Multiscale views of human anatomy

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Group

- LIACS
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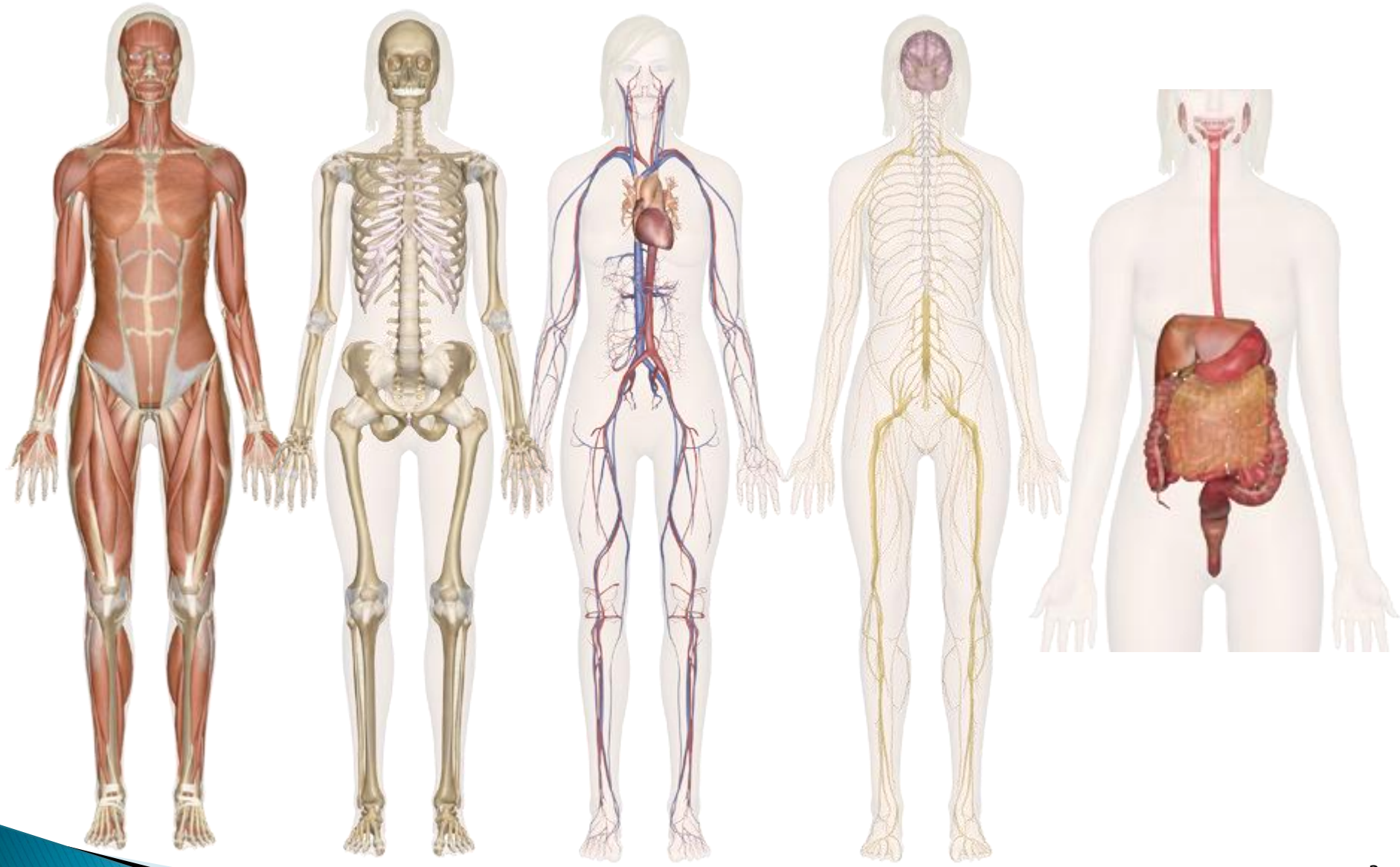
  - Michiel Helvensteijn – software developer
  - Irene Martorelli – bioinformatics expert (new)

- University College London (UCL)
  - Bernard de Bono – biomedical expert, doctor
  - Pierre Grenon – semantic expert
  - Samuel Alexander– software developer (server side)
  - Syed Islam – software developer (new)



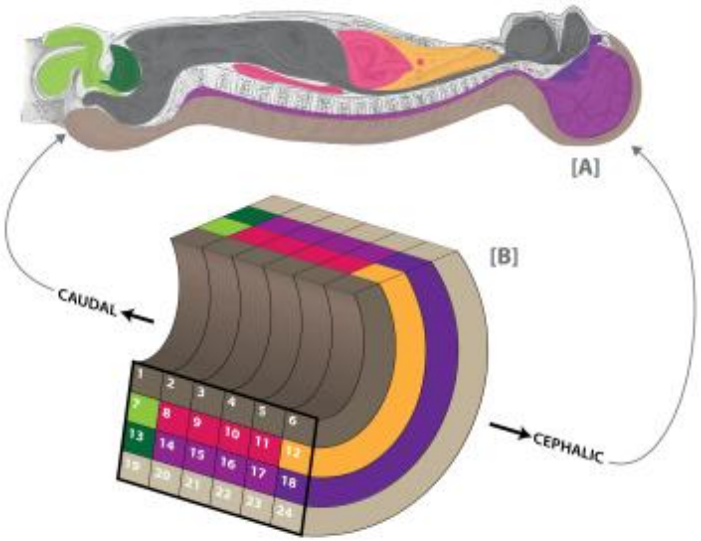
The human body
God's Masterpiece / A Wonderful Machine

- How many organs does a human being have?
  - About 7,500 named parts (according to The Terminologica Anatomica – the international standard on human anatomic terminology)
- How many blood vessels does a person have?
  - About **60,000** miles of blood vessels through which the heart pumps blood
  - Approximately 300 million capillaries
- How many cells are in a human body?
  - 37.2 trillion (estimated average number)

ApiNATOMY

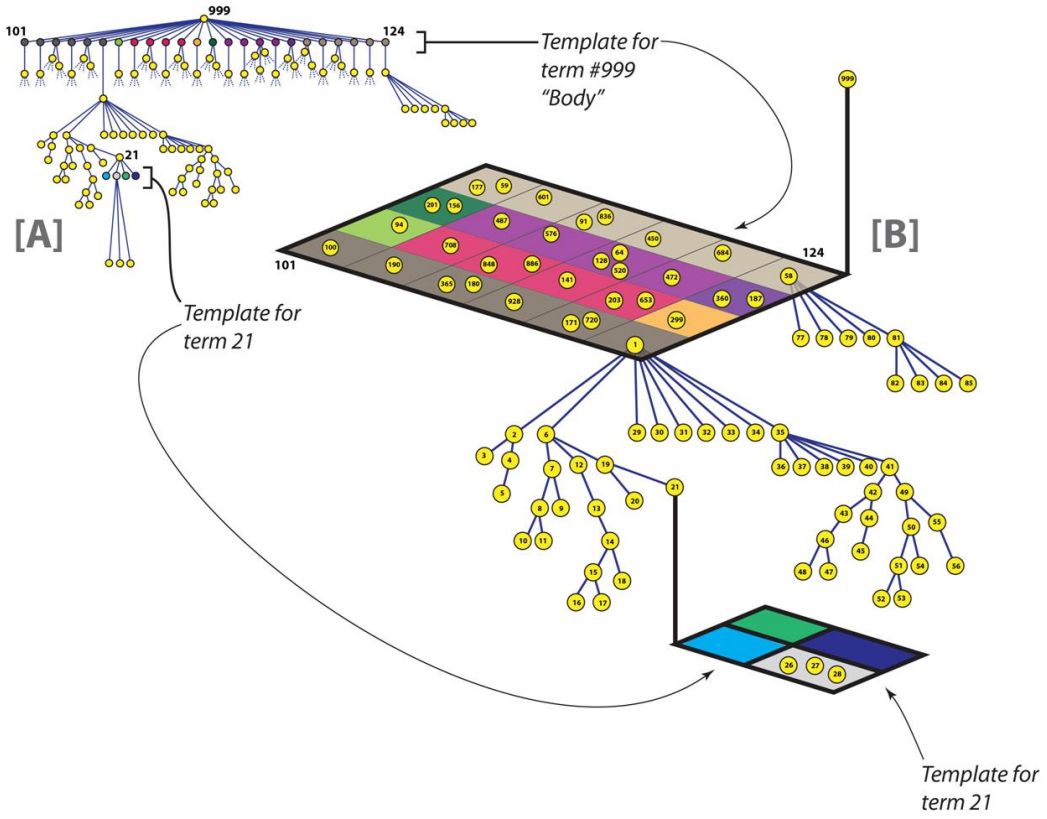
- Anatomy apps, even the most sophisticated, show static images and/or 3d models
- Our goal
  - Automatically generate schematic views of body organs, cells, proteins, genes, etc.
  - Based on open source structural data (ontologies, databases)
- Target audience
  - (Bio-medical) students
  - Researchers
  - Pharmacompanies

Schematic views of human anatomy



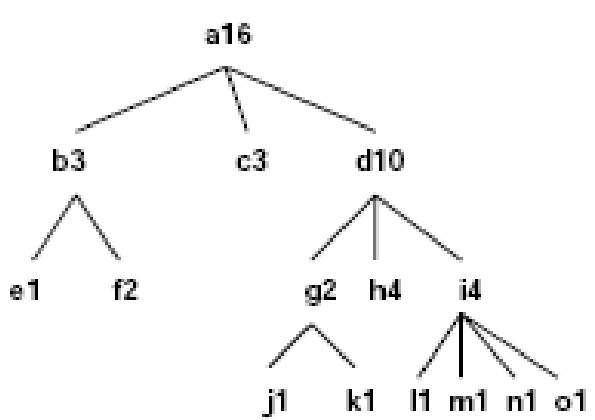
Large Intestine	Jejuno-Ileum	Liver Pancreas Duodenum	Stomach	Esophagus	Mouth Throat
Genitals Gonads	Vascular Caudal	Vascular Abdominal	Vascular Cardiac	Vascular Cephalic	Lungs
Urinary Tract	Nervous Caudal	Nervous Lower Spinal	Nervous Upper Spinal	Nervous Cephalic	Nasopharynx Conjunctiva
Lower Limb	Pelvis	Abdomen	Thorax	Neck Upper Limb	Head

[C]

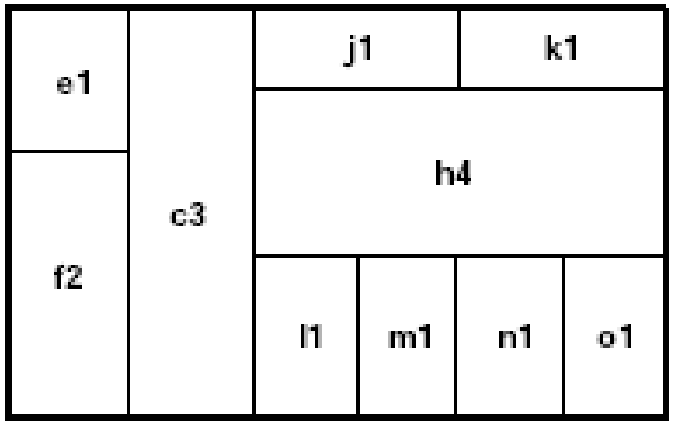


Treemaps

- A method for displaying hierarchical data by using nested rectangles
  - Example: folders on your computer:
    - Show hierarchy
    - Show (relative) folder sizes

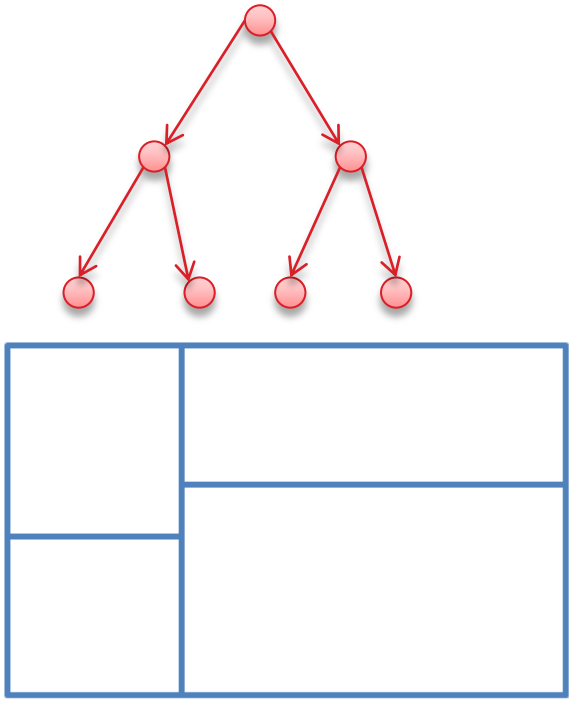


(a) Tree diagram

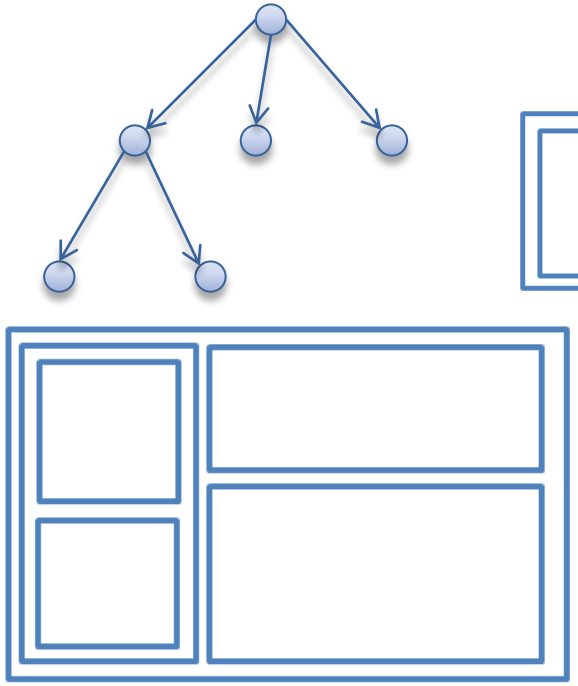


(b) Treemap

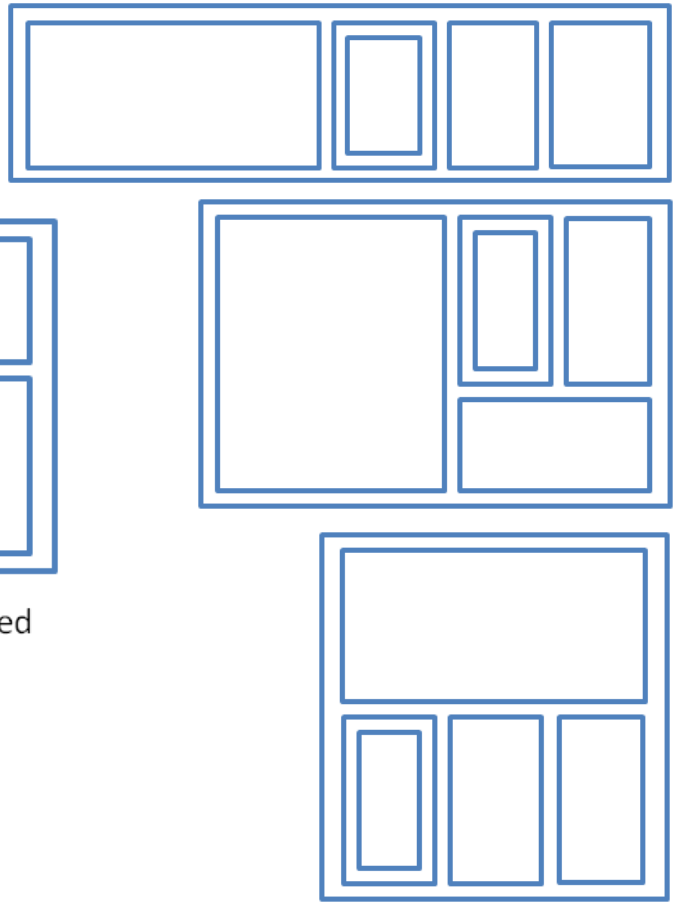
Variations of treemaps



a) Classic treemap



b) Hierarchical structure emphasized with a small fixed margin



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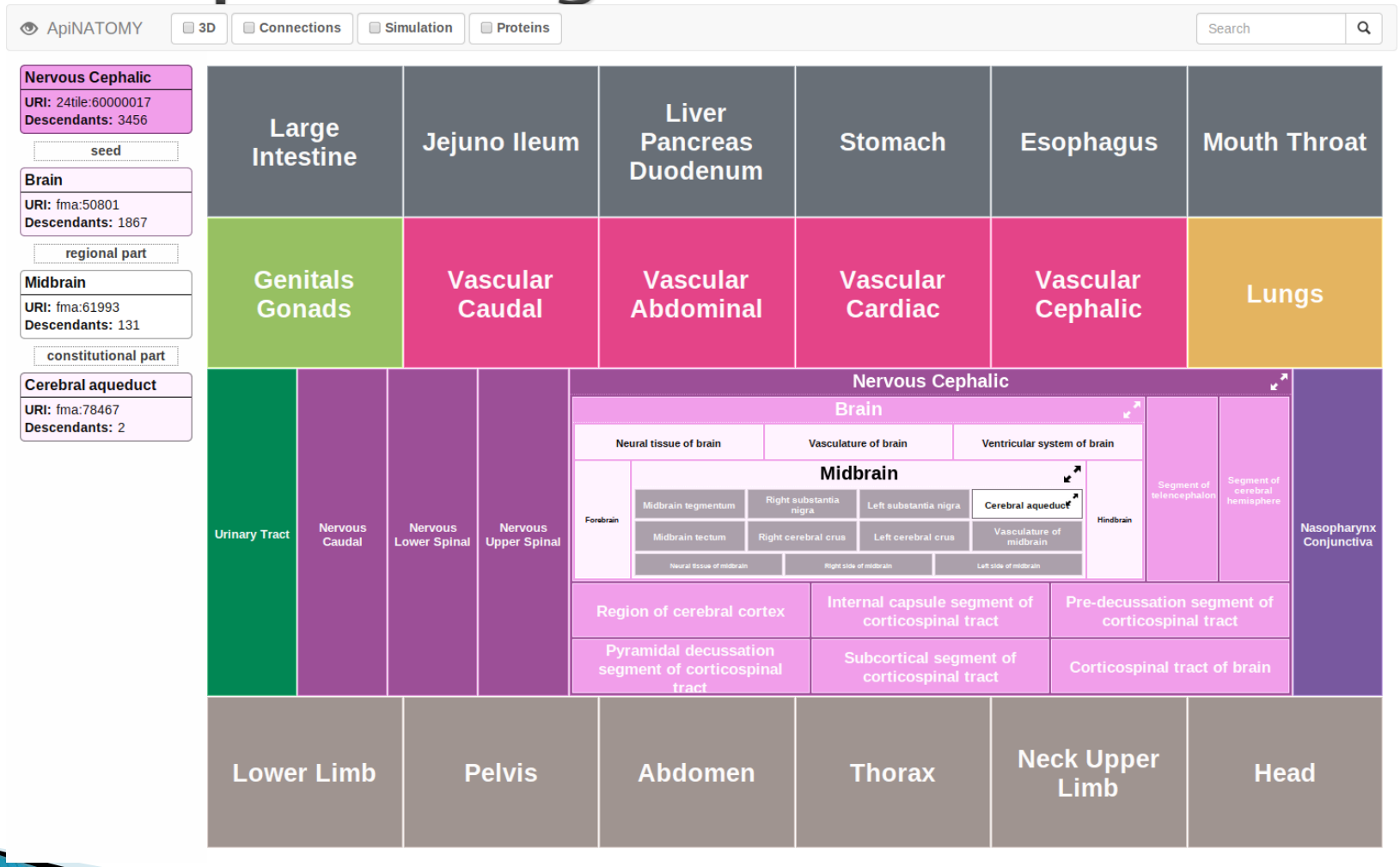
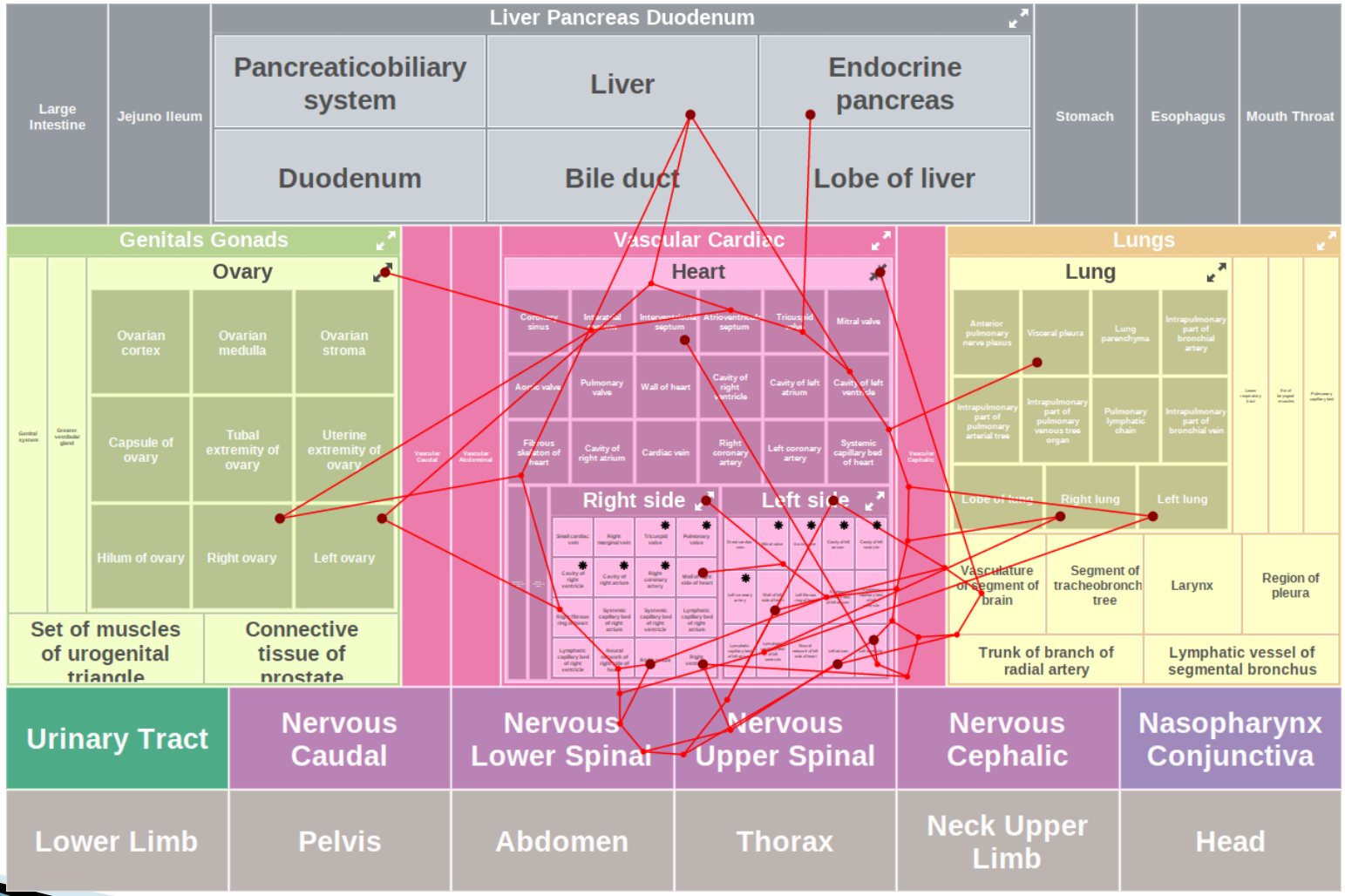
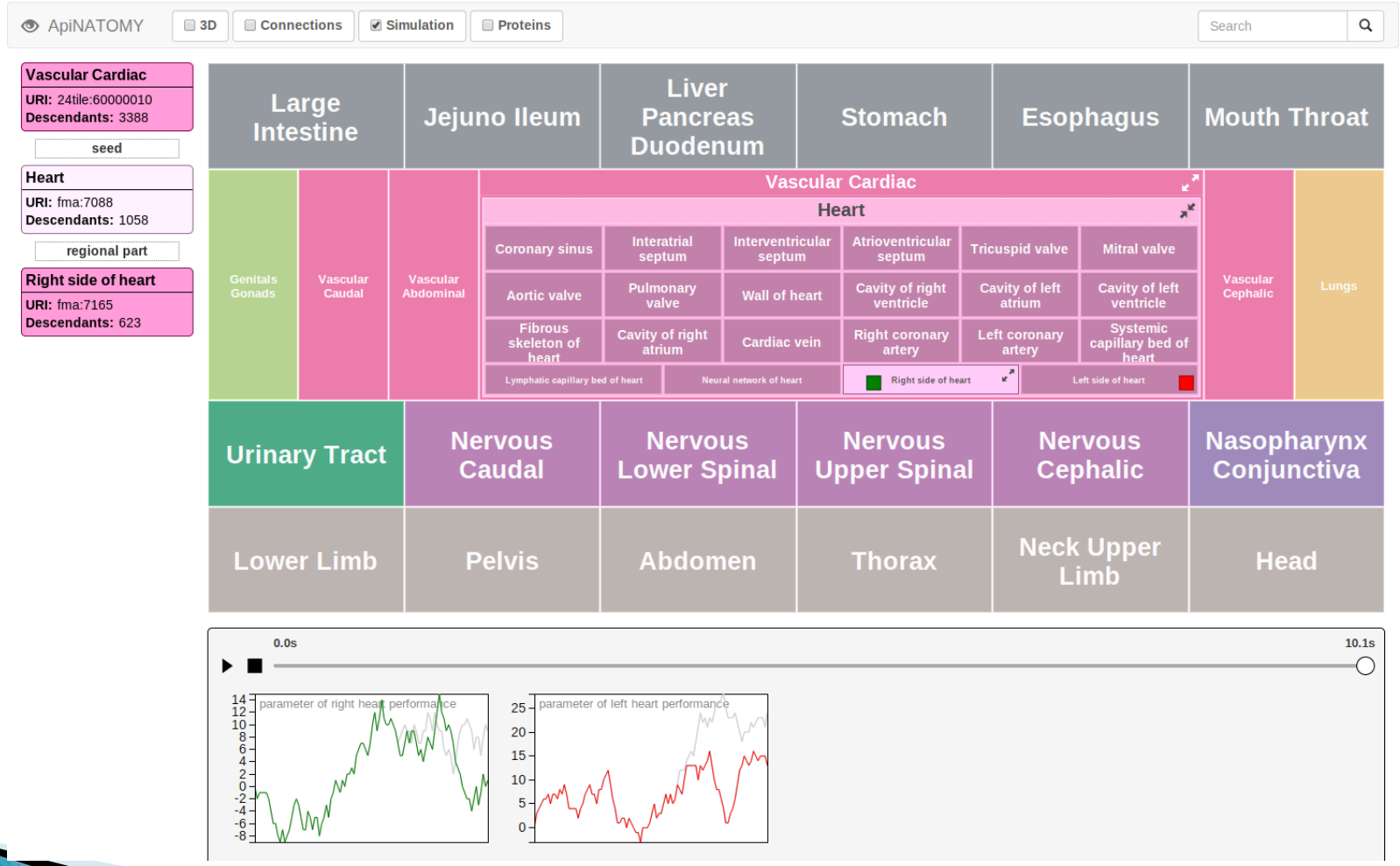
Tremap + navigation



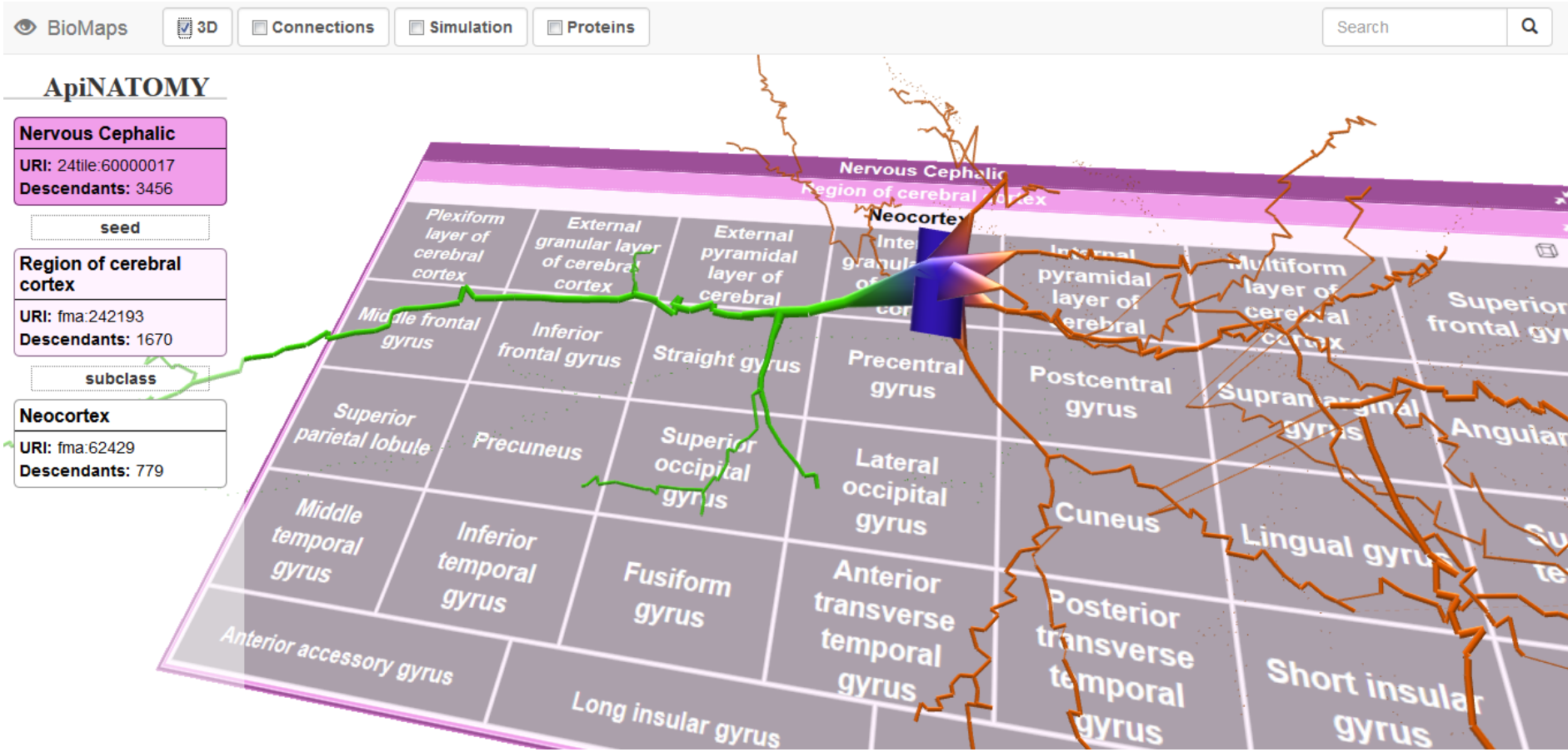
+ connections (blood vessels)



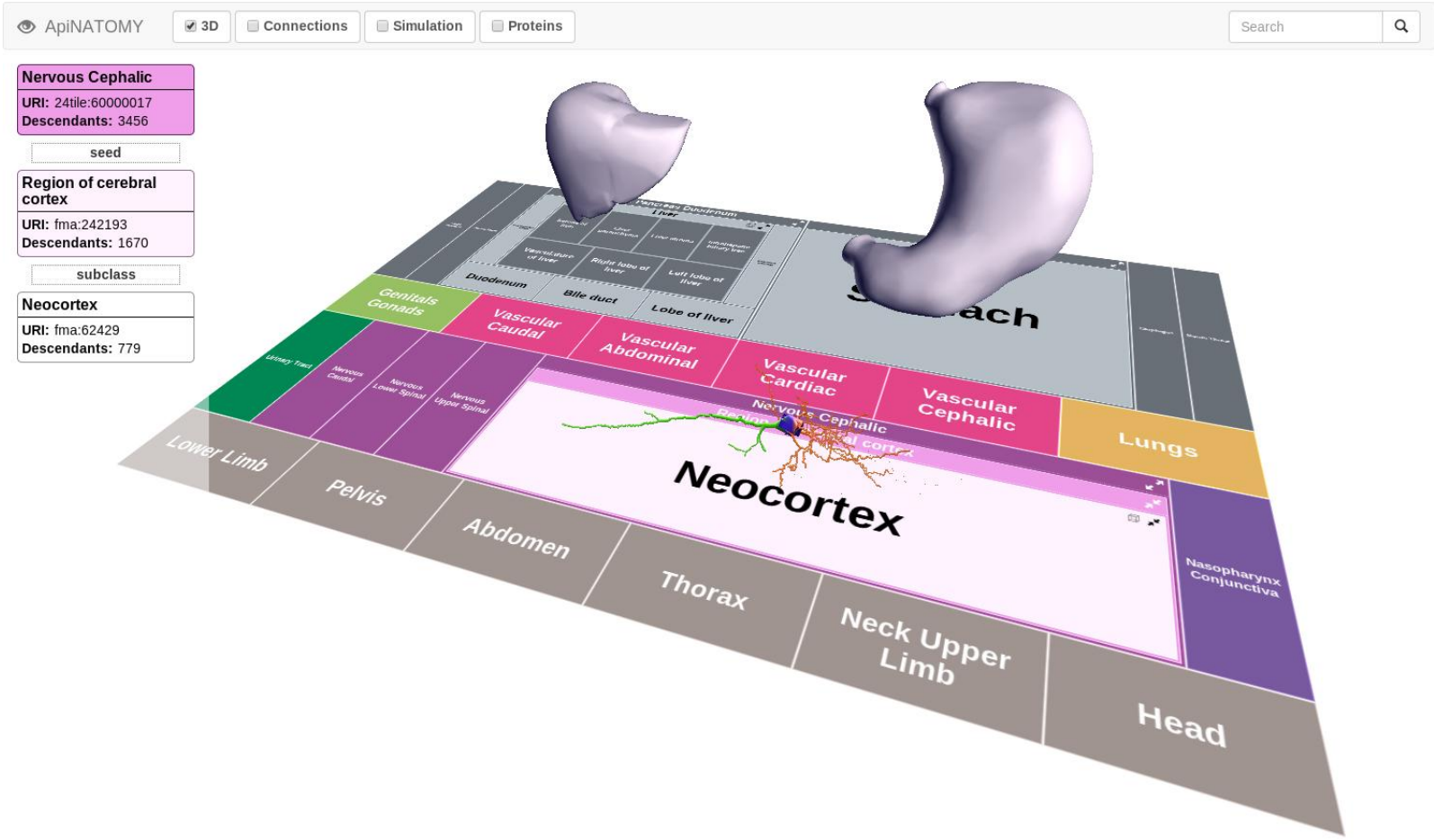
+ dynamic data (simulation, equations, plots)



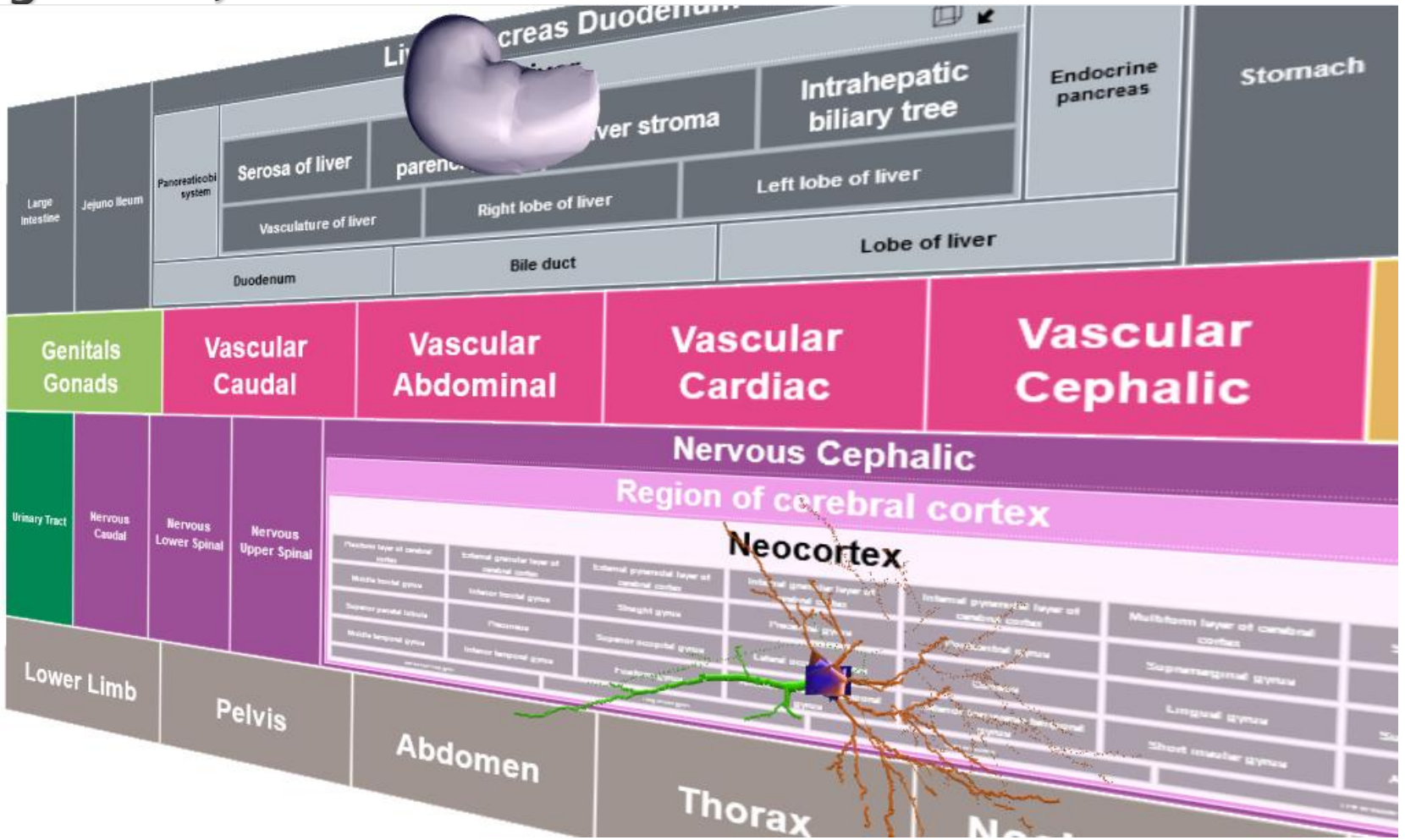
+ neurons


BioMaps
3D
Connections
Simulation
Proteins
Search
ApiNATOMY
Nervous Cephalic
URI: 24tile:60000017
Descendants: 3456
seed
Region of cerebral cortex
URI: fma:242193
Descendants: 1670
subclass
Neocortex
URI: fma:62429
Descendants: 779
Nervous Cephalic
Region of cerebral cortex
Neocortex
Plexiform layer of cerebral cortex
External granular layer of cerebral cortex
External pyramidal layer of cerebral
Middle frontal gyrus
Inferior frontal gyrus
Straight gyrus
Precentral gyrus
Postcentral gyrus
Superior parietal lobule
Precuneus
Superior occipital gyrus
Lateral occipital gyrus
Cuneus
Middle temporal gyrus
Inferior temporal gyrus
Fusiform gyrus
Anterior transverse temporal gyrus
Posterior transverse temporal gyrus
Anterior accessory gyrus
Long insular gyrus
Short insular gyrus

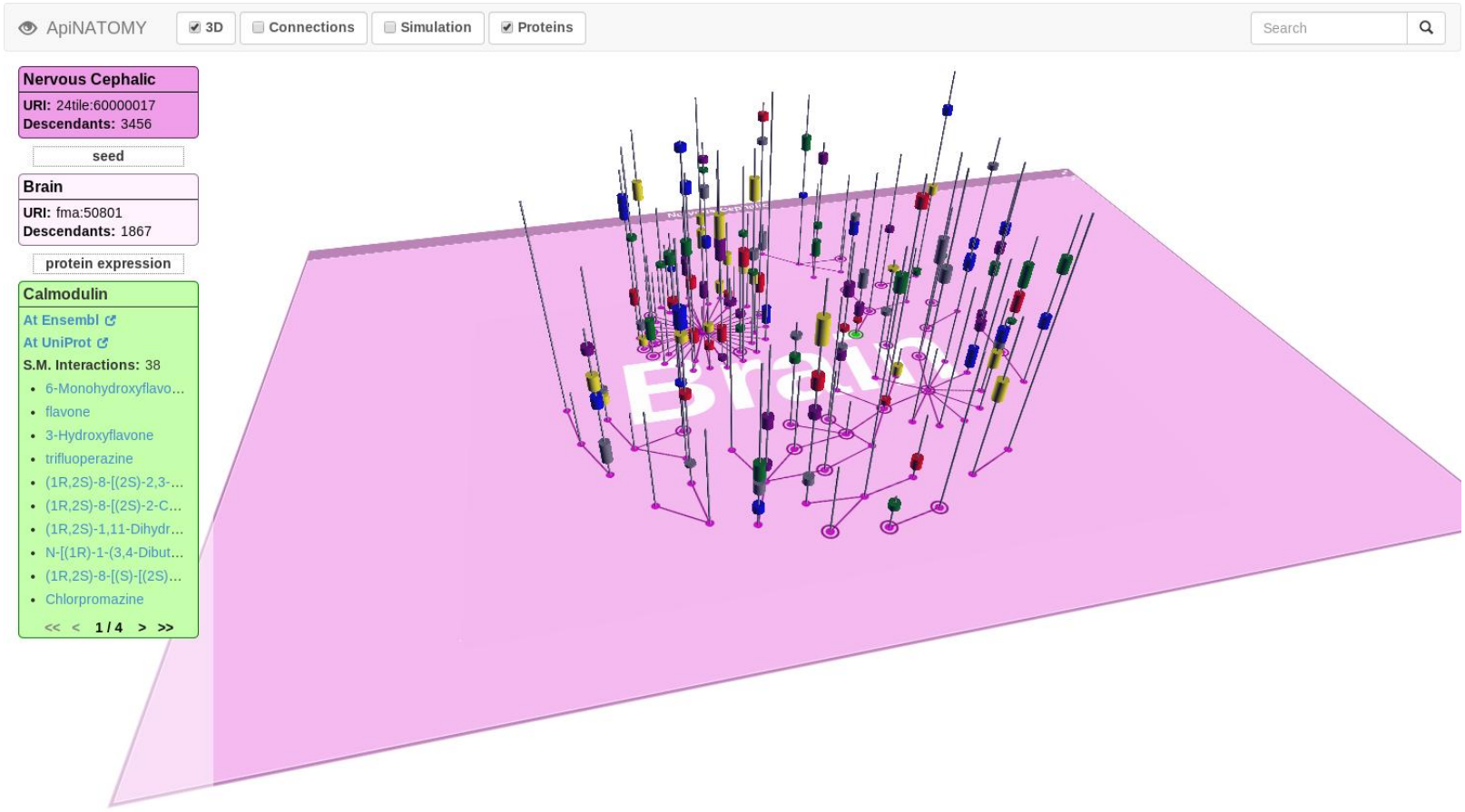
ApiNATOMY in 3d



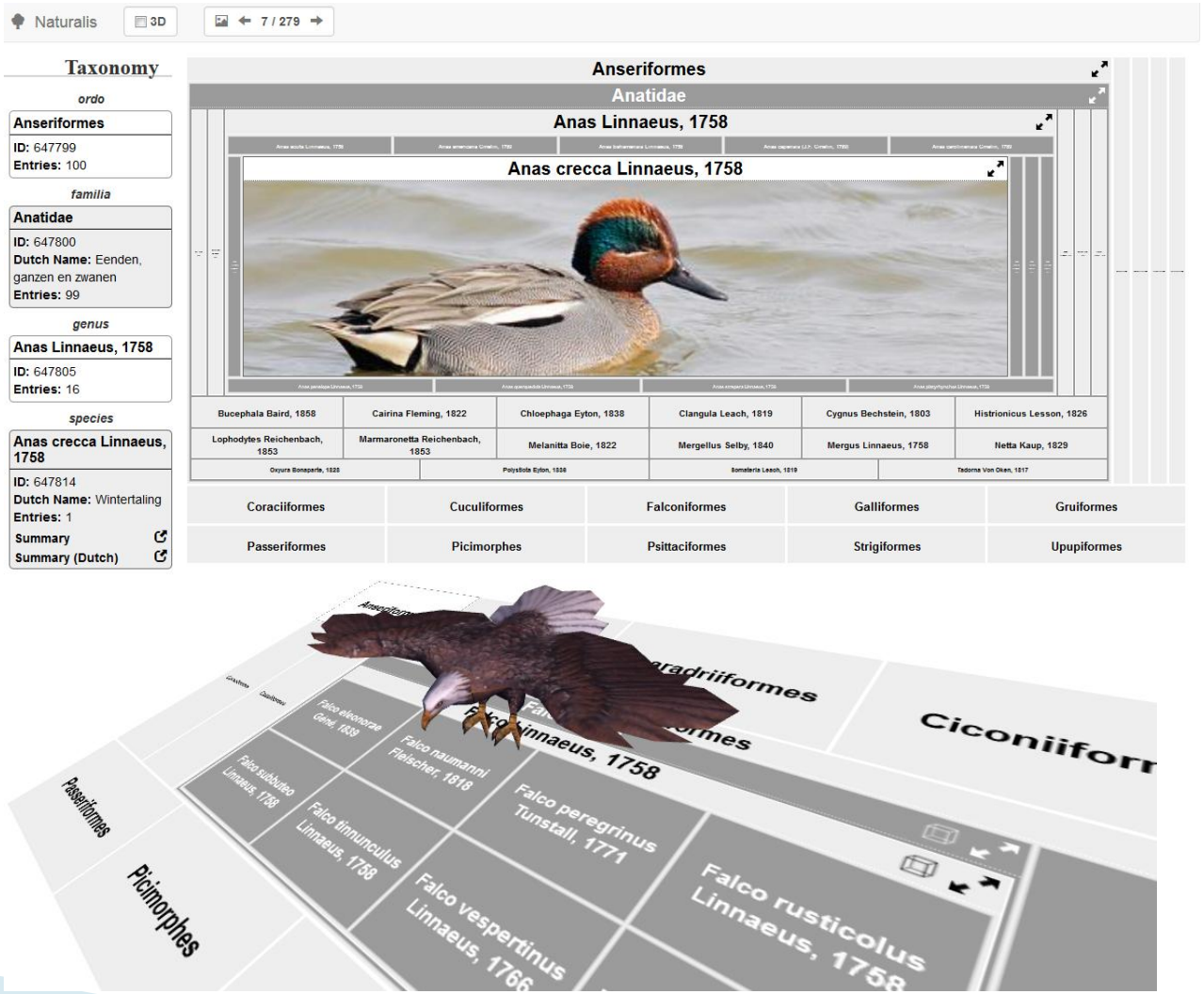
Any combination of tiles, 3d objects, connections can be shown



Protein structures



The tool can be used to visualize any taxonomy

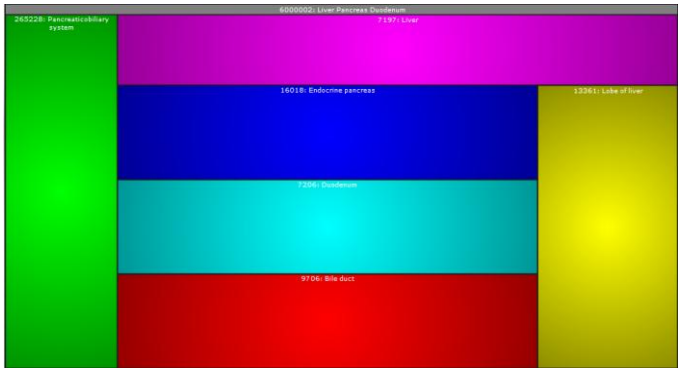


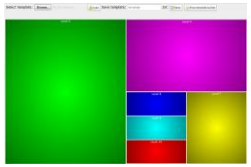
Want to know more?

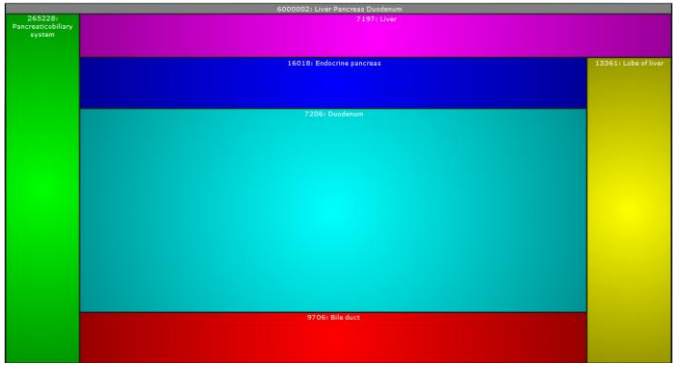
- Visit project web site
  - http://www.apinatomy.org/home
- Watch Youtube video
  - https://www.youtube.com/watch?v=QtnrA25n19U

Algorithms on trees/treemaps

- Constrained treemaps
  - A template defines the relative positions of tiles
  - Treemap = template + data
    - A tile stretches to get a certain area





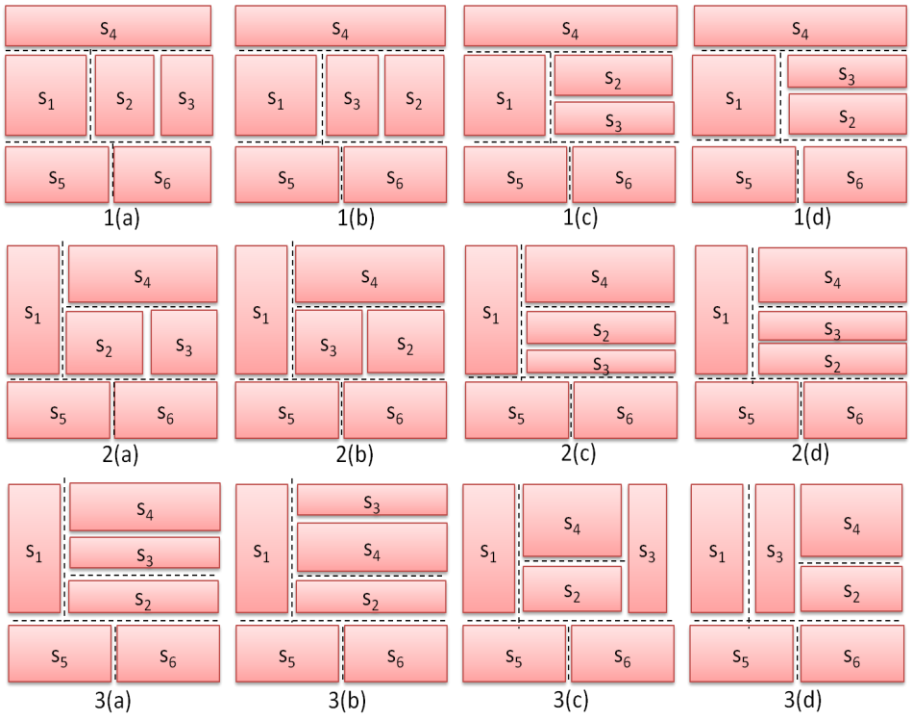


Automatic generation of templates

- Given a set of constraints, generate a treemap with suitable layout
  - "x left (right) of y"
  - "x above (below) of y"
- Example

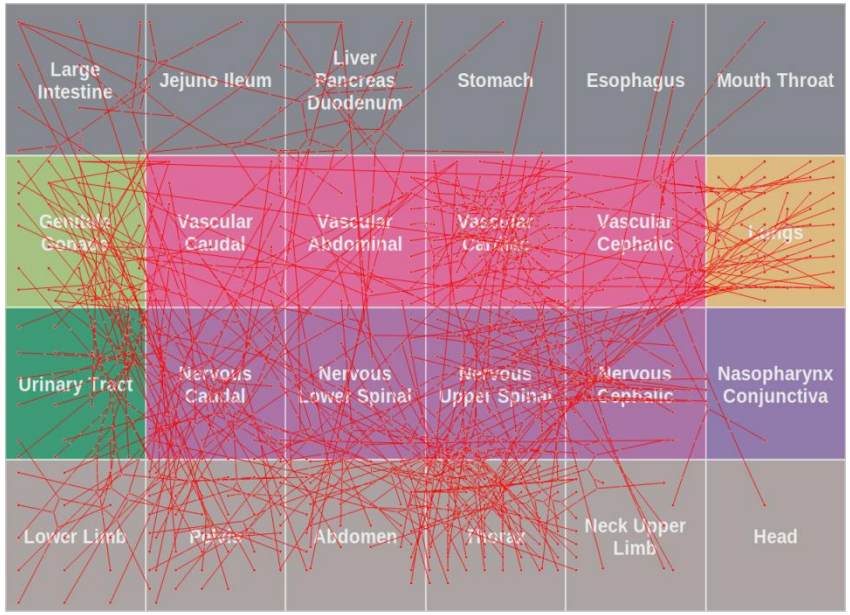
$\{s_1, s_2, s_3, s_4, s_5, s_6\}$

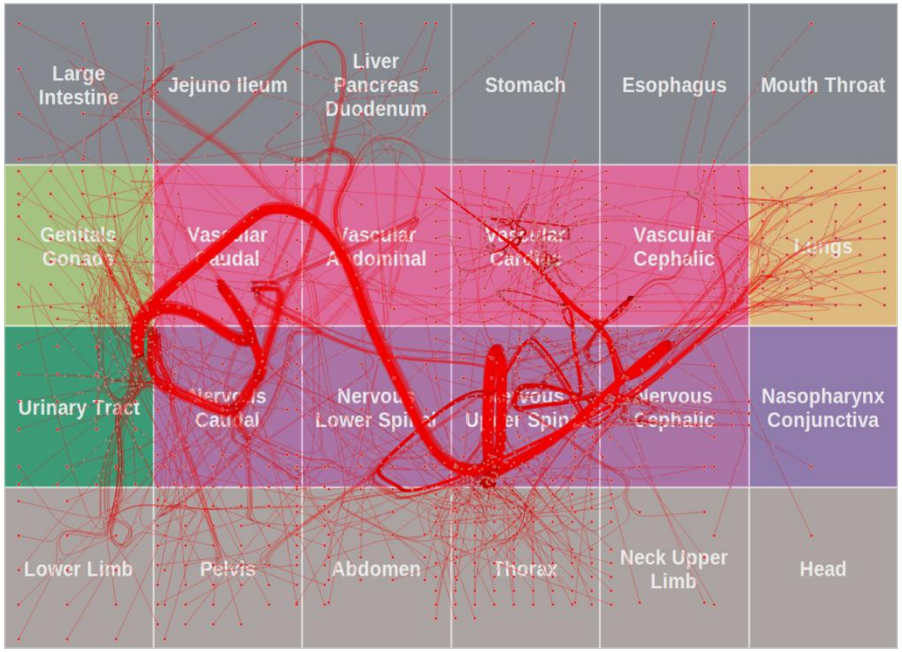
$$s_1 \rightarrow \{s_2, s_3\} \qquad s_6 \uparrow s_1$$
$$s_5 \rightarrow s_6, \qquad s_3 \uparrow s_5$$
$$s_2 \uparrow s_4$$



Algorithms on graphs

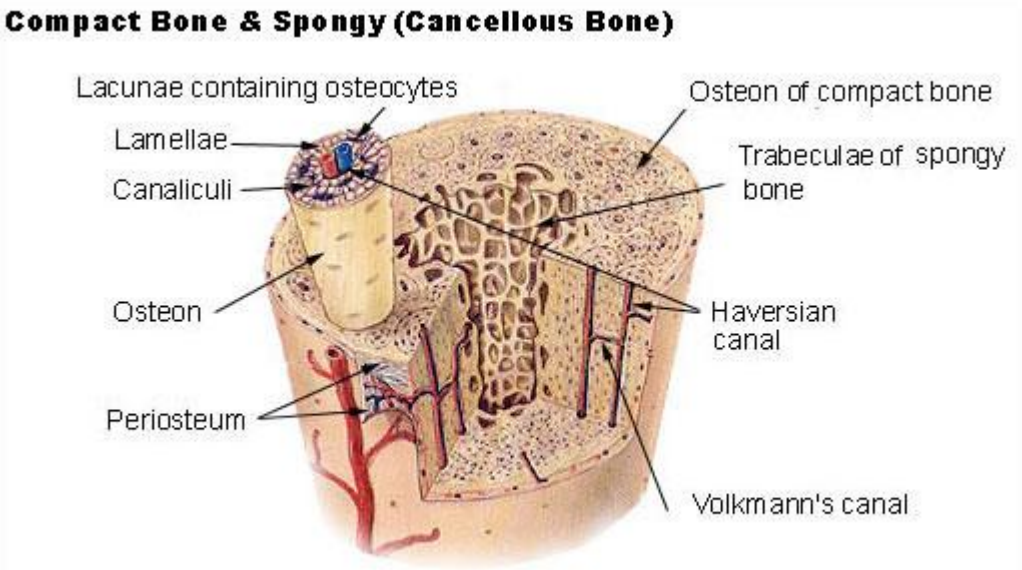
- Edge bundling

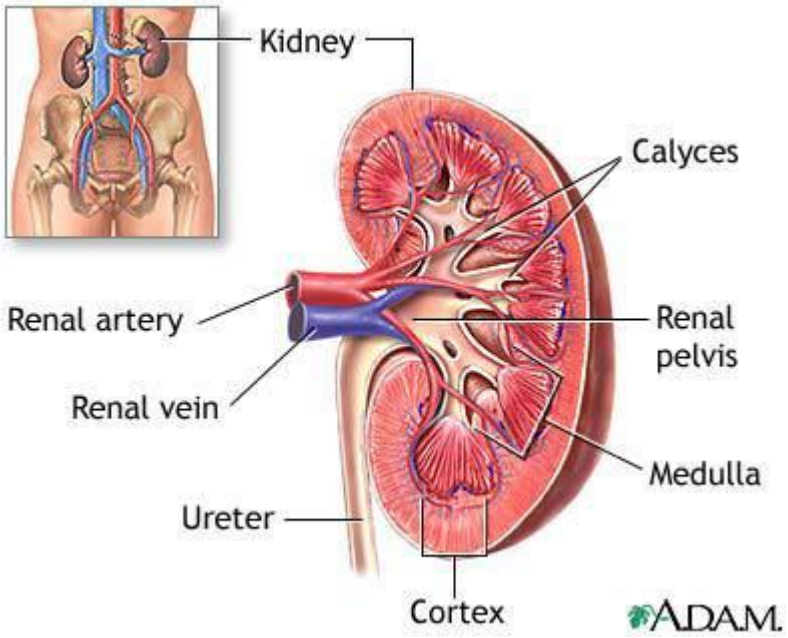




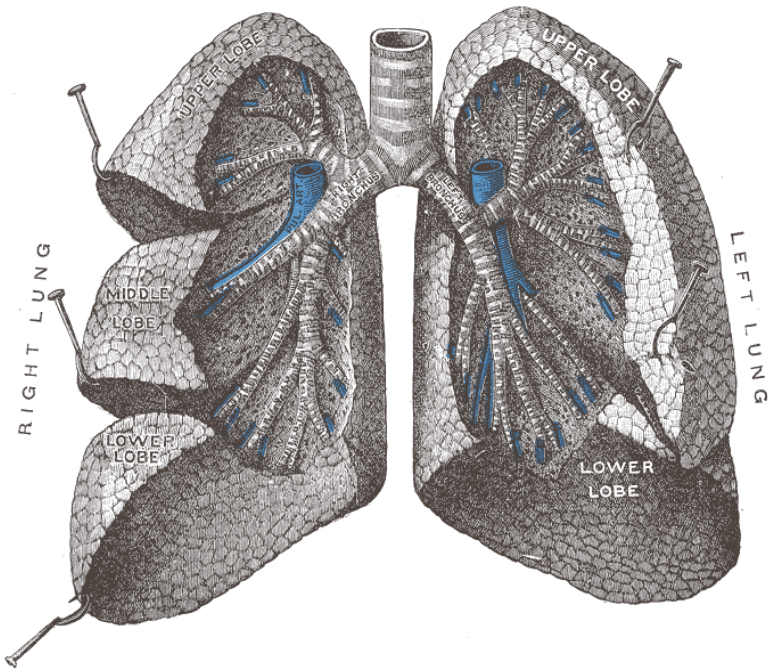
ApiNATOMY-2

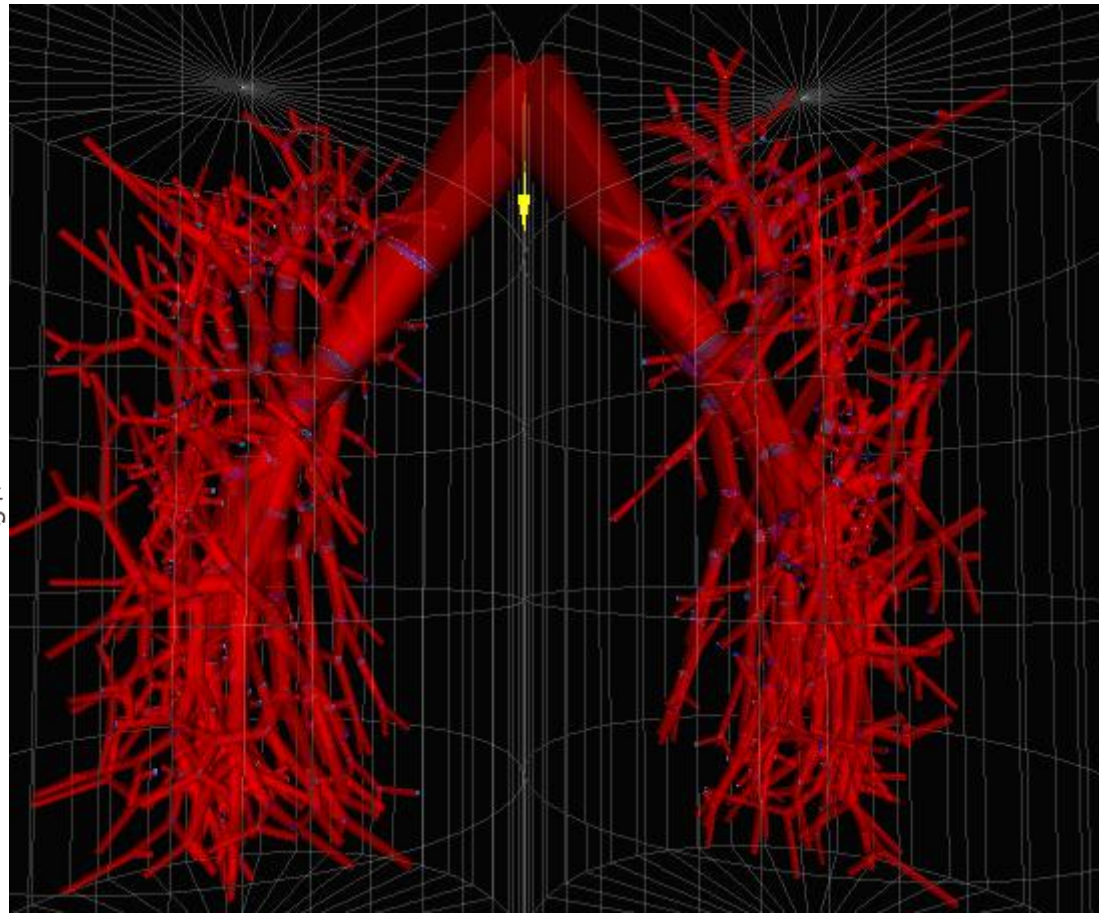
- Show internal structure of organs, conductive airways, blood vessels, etc.
- Dynamic processes in the body



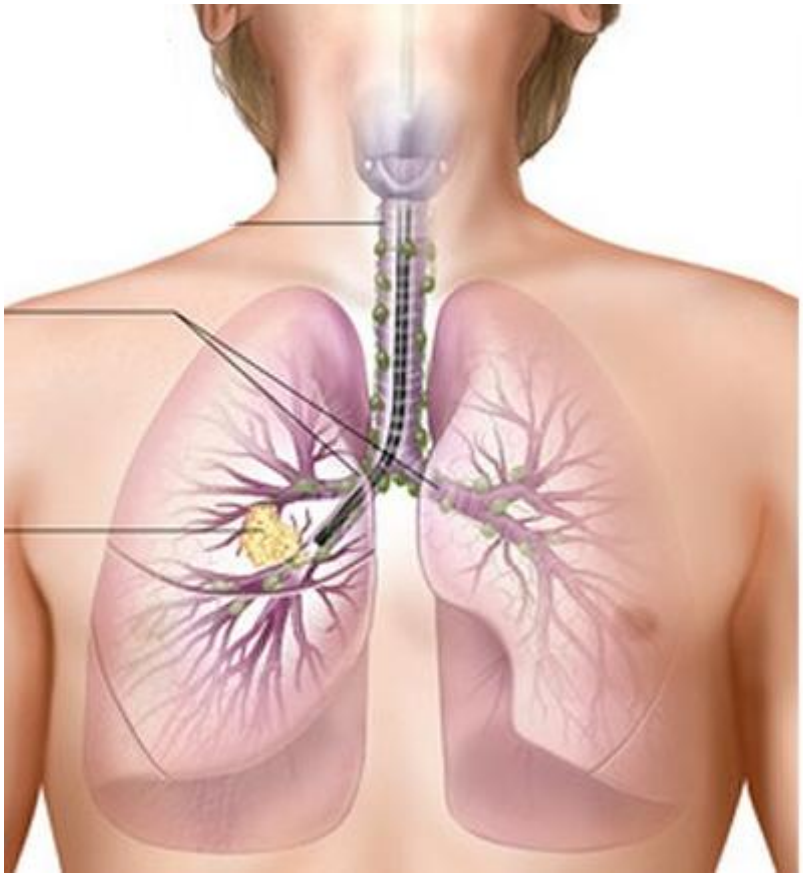


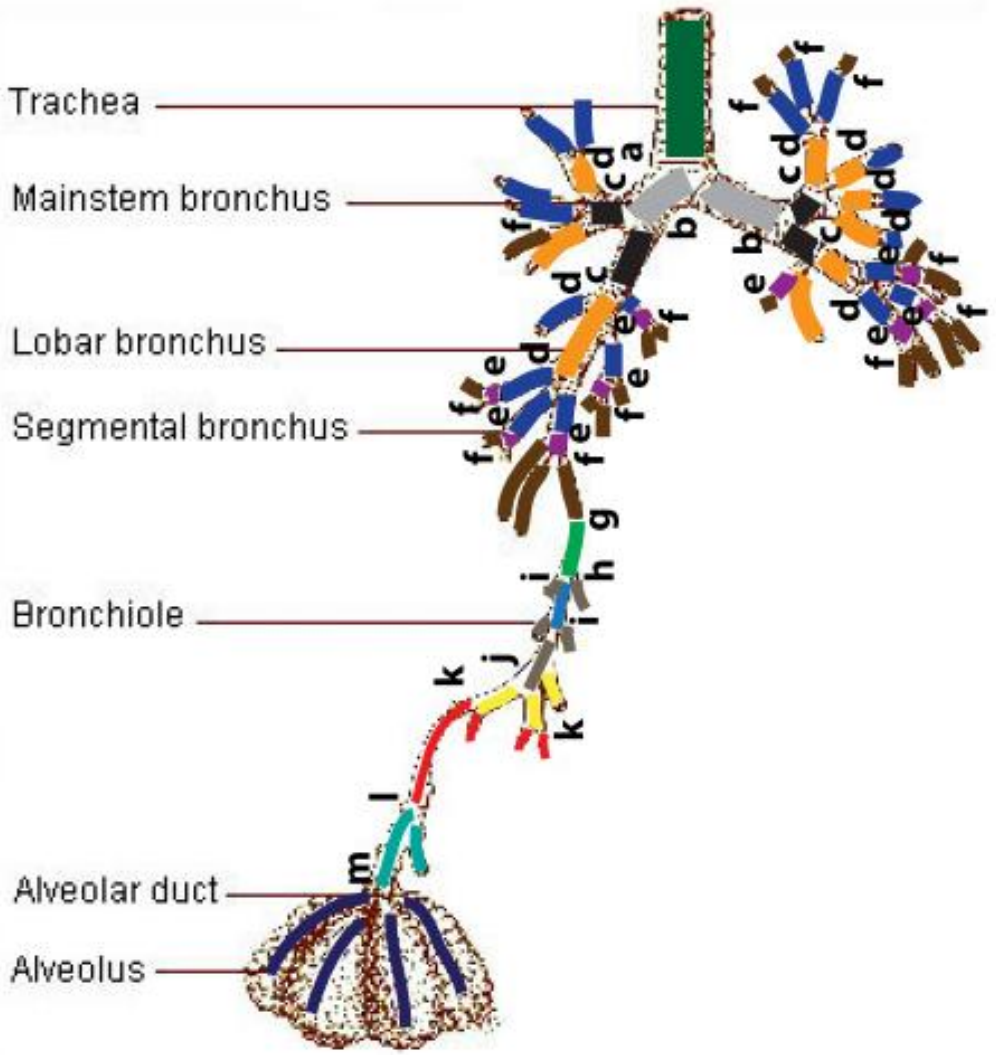
Algorithms – generate 3d trees



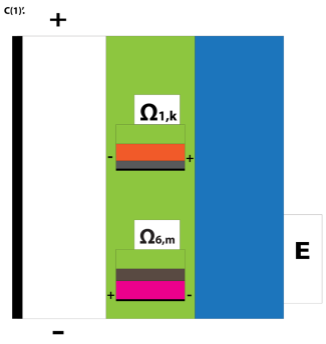


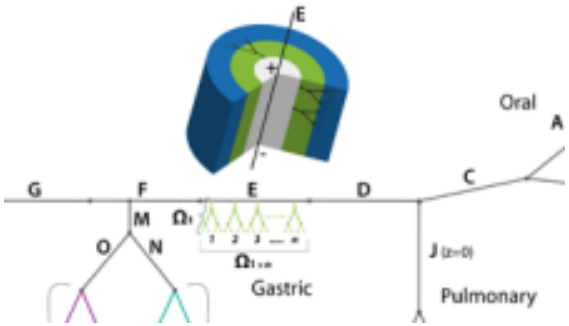
Not just any 3d tree



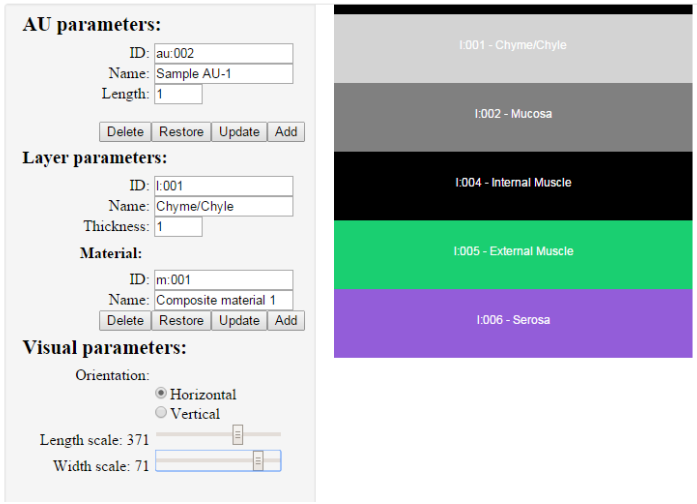


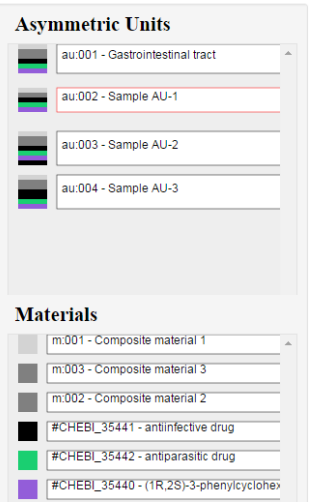
Design patterns for each tree level



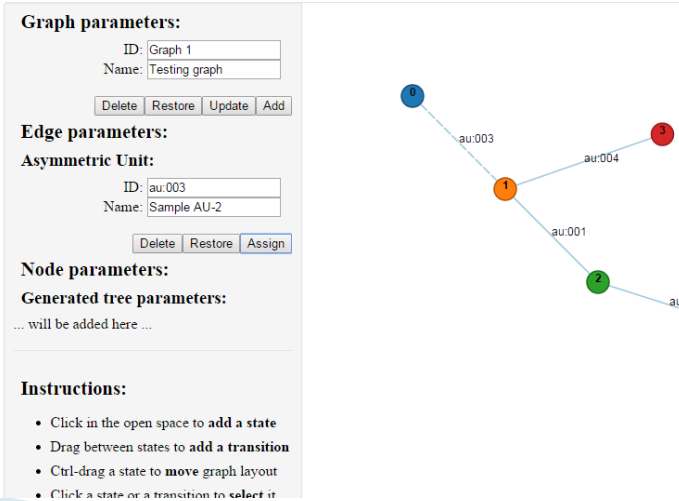


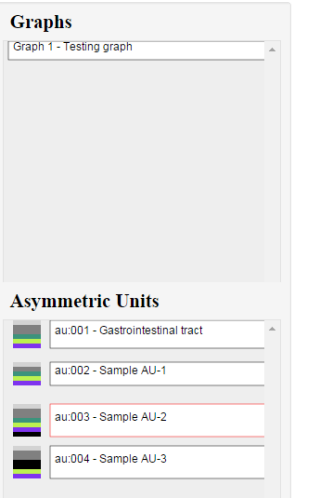
Asymmetric Unit Editor





ApiNATOMY graph editor





Project options:

- Algorithms (example)
  - Basic task:
    - Implement template generation algorithm to satisfy layout constraints
  - Unveil your research skills
    - Consider different constraints and assumptions
      - How to generate/choose the best suitable template
      - What if (small) gaps among tiles are allowed
      - Tile area proportions can be (slightly) distorted,…
- Applications
  - Work with our bio-medical advisor to produce an interesting demo
- Computer-human interface
  - How to represent/edit data on mobile devices

Skills required

- JavaScript
  - It is possible to use other programming languages for prototype or standalone algorithm implementation
- JavaScript libraries for 2d & 3d visualization
  - d3.js, three.js,…
- Interest in algorithms