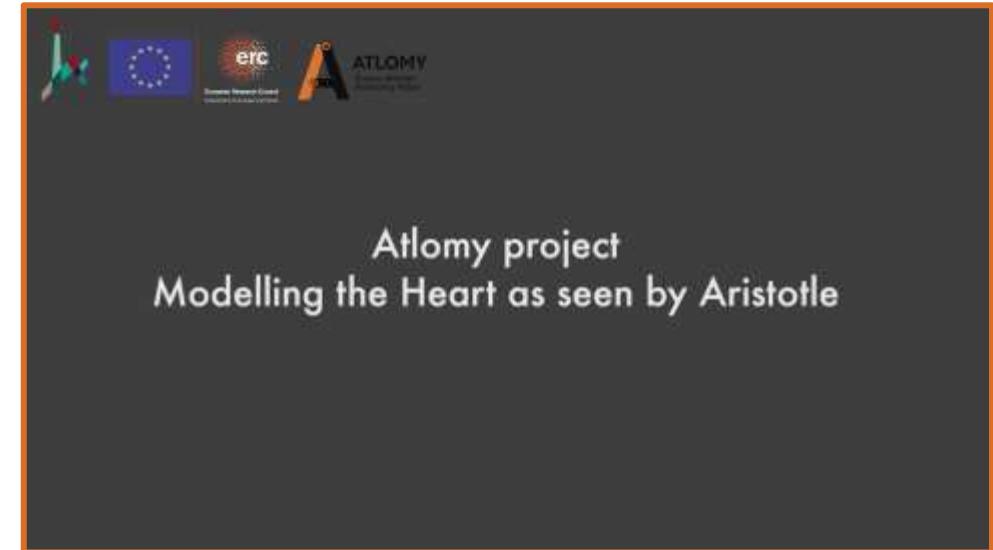
3D model of the viscera
according to *Sacred Disease*
(© ATLOMY)

From Text to Model



The screenshot shows a software interface titled "View of Modelling instructions - Sub-items". It lists various anatomical structures with their names and corresponding instructions from Aristotle. The structures include the Esophagus, Membrane bands, Stomach, Thin intestine, Large intestine, Cecum, Colon, and Rectum. Each entry has a "Name of item / sub-item" and a "Instructions" section containing a bulleted list of Aristotle's descriptions.

Sub-item	Name of item / sub-item	Instructions	Source
1	Esophagus	stomachos_aesophagus_text	Aristotle does not differentiate between the laryngopharynx and... text
2	Membrane bands	humenodes_diemol_, membrane b...	Draw connections of membranous material from the esophagus ... text
3	Stomach	ant kolika_stomach_text	The basic model for the stomach is canine and not human. See p... text
4	Thin intestine	enteron_thin_intestine_start	From the "test" of the stomach, draw a tube-like structure, visib... text, unde
5	Large intestine	katō kolika_cecum_text	The large intestine is a general name which refers to everything ... textual-pr
6	Cecum	koreis_cecum_text	For Aristotle, the cecum is a second cavity, symmetrical in size a... textual-pr
7	Colon	to stenēteron kai elgmenon_large_L...	Based on the layout of the ascending, transverse, descending a... text, unde
8	Rectum	arches_rectum_text	After the coiled part, draw a straight, wider tube connecting the ... text, unde



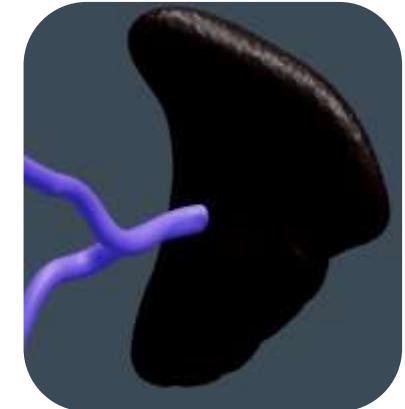
The screenshot shows the homepage of the ATLOMY project. At the top, there are logos for the European Union, the European Research Council (ERC), and the project itself. The main title is "Atlomy project" followed by the subtitle "Modelling the Heart as seen by Aristotle".

Modelling as part of the Research Process

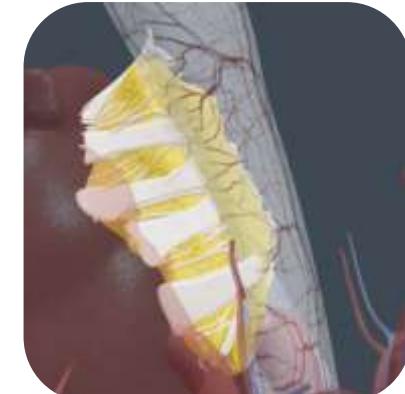
Requires clearer decisions than in writing

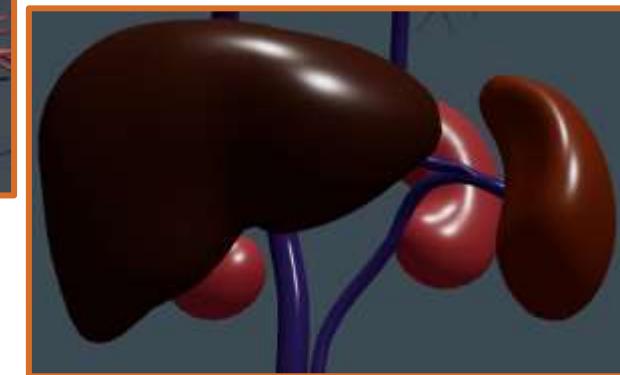
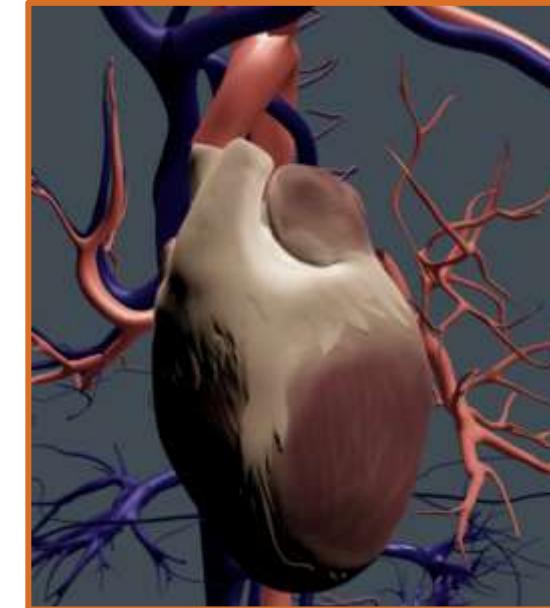
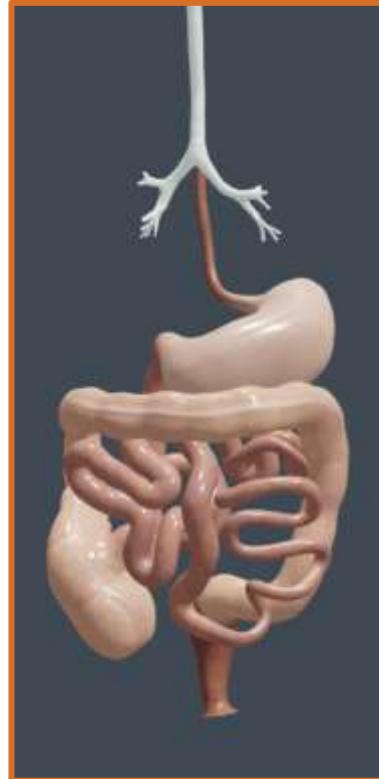
Forces a deeper analysis of the text:

- “The vessel splits near (*para*) the ear.”
- “A vessel extends from the spleen.”
- “Fatty and fibrous bonds connect heart to windpipe”
 - Where *exactly* is “near”?
 - From which point *precisely* on the spleen?
 - How do the fatty and fibrous bonds connect?



(© ATLOMY)







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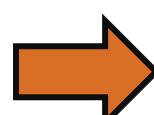
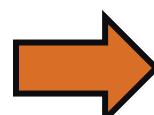
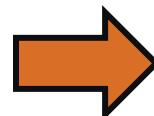
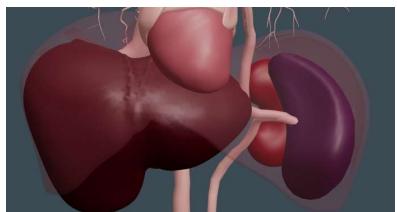
ATLOMY
Greco-Roman
Anatomy Atlas

Embedding in the Atlas

Making Models and Research
Accessible
- with their Data!

Interactive Atlas

Sacred Disease. Ch. 3 [1] Certainly, the brain is responsible for this affliction, just as for the other gravest diseases as well. How it happens and from what cause, I will make clear. [2] The brain of humans is double, just as that of all other animals. A thin membrane separates it in the middle [lit. separate its middle]; therefore, it does not always hurt on the same [part] of the head, but sometimes on one of the two sides; sometimes on the entire head. [3] And vessels (phibes) extend (reinouein) to it from all over the body, many thin ones and two thick ones – one [extending] from the liver and one from the spleen. [4] And the one from the liver is as follows: part of the vessel extends downwards through the parts on the right, along the kidney itself and the lower back into the inner part of the thigh and reaches down to the foot – and it is called the 'hollow vein'. The other part [lit: the outer part of the vessel] extends upwards through the ear and the neck up to the right side, and splits also to the heart and the right arm; and the remaining part carries upwards through the collar-bone to the right side of the neck, to the skin itself, so that it is visible; but along the ear itself it is hidden, and there it splits. And the thickest, largest and hollowest part ends at the brain; whereas the other part ends at the right ear, another part at the right eye and another at the nostril.





ATLOMY
Greco-Roman
Anatomy Atlas BETA

Search

Learn how to use ATLOMY.

Available Models

Aristotle -
Respiratory
System
by: Aristotle

Aristotle -
Gastrointestinal
System
by: Aristotle

Hippocratic Sacred
Disease - Vascular
System
by: Hippocratic Corpus

Hippocrates - De
Corde
by: Hippocratic Corpus

Aristotle - Vascular
System
by: Aristotle

About ATLOMY

ORIGIN OF HUMAN KNOWLEDGE
THE HERACLITUS UNIVERSITY OF STAVROUPI

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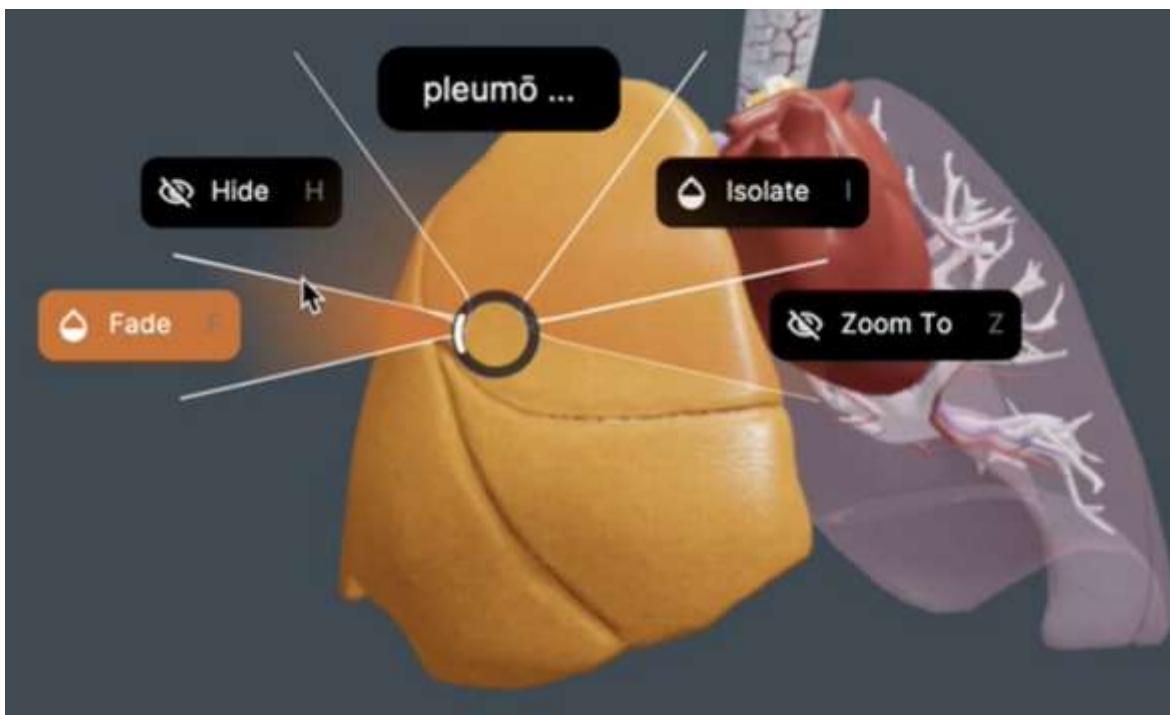
References

 Search for reference...

FILTER BY Author ▾ Treatise ▾ Reset

74 Reference

1. Hipp., *Cord.* 7.1 (192,20 Duminil= IX.84 L.); **vessel**
 ἡ γάρ παχεῖται φλέψ ἐκ μιᾶς ἀναθέουσα πλανᾷ τὴν ὄψιν ἢν ἀνατμηθῇ
2. Hipp., *Cord.* 8.1 (192,25 Duminil= IX.84 L.); **vein**
 Αγχοῦ δὲ τῆς ἐκφύσιος τῶν φλεβῶν σώματα τῆσι κοιλίηστιν ἀμφιβεβήκασι, μαλθακά, σπραγγώδε, ἀκληίσκεται μὲν οὖν τρήματα, τρήματα δὲ οὐκ ἔστιν οὐάτων
3. Hipp., *Cord.* 9.1 (193,11 Duminil= IX. L.); **vessel**
 Διὰ τούτο δέ φημι καὶ φλεβία μὲν ἐργάζεται τὴν ἀναπνοήν ἐξ τὴν ἀριστερὴν κοιλίην, ἀρτηρίη δὲ ἐξ τὴν ἄλλην



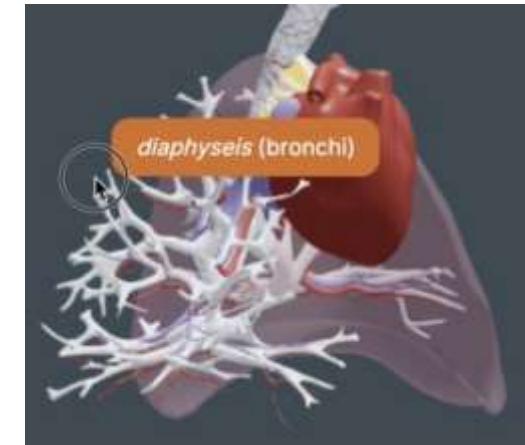
φλέψ (Vessel) ×
phleps

The term is found already in our earliest medical and literary texts such as Homer (seventh c. BCE) and *The Sacred Disease* (fifth c. BCE) to refer to vessels, that is, elongated pipe-like structures which are perforated and contain some liquid or airy substance - air, blood, humours, marrow, or some combination of the above. Once veins and arteries were distinguished (in the late fourth century) as two distinct systems differing anatomically and physiologically, φλέψ was mostly used to refer to veins in contrast to arteries.

Cardiovascular > *phleps (vessels)*

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 Full Details



3D Printing



Photo: Matan Divald



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Yael Baron
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Lidia Ozarowska
Andrés Pelavski Atlas
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Nur Salaymeh
Zeina Shihabi
Marco Vespa
Roey Zowerbach

Collaborations

The Laboratory of
Bone Mechanics and Structure



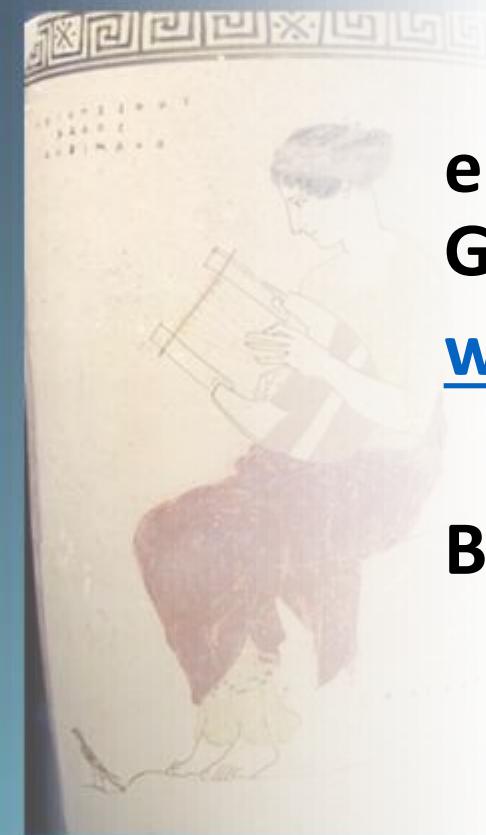
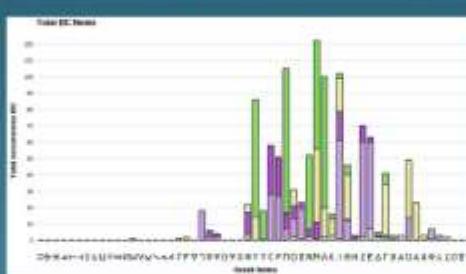
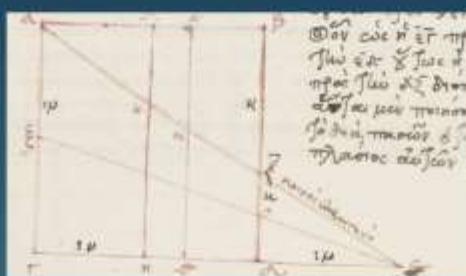
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By Prof. Tosca Lynch

DIGITAL HUMANITIES,
ENGLISH-MEDIUM EDUCATION,
CRITICAL THINKING



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Modelling for 3D Printing

Michael Donnay

Digital Humanities Research Hub

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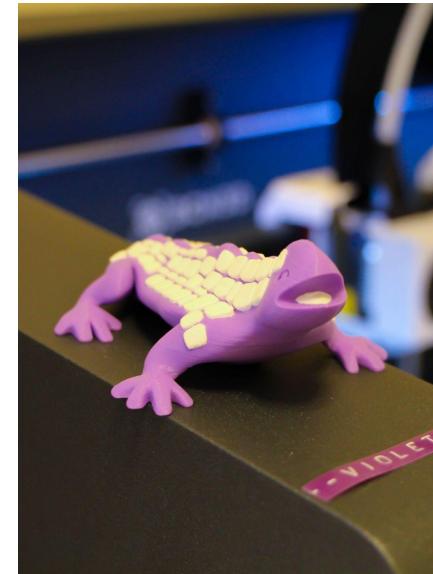


Modelling for 3D Printing

Why do you want to
print the object?



Functional Display

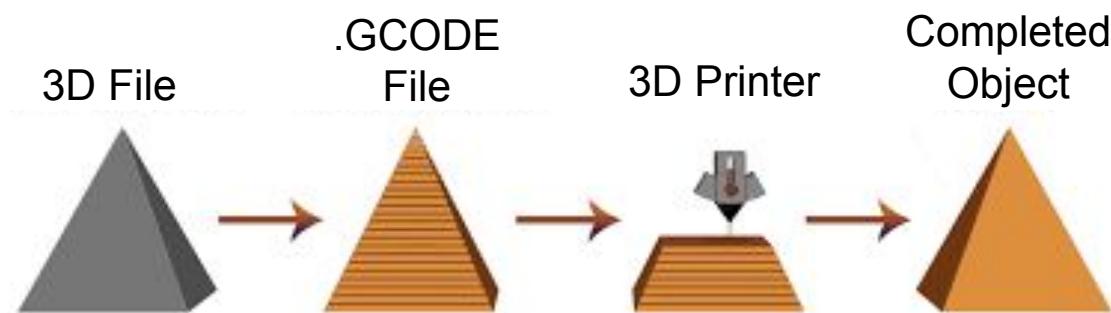
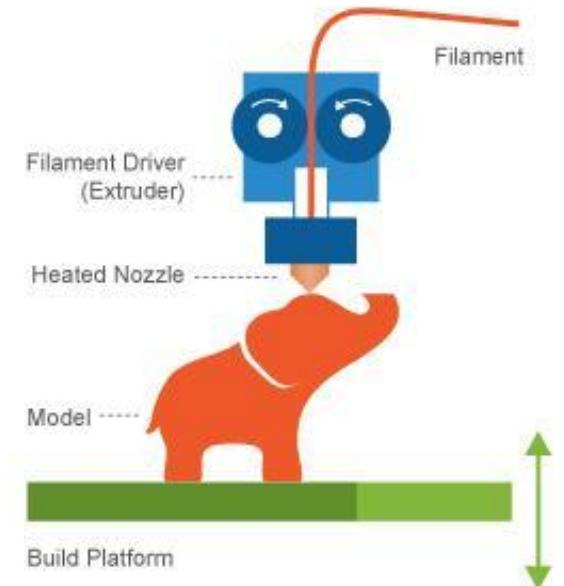


Overview of 3D Printing

Translating a 3D model from triangle-based geometry to layered geometry

Additive manufacture – stacking layers on top of one another to create objects

Fused filament fabrication – heating and extruding a material, that cools into a new shape



3D Printing Constraints: The Model

Essential: Model needs to be **manifold** (i.e. watertight)

Design considerations

- Bridging and overhangs
- Material spread
- Bed adhesion
- Time & material use
- Functionality – Moving parts? Strength needs?



3D Printing Constraints: The Printer



Size limits for your printer

- Overall size of object
- Potential reassembly

Orientation & support

Material characteristics

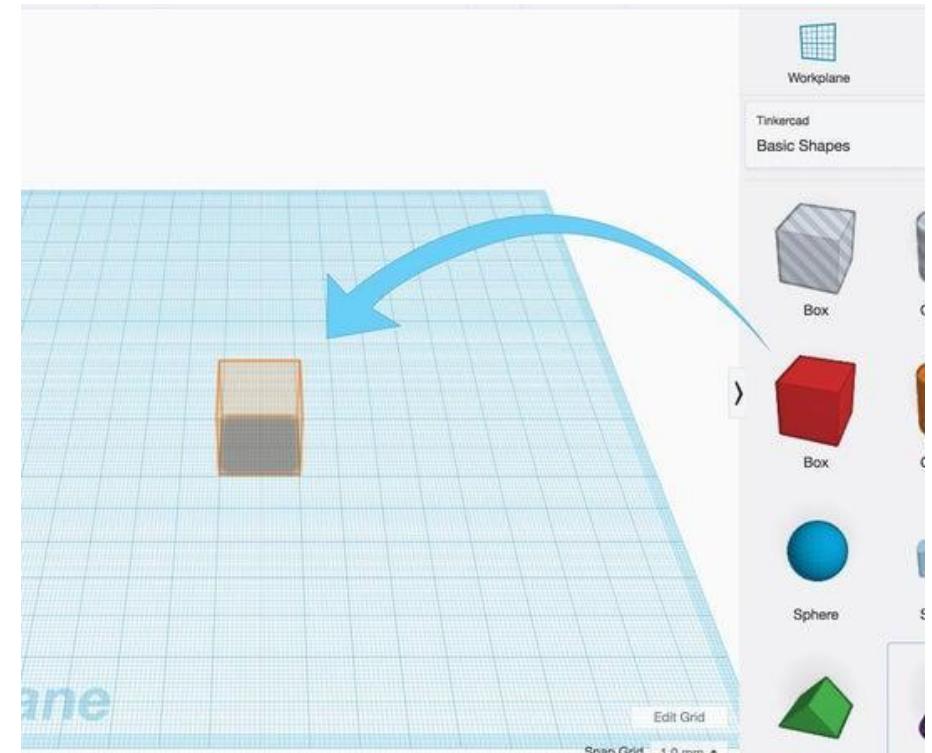


AUTODESK Tinkercad

Advantages: easy to learn, works online, free, easy export to 3D printing formats (STL & OBJ)

Disadvantages: basic functionality, less flexible than SketchUp

Useful for: designing objects to print





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Demo

