

MULTISCALE VIEWS OF HUMAN ANATOMY

Natallia Kokash, LIACS

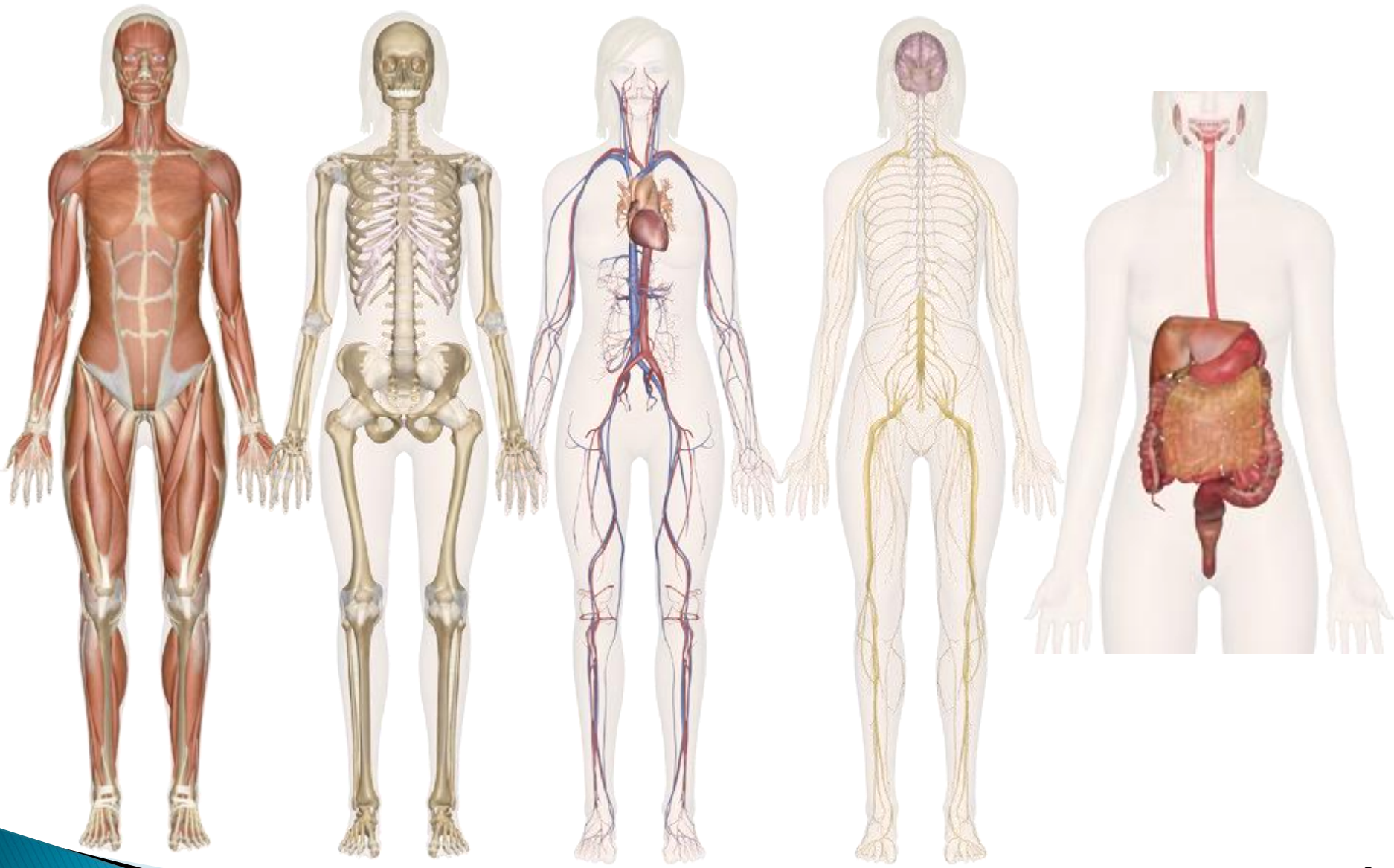
Group

▶ LIACS

- Joost Kok – project coordinator
- 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

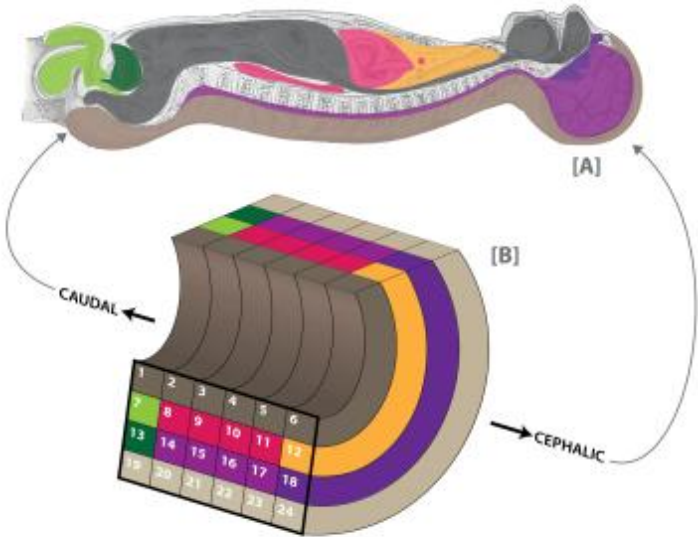
God's Masterpiece / A Wonderful Machine

- ▶ 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)

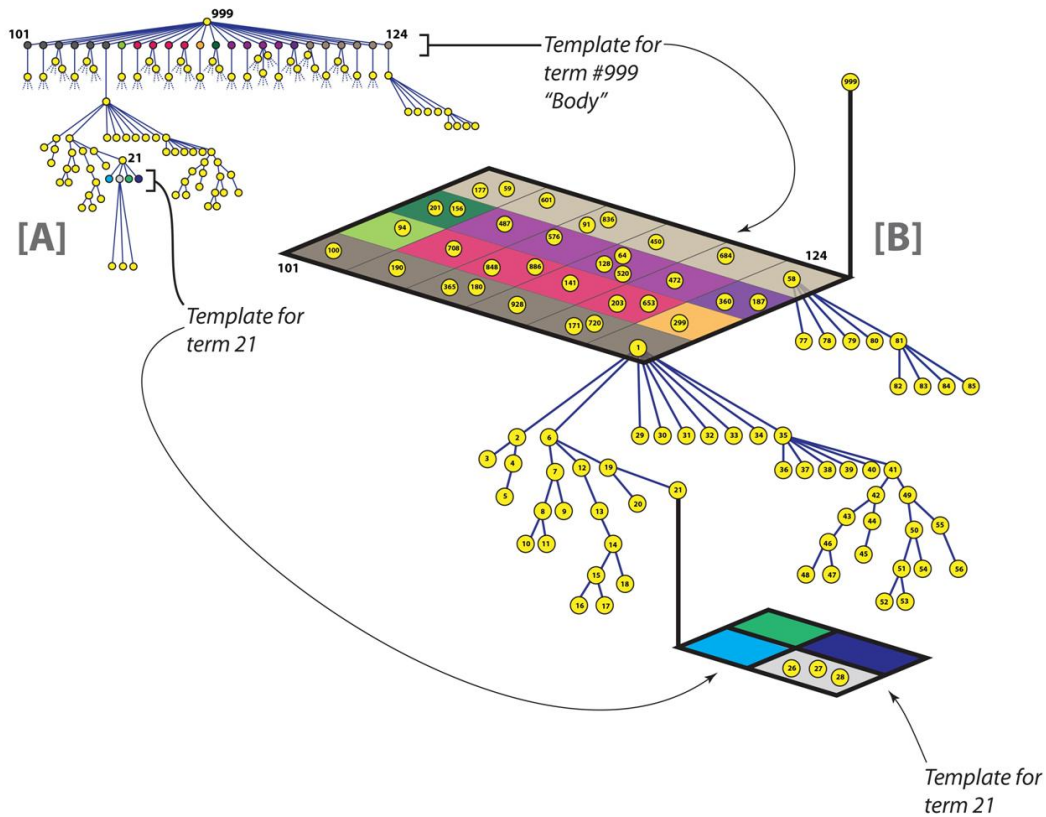
ApiNATOMY

- ▶ 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

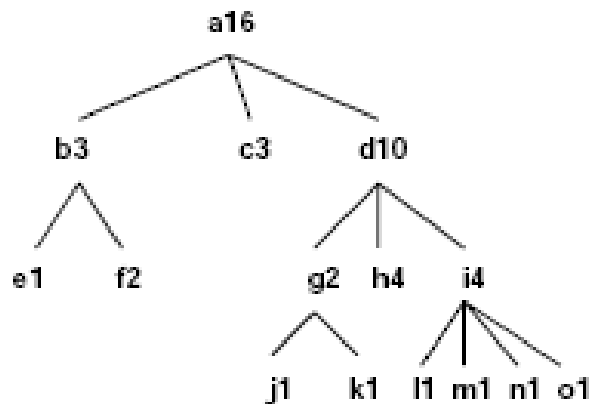


Large Intestine	Jejunum-Ileum	Liver Pancreas Duodenum	Stomach	Esophagus	Mouth Throat
Genitals Gonads	Vascular Caudal	Vascular Abdominal	Vascular Cardiac	Vascular Cephalic	Lungs
Urinary Tract	Nervous Caudal	Nervous Lower Spinal	Nervous Upper Spinal	Nervous Cephalic	Nasopharynx Conjunctiva
Lower Limb	Pelvis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

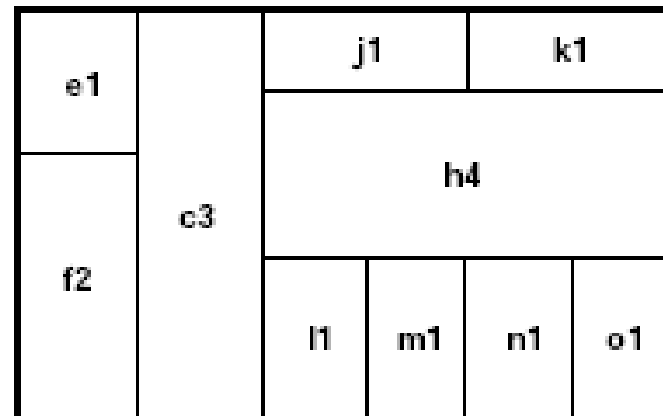


Treemaps

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

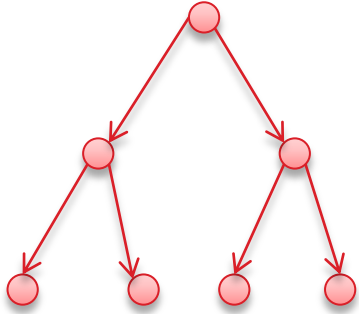


(a) Tree diagram

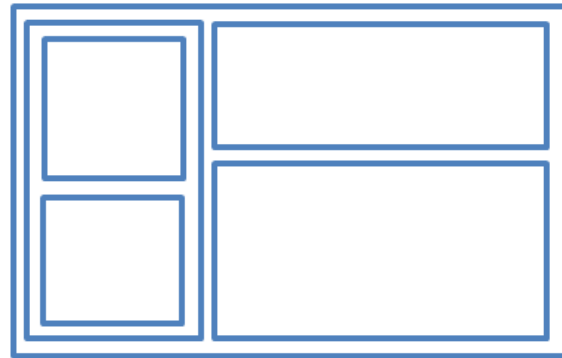
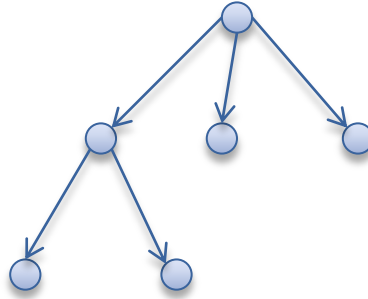


(b) Treemap

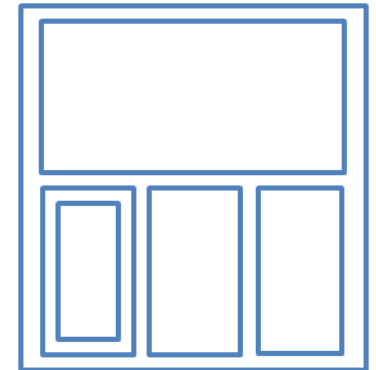
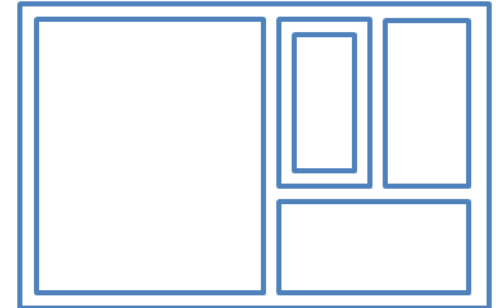
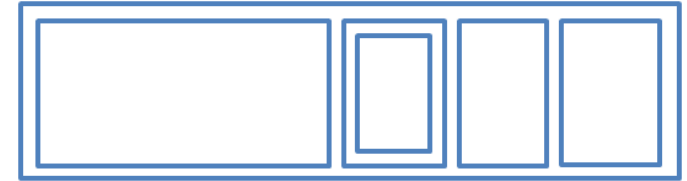
Variations of treemaps



a) Classic treemap



b) Hierarchical structure emphasized with a small fixed margin



ApiNATOMY

Tremap + navigation

ApiNATOMY 3D Connections Simulation Proteins

Nervous Cephalic
URI: 24tile:60000017
Descendants: 3456

seed

Brain
URI: fma:50801
Descendants: 1867

regional part

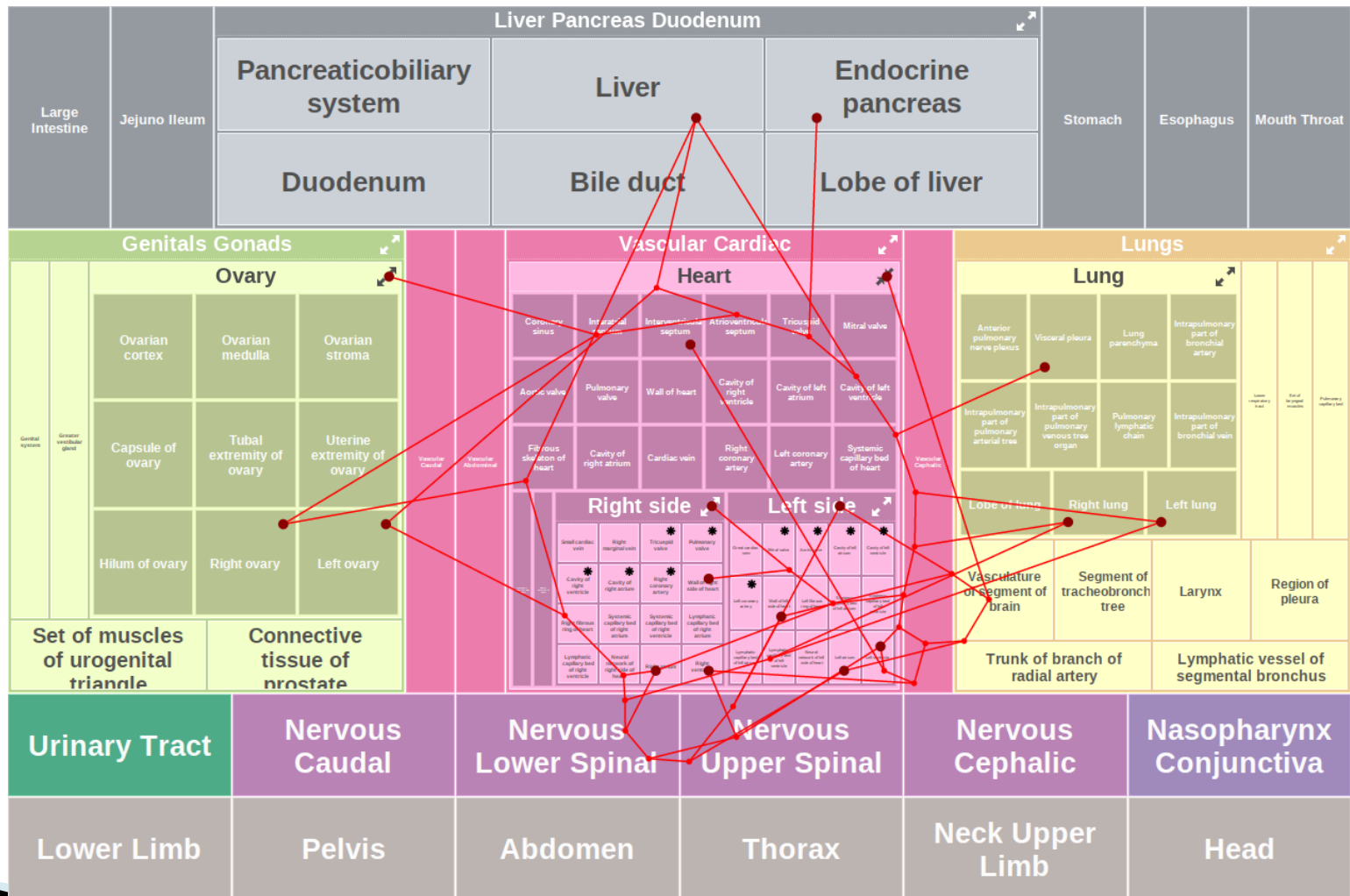
Midbrain
URI: fma:61993
Descendants: 131

constitutional part

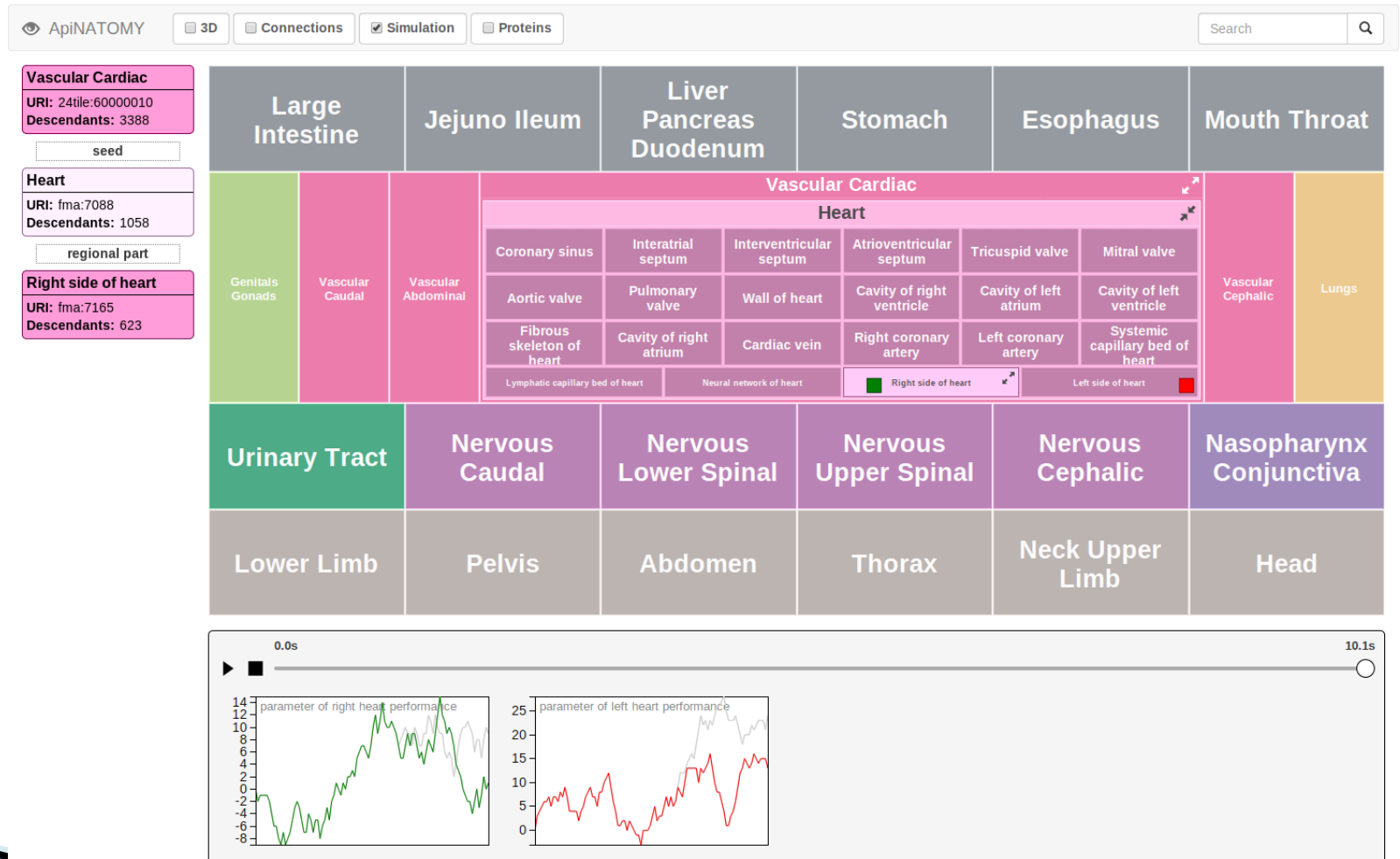
Cerebral aqueduct
URI: fma:78467
Descendants: 2

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					
				Brain					
				Neural tissue of brain		Vasculature of brain		Ventricular system of brain	
				Midbrain				Segment of telencephalon	Segment of cerebral hemisphere
				Forebrain	Midbrain tegmentum	Right substantia nigra	Left substantia nigra		
					Midbrain tectum	Right cerebral crus	Left cerebral crus	Vasculature of midbrain	
Neural tissue of midbrain		Right side of midbrain		Left side of midbrain					
Region of cerebral cortex		Internal capsule segment of corticospinal tract		Pre-decussation segment of corticospinal tract					
Pyramidal decussation segment of corticospinal tract		Subcortical segment of corticospinal tract		Corticospinal tract of brain					
Lower Limb	Pelvis	Abdomen	Thorax	Neck Upper Limb	Head				

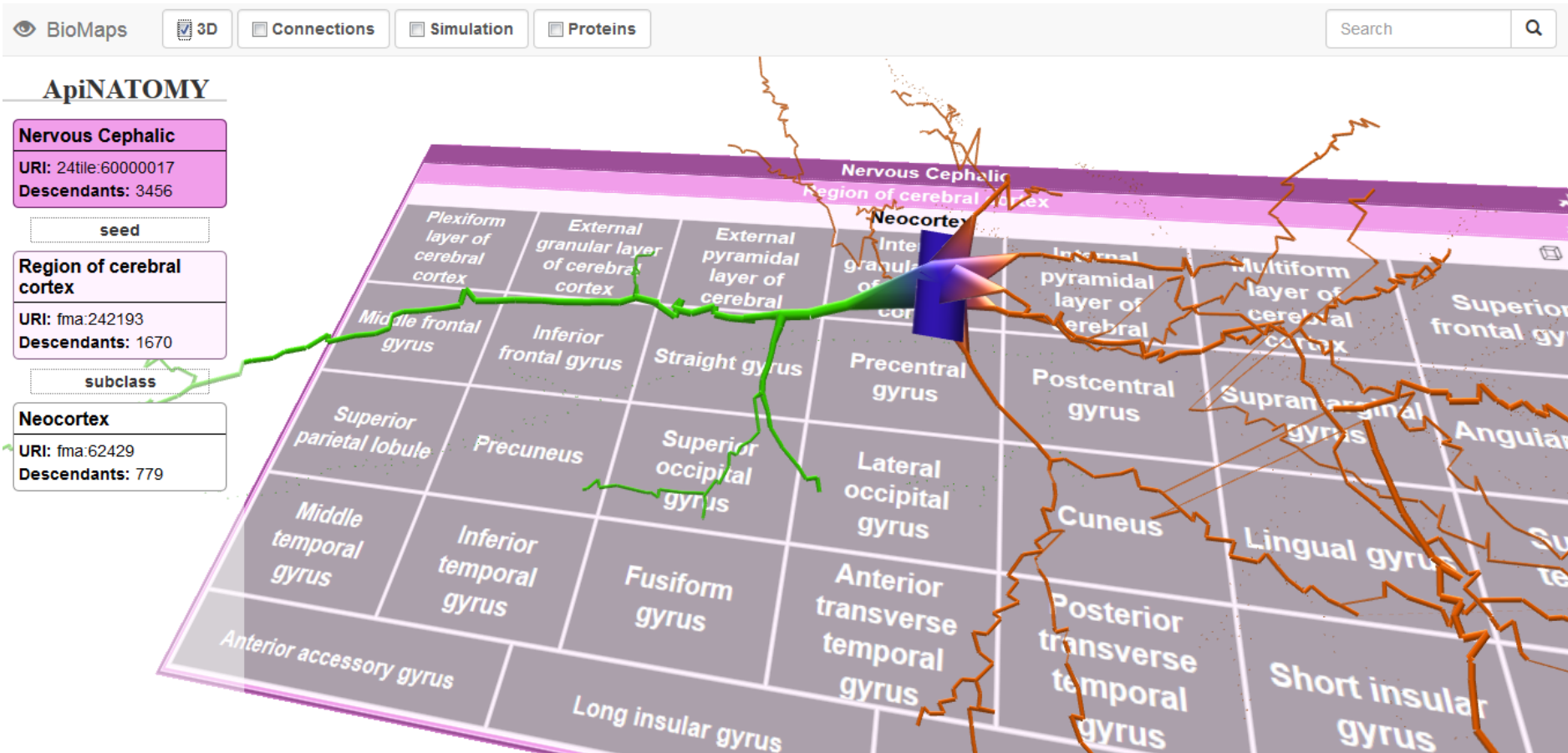
+ connections (blood vessels)



+ dynamic data (simulation, equations, plots)



+ neurons



ApiNATOMY in 3d

ApiNATOMY 3D Connections Simulation Proteins

Nervous Cephalic
URI: 24tile:60000017
Descendants: 3456

seed

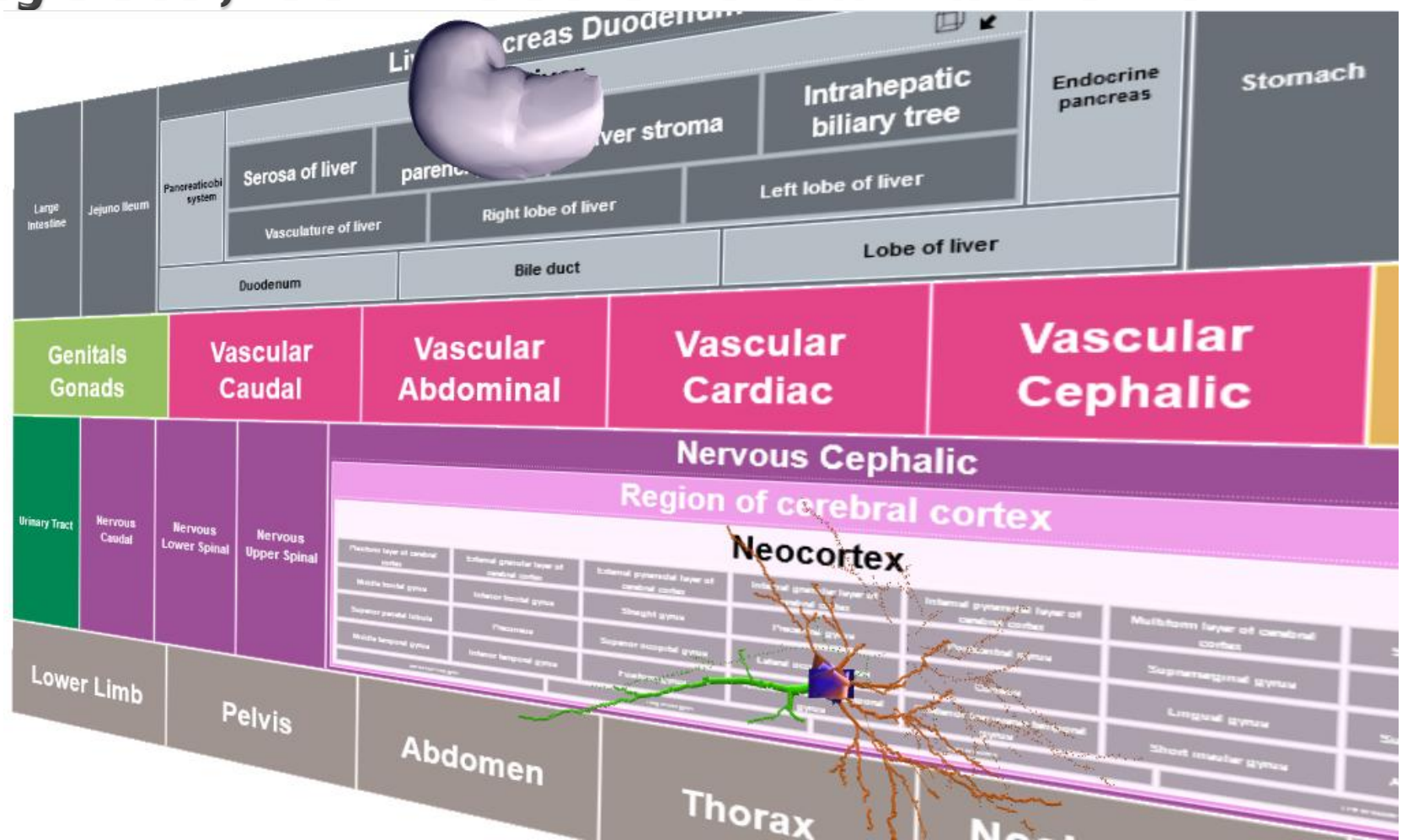
Region of cerebral cortex
URI: fma:242193
Descendants: 1670

subclass

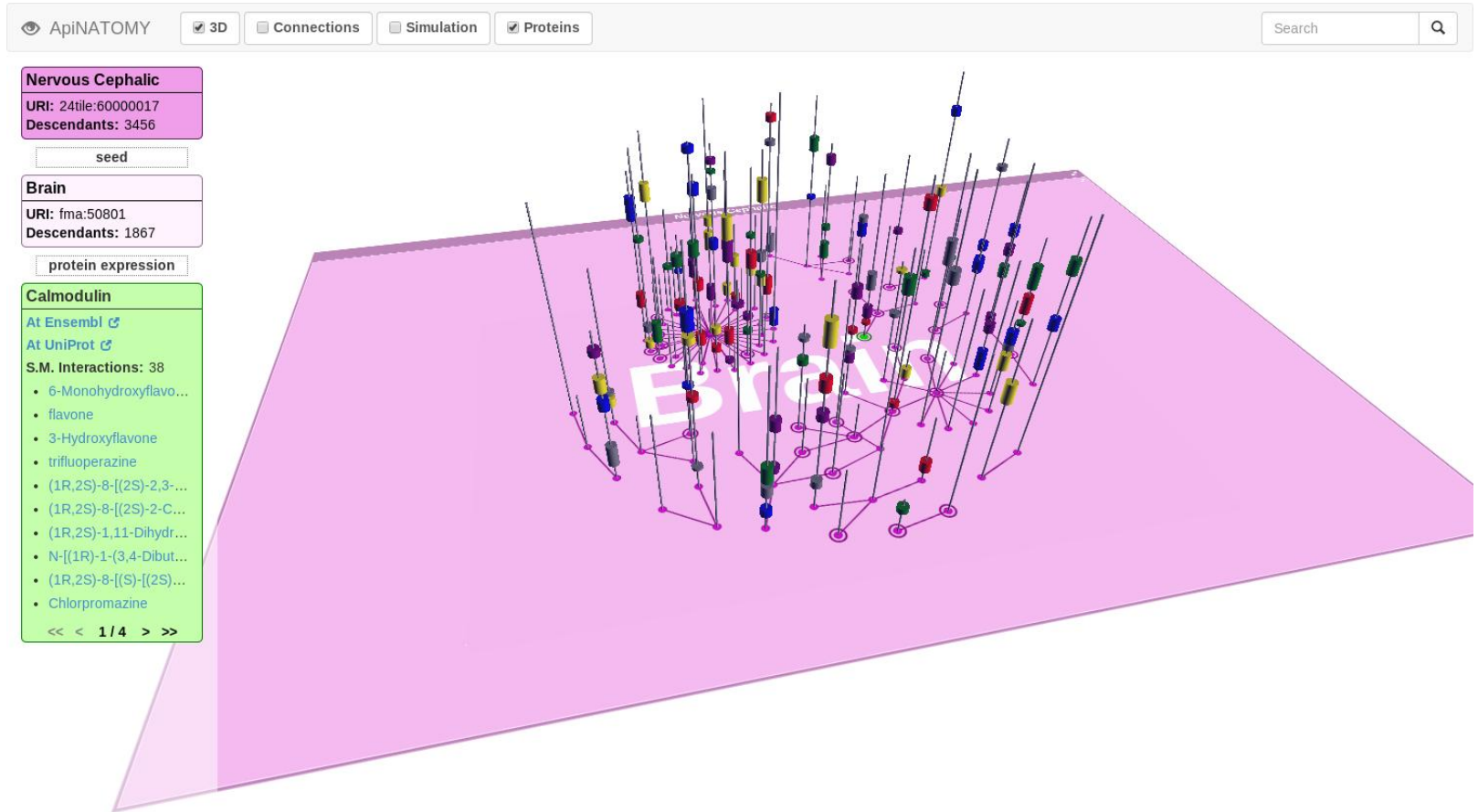
Neocortex
URI: fma:62429
Descendants: 779

The image shows a 3D anatomical map of the human body, viewed from an isometric perspective. The map is divided into various colored regions, each labeled with an anatomical term. The regions include: Lower Limb, Pelvis, Abdomen, Thorax, Neck Upper Limb, Head, Lungs, Nasopharynx Conjunctiva, Nervous Cephalic, Vascular Cephalic, Vascular Cardiac, Vascular Abdominal, Vascular Caudal, Gonads, Genitals, Duodenum, Bile duct, Lobe of liver, Right lobe of liver, Left lobe of liver, Liver, Liver vessels, and Stomach. Two 3D models are overlaid on the map: a purple, curved model of the stomach and a larger, more complex purple model of the liver. A network of green and orange lines is visible on the Neocortex region, representing neural connections. The interface at the top includes a search bar and several toggle buttons for 3D, Connections, Simulation, and Proteins. On the left side, there are three panels providing hierarchical information for 'Nervous Cephalic', 'Region of cerebral cortex', and 'Neocortex', including their URIs and the number of descendants.

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



Protein structures



The tool can be used to visualize any taxonomy

Naturalis 3D 7 / 279

Taxonomy

ordo

Anseriformes
ID: 647799
Entries: 100

familia

Anatidae
ID: 647800
Dutch Name: Eenden, ganzen en zwanen
Entries: 99

genus

Anas Linnaeus, 1758
ID: 647805
Entries: 16

species

Anas crecca Linnaeus, 1758
ID: 647814
Dutch Name: Wintertaling
Entries: 1
Summary
Summary (Dutch)

Anseriformes
Anatidae
Anas Linnaeus, 1758
Anas crecca Linnaeus, 1758

Bucephala Baird, 1858	Cairina Fleming, 1822	Chloephaga Eyton, 1838	Clangula Leach, 1819	Cygnus Bechstein, 1803	Histrionicus Lesson, 1826
Lophodytes Reichenbach, 1853	Marmaronetta Reichenbach, 1853	Melanitta Boie, 1822	Mergellus Selby, 1840	Mergus Linnaeus, 1758	Netta Kaup, 1829
Oxyura Bonaparte, 1825	Polystibis Eyton, 1838	Somateria Leach, 1819	Tadorna Von Oken, 1817		

Coraciiformes	Cuculiformes	Falconiformes	Galliformes	Gruiformes
Passeriformes	Picimorphes	Psittaciformes	Strigiformes	Upupiformes

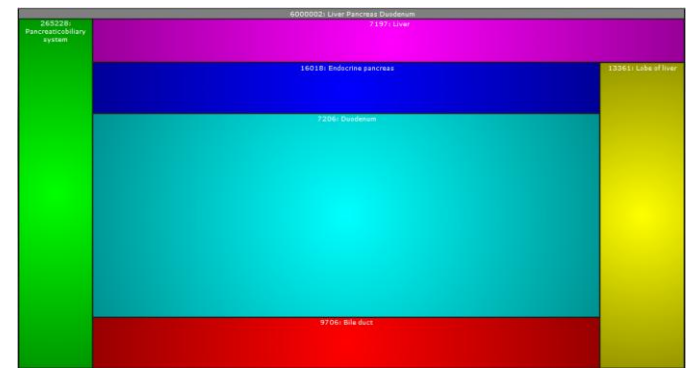
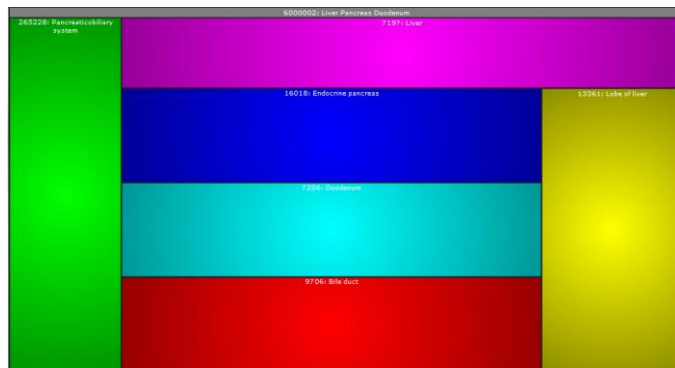


Want to know more?

- ▶ 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



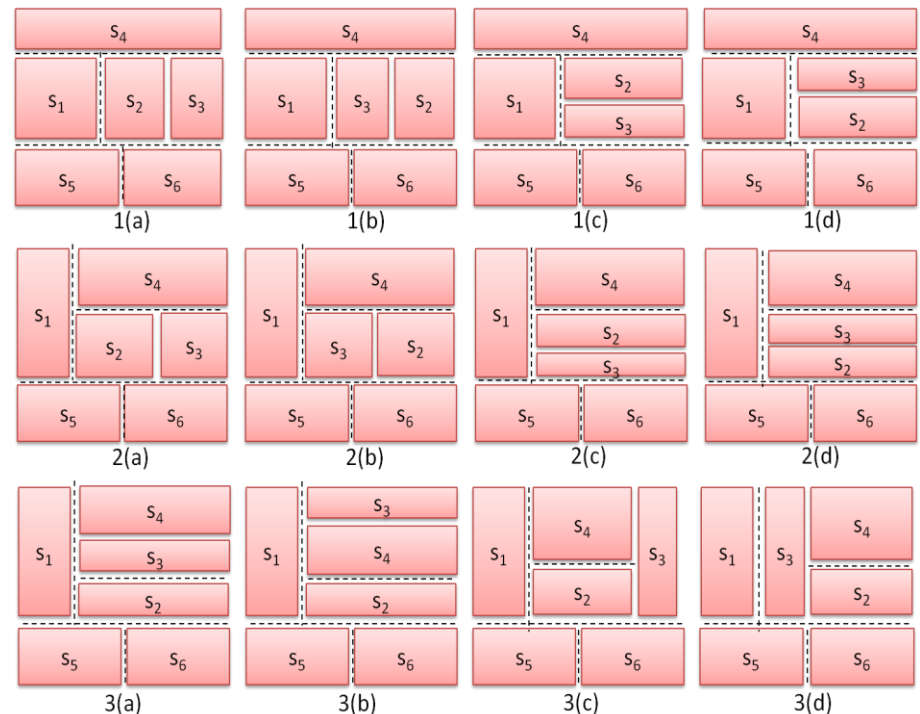
Automatic generation of templates

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

▶ Example

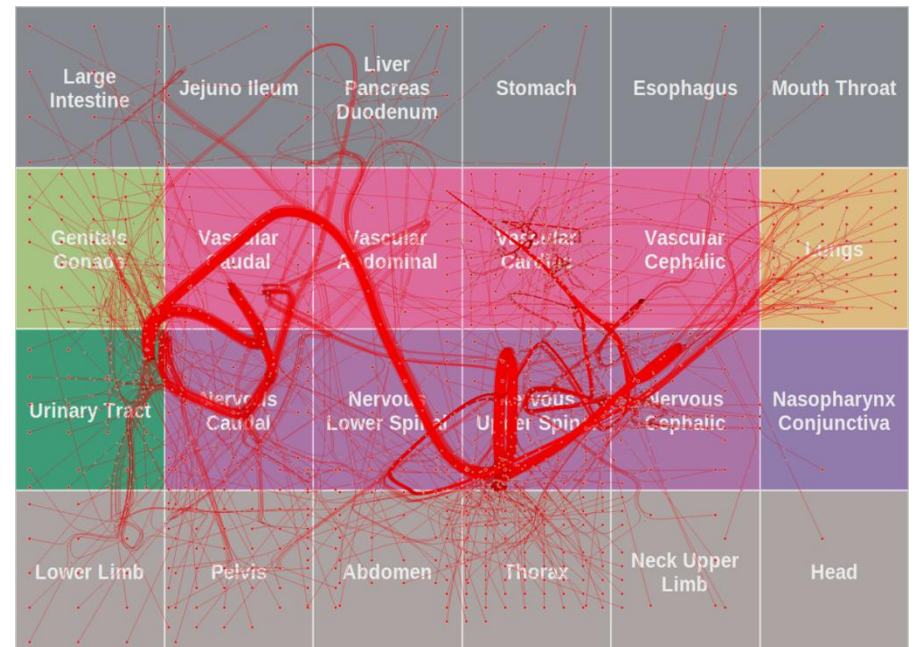
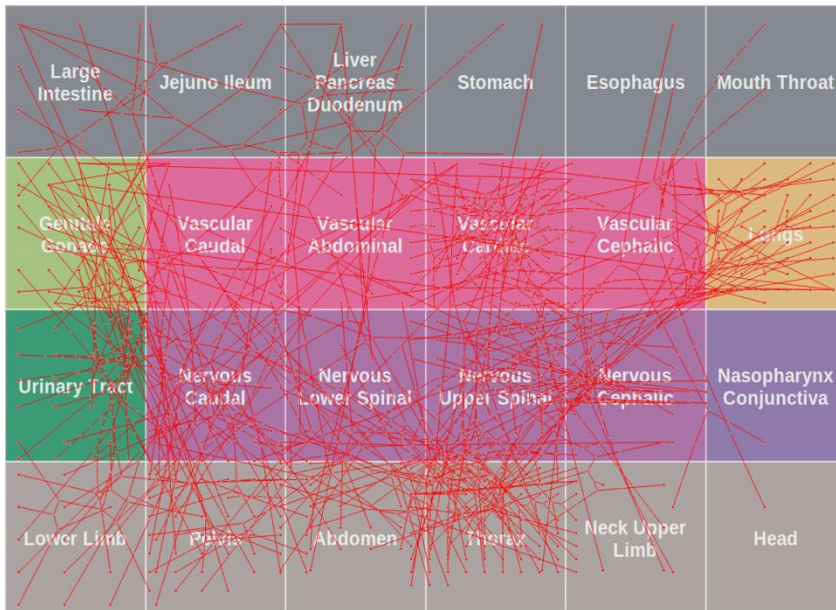
$\{s_1, s_2, s_3, s_4, s_5, s_6\}$

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



Algorithms on graphs

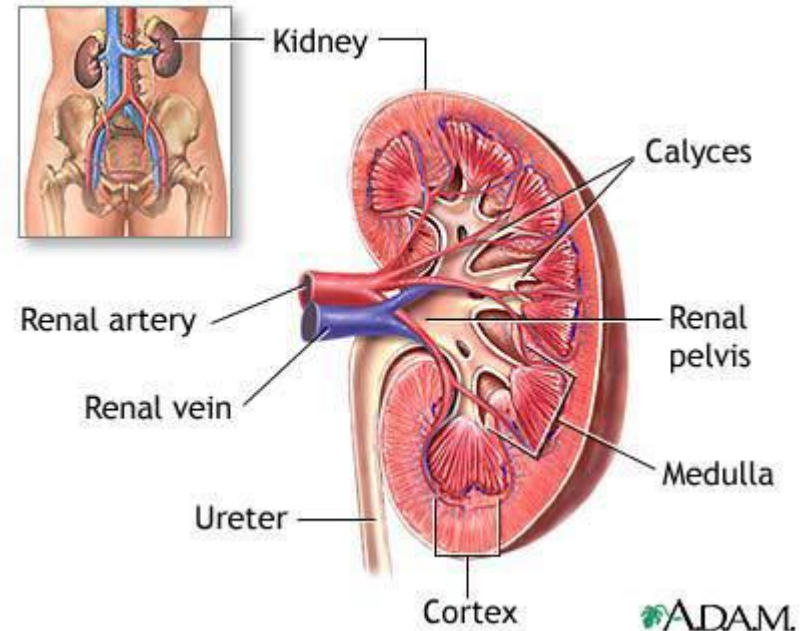
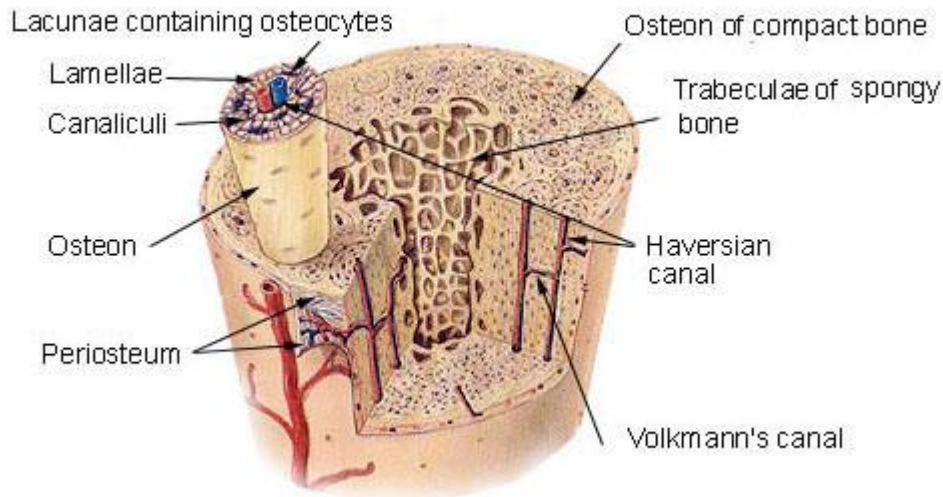
▶ Edge bundling



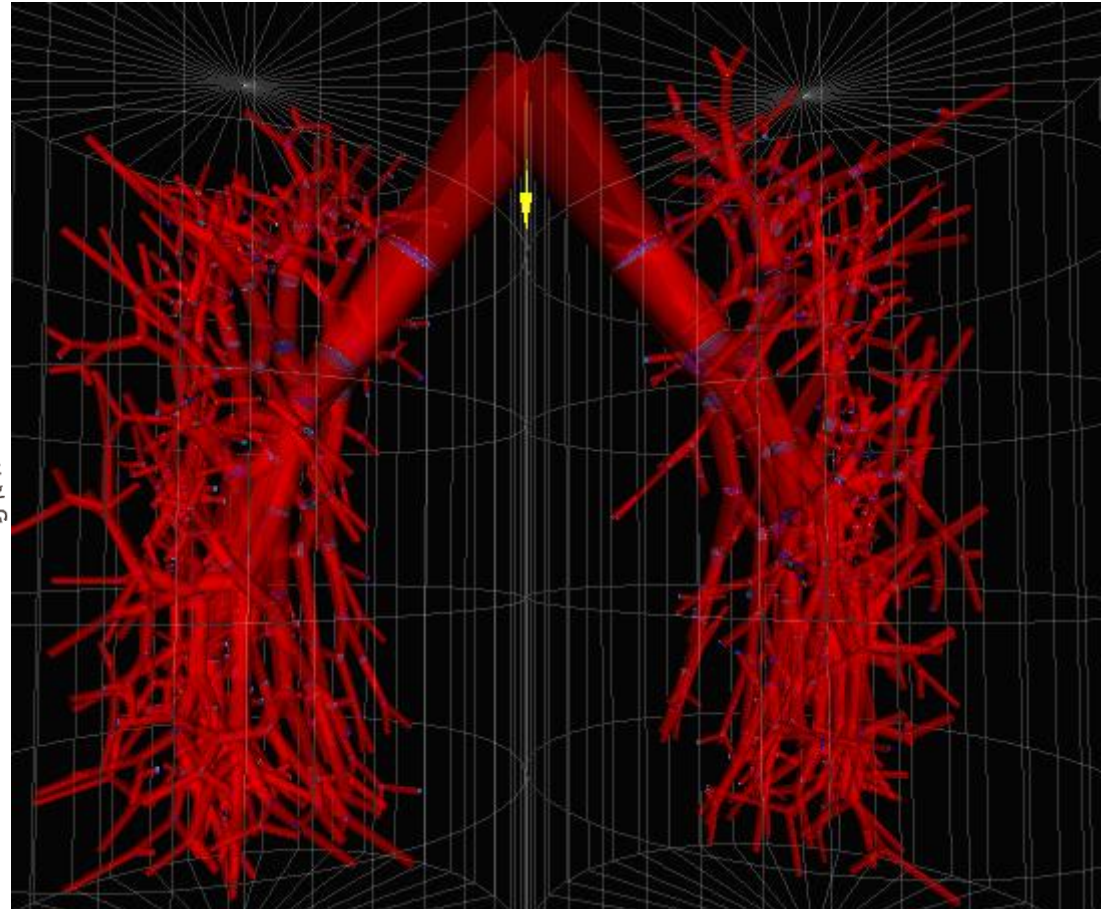
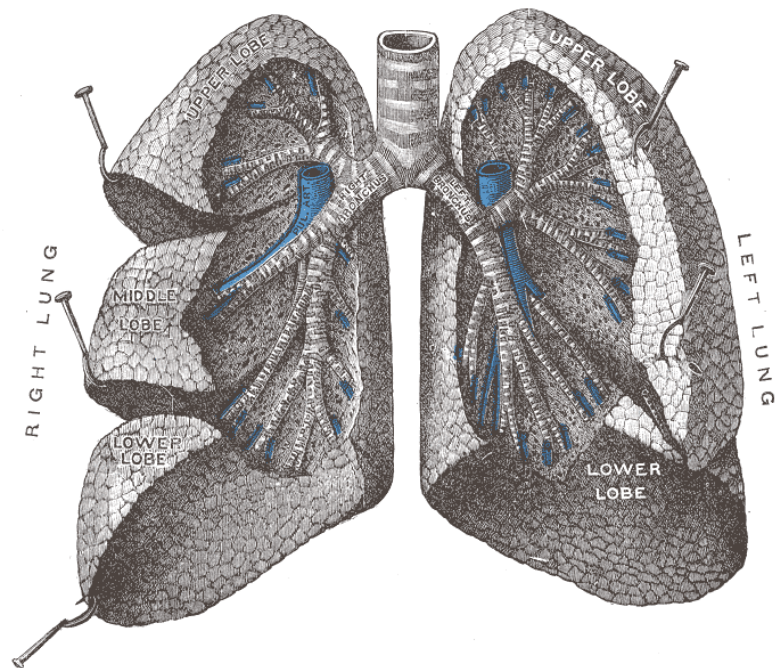
ApiNATOMY-2

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

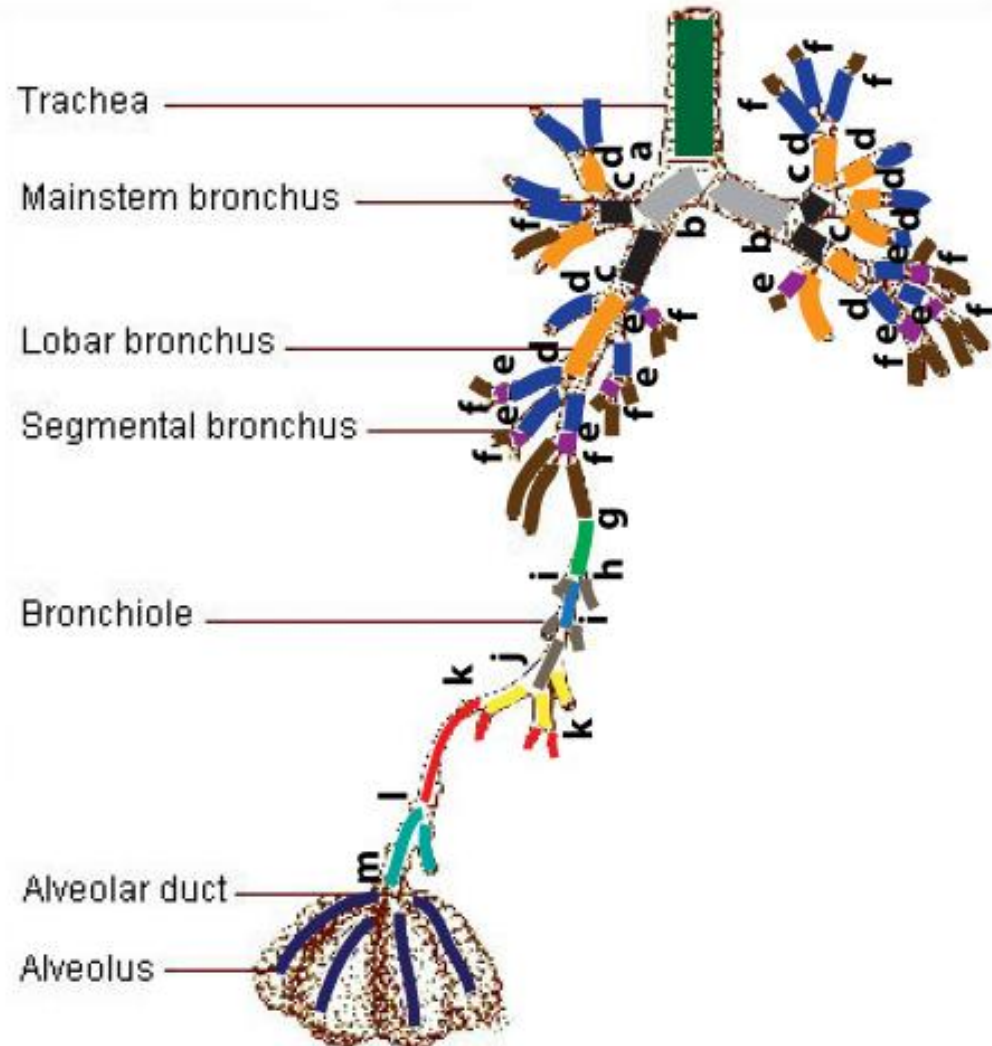
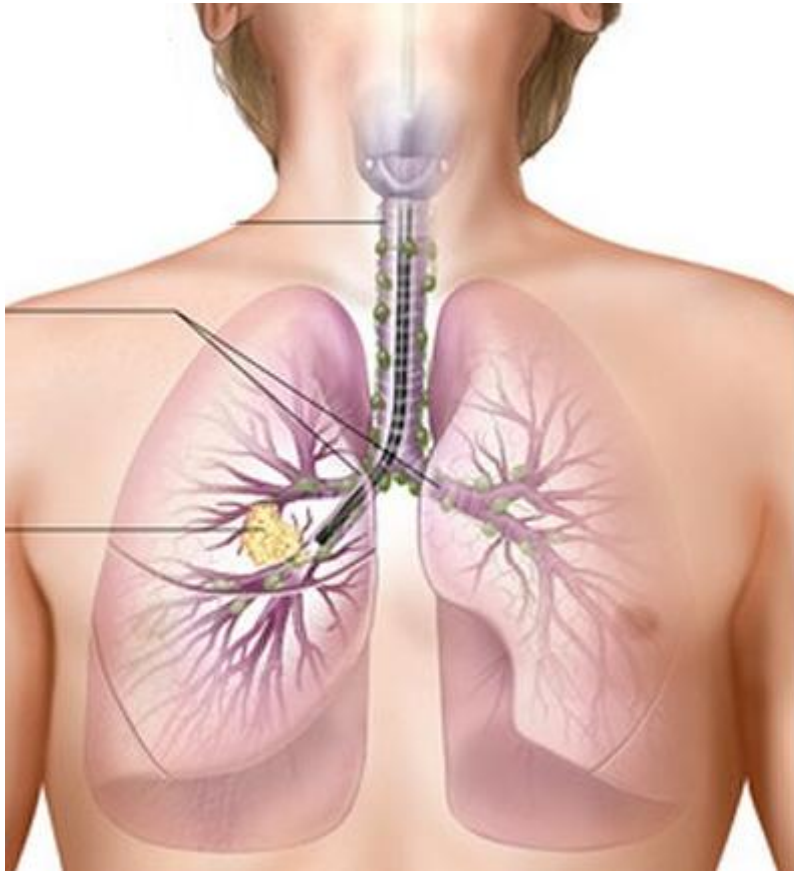
Compact Bone & Spongy (Cancellous Bone)



Algorithms – generate 3d trees

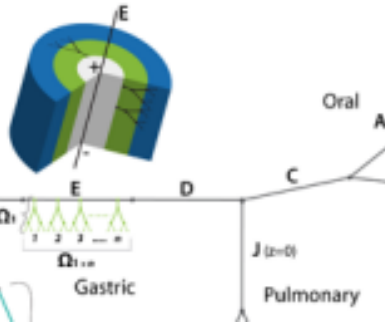
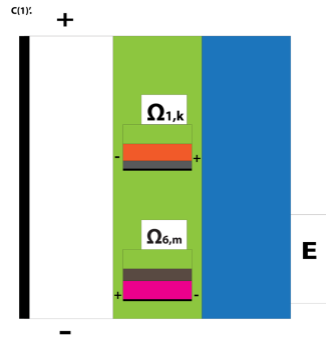


Not just any 3d tree



Design patterns for each tree level

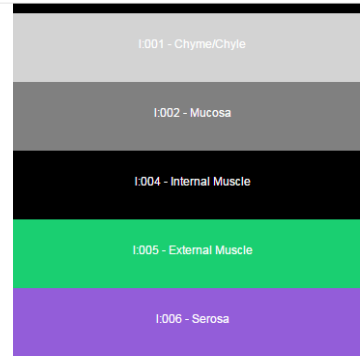
Asymmetric Unit Editor



AU parameters:
 ID: au:002
 Name: Sample AU-1
 Length: 1
 [Delete] [Restore] [Update] [Add]

Layer parameters:
 ID: l:001
 Name: Chyme/Chyle
 Thickness: 1
Material:
 ID: m:001
 Name: Composite material 1
 [Delete] [Restore] [Update] [Add]

Visual parameters:
 Orientation:
 Horizontal
 Vertical
 Length scale: 371
 Width scale: 71



Asymmetric Units

- au:001 - Gastrointestinal tract
- au:002 - Sample AU-1
- au:003 - Sample AU-2
- au:004 - Sample AU-3

Materials

- m:001 - Composite material 1
- m:003 - Composite material 3
- m:002 - Composite material 2
- #CHEBI_35441 - anti-infective drug
- #CHEBI_35442 - antiparasitic drug
- #CHEBI_35440 - (1R,2S)-3-phenylcyclohex

ApiNATOMY graph editor

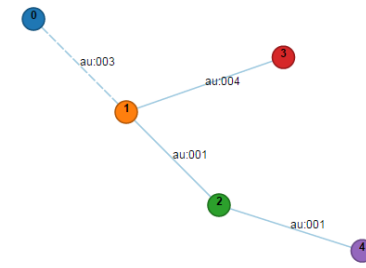
Graph parameters:
 ID: Graph 1
 Name: Testing graph
 [Delete] [Restore] [Update] [Add]

Edge parameters:
Asymmetric Unit:
 ID: au:003
 Name: Sample AU-2
 [Delete] [Restore] [Assign]

Node parameters:
Generated tree parameters:
 ... will be added here ...

Instructions:

- Click in the open space to **add a state**
- Drag between states to **add a transition**
- Ctrl-drag a state to **move graph layout**
- Click a state or a transition to **select it**



Graphs

- Graph 1 - Testing graph

Asymmetric Units

- au:001 - Gastrointestinal tract
- au:002 - Sample AU-1
- au:003 - Sample AU-2
- au:004 - Sample AU-3

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