Datathon MAPcore Documentation

Release 1.0

Sonia Sharma

Aug 22, 2019

User interface guides:

The SPARC Portal provides interactive access to a growing collection of data, maps, and computational studies that focus on the role of the autonomic nervous system in controlling organ function. These resources are made available to the public with the intent of advancing bioelectronic medicine towards more precise treatment of diseases and conditions.

Here, we provide instructions on how to use the various map visualization and interaction tools available on the SPARC Portal, as well as detailed instructions guiding users of the portal through specific exemplar use cases. These specific use cases highlight various types of data and visualizations that are available.

A collection of introductory videos are available on the MAP-Core YouTube channel.

CHAPTER 1

Map visualization interface

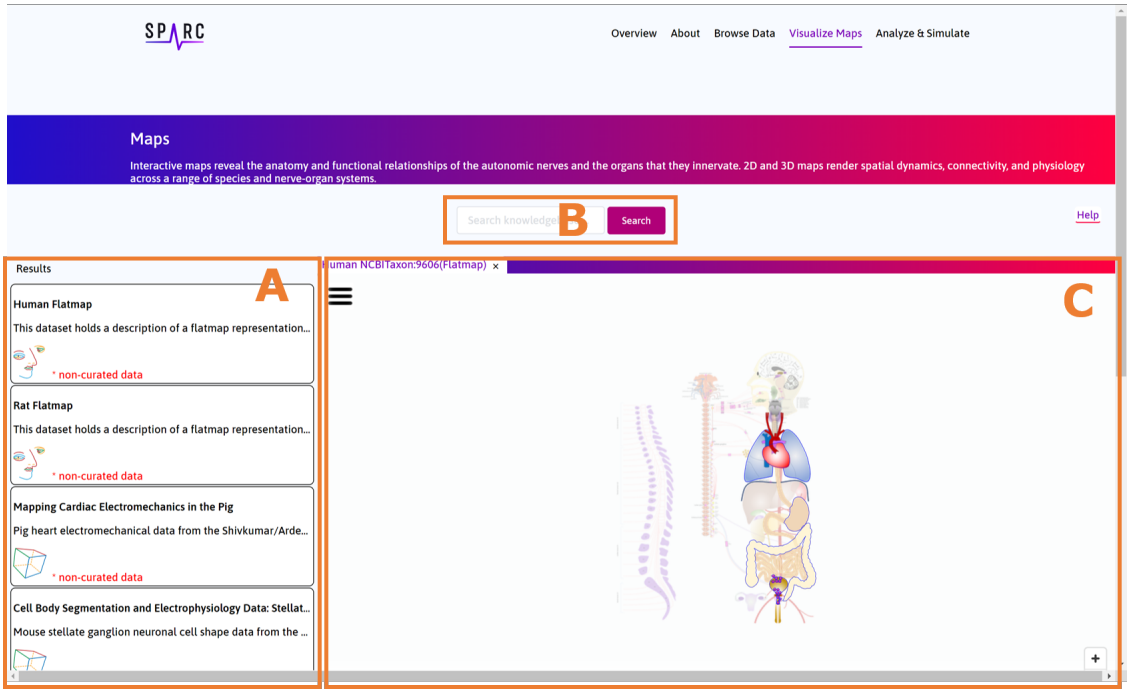


Fig. 1: The initial user interface for the map visualization interface. (A) shows the listing of exemplary use cases, selecting one will display further details and allow access to the appropriate viewers for that use case. (B) can be used to directly enter terms to query the knowledgebase for relevant data. (C) will, by default, show the human flatmap viewer, but will have tabs added with the appropriate viewers, as requested by the user.

1.1 Flatmap Viewer

Contents:

1.1.1 Overview

The flatmap viewer tool available on the SPARC Data Portal is used to navigate a `flatmap` – a zoomable map showing representing anatomical features – in order to easily search for knowledge about features on the map.

A map consists of a number of image and vector tiles at different resolutions stored on a server. These are displayed in the web-browser using similar technology to that used by interactive geographical maps.

1.1.2 Usage

Interactive map layers

A map is made up of one or more interactive layers, and is initially displayed with a number of these layers active.

When there is more than one interactive layer, the `layer-switcher` control, represented by the ☰ icon at the top-left corner, can be used to manage active layers.

Querying a map's features

Some features in a layer are annotated as modelling one or more anatomical entities. These features show a tooltip when the mouse pointer hovers over them, and knowledge about the feature can can be searched for by clicking on the highlighted feature.

Some layers, such as the `neural` layer, have been configured to allow queries to also be made against the displayed `nodes`. There are two types of such node queries:

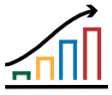
1. Find all `edges` that belong to the node, that is edges that start, stop, or pass through the node.
2. Find all other nodes connected by some edge to the queried node. This query also results in knowledge searches being made for those found nodes that model an anatomical entity.

Queryable nodes are highlighted when the mouse pointer is over them – they will only show a tooltip if they have an anatomical identifier.

Node queries are made using the `right-click` context menu.

Map interaction

Besides zoom and pan, using standard mouse or touchpad controls, a `left-click` will query for knowledge about the current anatomical entity, and a `right-click` will show a context menu, allowing the different node connectivity queries to be made.

1.2  Data Viewer

A module of the data portal designed for viewing and exporting Ephys and Genome data.

Contents:

1.2.1 Overview

This document describes how to use the data plotting viewer tool available on the SPARC Data Portal. Examples of this tool in action are available at https://data-viewer-demo.netlify.com/.

This module has the ability to:

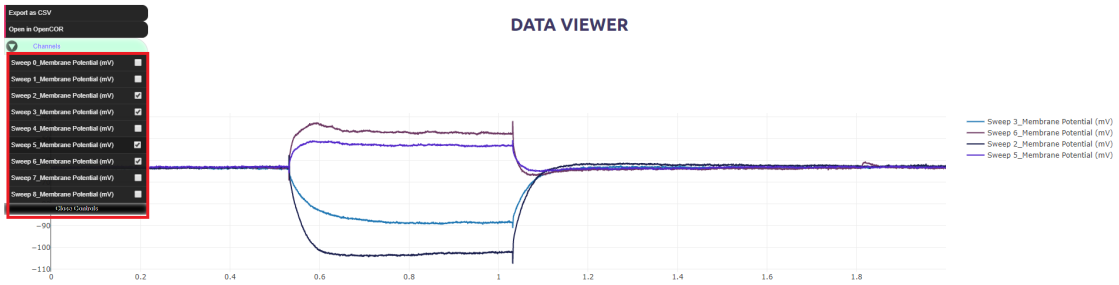
- Plot electrophysiological CSV datasets in the knowledgbase or Blackfynn.
- Plot genome and other static CSV datasests.
- Navigate large datasets via the user interface.
- Add and remove channels from a plot and export them.
- Export selected channels as CSV for use in Excel or OpenCOR.

1.2.2 Viewer Configuration

The viewer has two modes, for small and large datasests.

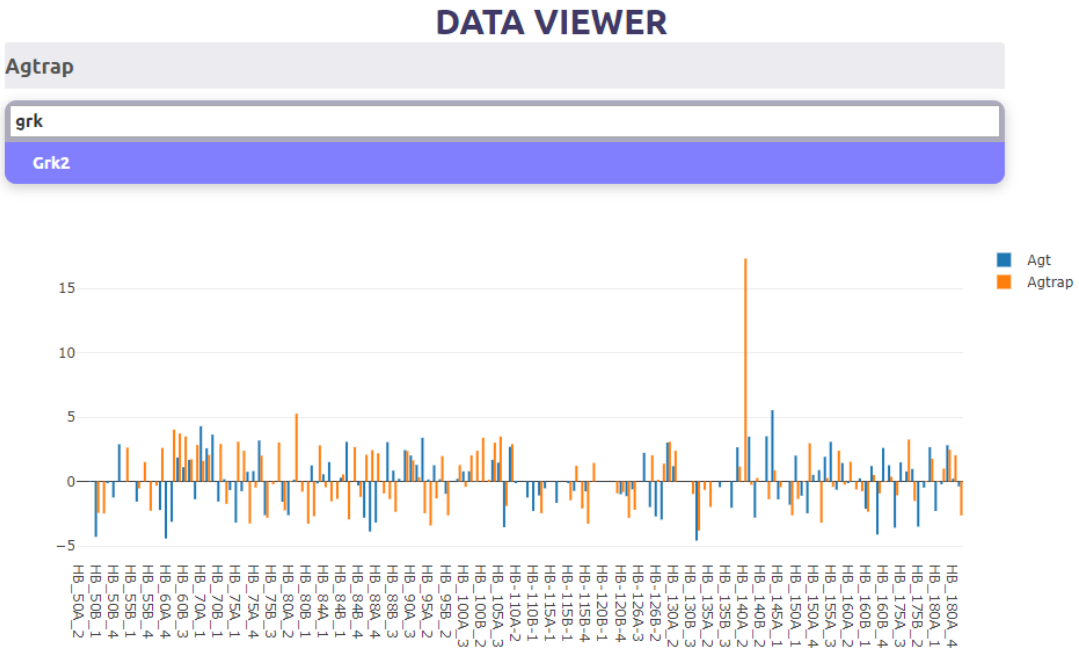
Small Datasets

This mode is used for smaller datasets and has more control over exports. (All checked channels will be exported.)



Large Datasets

This mode is used to navigate larger datasets. It has search capability to plot the desired channels.



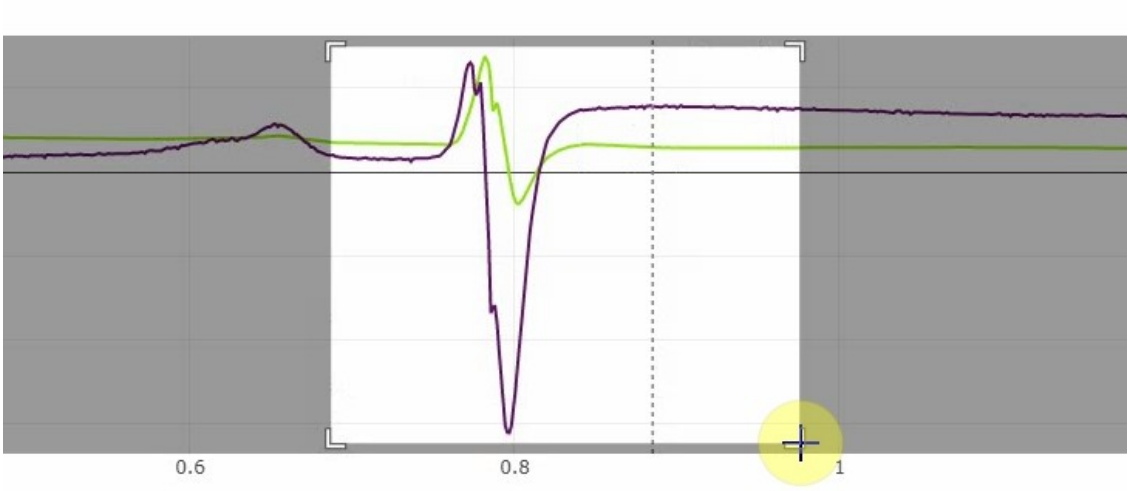
1.2.3 Interactive Graphics Controls

You can refine the view by dragging over a region of interest.

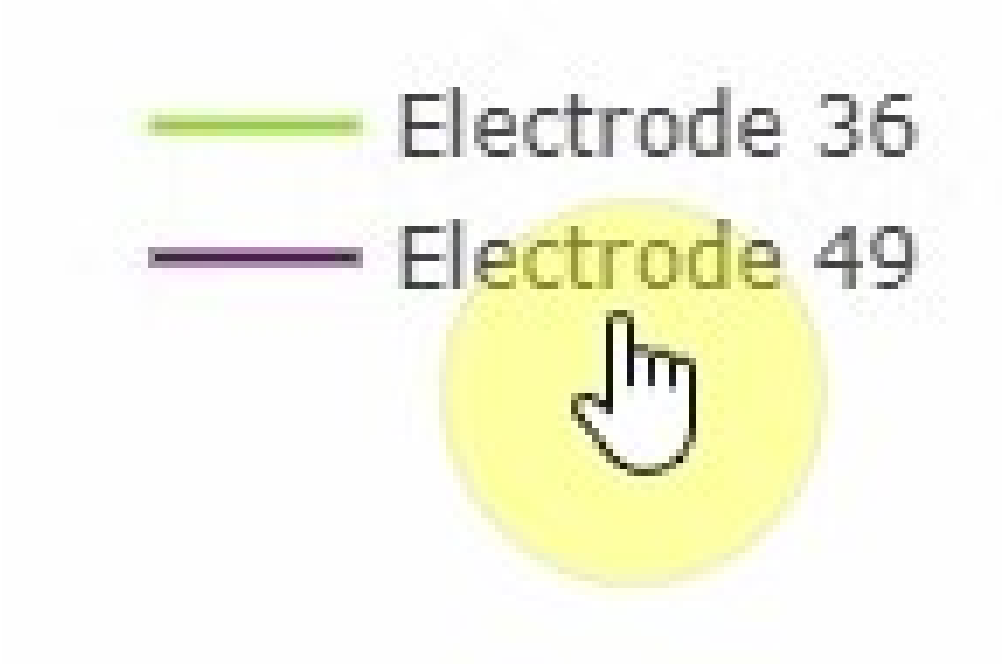
You can also add or remove data by clicking on its label.

The table below describes the effect of different user actions in the flatmap being displayed.

Mouse action	Result
`left-click`	Zoom in via box selection
`middle-click`	Zoom in via box selection
`double-click`	Reset the view


0.6
0.8
1

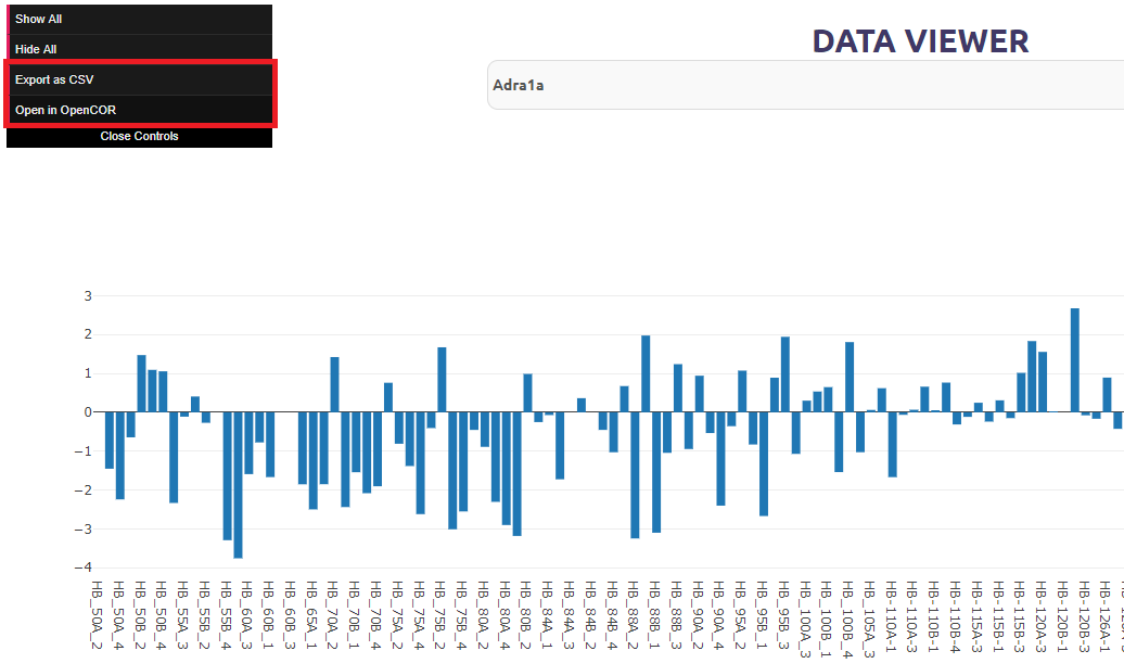

Electrode Data Viewer
Electrode 49
2.755206 Electrode 36
0.464935 Electrode 49
Electrode 36
Electrode 49
mV
0.7815126
Seconds


Electrode 36
Electrode 49

1.2.4 CSV (Comma-Separated Values) Exports

The selected data traces plotted are exported to a CSV file for use in Excel, OpenCOR or any CSV-capable software.

Export as CSV



Data in Excel

1.3 Scaffold Viewer

Contents:

1.3.1 Overview

Some datasets in the SPARC knowledgebase search results are registered to an *anatomical scaffold*: a 3D model of the anatomy of interest. This is indicated by the 3D box icon shown at the top of this page. To click on the icon in the search results opens a *Scaffold Viewer* tab in which the scaffold and embedded data can be viewed and interacted with in 3D. The following image of the Scaffold Viewer tab shows a fitted rat stomach scaffold with neurite data from Powley *et al*.

sparc-export-j6p0n.csv - Excel

File Home Insert Page Layout Formulas Data Review View SOLIDWORKS PDM ACROBAT Tell me what you want to do...

Cut Copy Format Painter Paste Clipboard

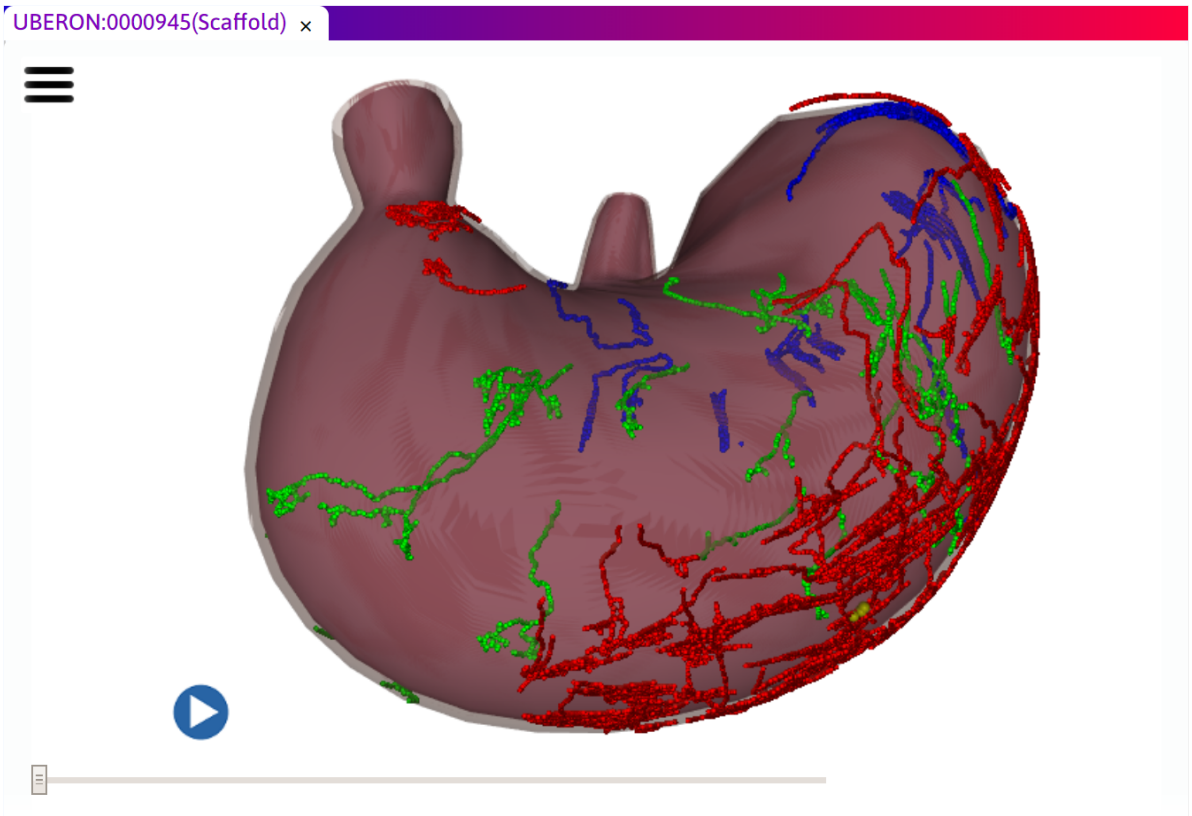
Calibri 11 Font

Wrap Text Merge & Center Alignment

General Number

A1 Sample_Name

	A	B
1	Sample_Name	Adra1a
2	HB_50A_2	-1.452565137
3	HB_50A_3	-2.24247284
4	HB_50A_4	-0.644709117
5	HB_50B_1	1.47203539
6	HB_50B_2	1.092197581
7	HB_50B_3	1.054916616
8	HB_50B_4	-2.334233892
9	HB_55A_1	-0.112464715
10	HB_55A_3	0.406249793
11	HB_55B_1	-0.270141552
12	HB_55B_2	NA
13	HB_55B_3	-3.293050883
14	HB_55B_4	-3.759006769
15	HB_60A_1	-1.591948712
16	HB_60A_3	-0.775397471
17	HB_60A_4	-1.668319227
18	HB_60B_1	NA
19	HB_60B_2	NA
20	HB_60B_3	-1.854099617
21	HB_60B_4	-2.50048299
22	HB_65A_1	-1.851556824
23	HB_70A_1	1.421741582
24	HB_70A_2	-2.44020075
25	HB_70A_4	-1.542942138
26	HB_70B_1	-2.082886086
27	HB_70B_3	-1.904750939
28	HB_70B_4	0.76011344



1.3.2 Interaction and Viewing

Moving the mouse pointer over the scaffold or embedded data highlights and overlays a label for what is under it. With an entity highlighted, to click the left button performs a search for the label terms in the SPARC knowledgebase. The search can bring up related datasets for the study, allowing further viewer tabs to be opened.

Interactively rotating, zooming and panning the view gives a greater understanding of the 3D structure. Hold down one of the mouse buttons and drag to change the view. The following table lists the controls.

Mouse action	Result
`left-click`	Search knowledgebase for highlighted entity
`Left-drag`	Rotate
`Middle-drag`, `wheel`	Zoom
`right-click`	Pan

On some systems, e.g. macOS, modifier keys `Ctrl`, `Alt`, etc. may be used in place of different buttons.

Some Scaffold views may contain time-varying or multi-state data. In these cases, a slider control is shown to change the time or state, and a play button enables animation between states. These controls are shown in the above rat stomach Scaffold viewer.

1.3.3 Viewer Configuration

The  icon at the top-left corner of the window brings up a menu of additional viewing controls:

- *Reset View* - Restore the initial view of the scaffold to the default state.
- *View All* - Zoom in/out to see all of the scaffold in its current orientation.
- *Visibilty Controls* - Checkboxes controlling the visibility of each entity.

To click on the  icon closes this menu.

CHAPTER 2

Cell Body Segmentation and Electrophysiology Data: Stellate Ganglion

Contents:

2.1 Overview

Mouse stellate ganglion neuronal cell shape data from the Shivkumar/Tompkins group are displayed in a 3D stellate scaffold. 15 neurons, including their cell bodies, axons and dendrites, are displayed on five cross-sections of the stellate with the high resolution image displayed as a texture map. Electrophysiological data from these cells can be visualized by clicking on the cell. *Note* that the scaffold in this example is a geometrically simple shape designed to register the images in the appropriate anatomical location. The shape of the scaffold will be improved once more data are available to define the stellate boundaries.

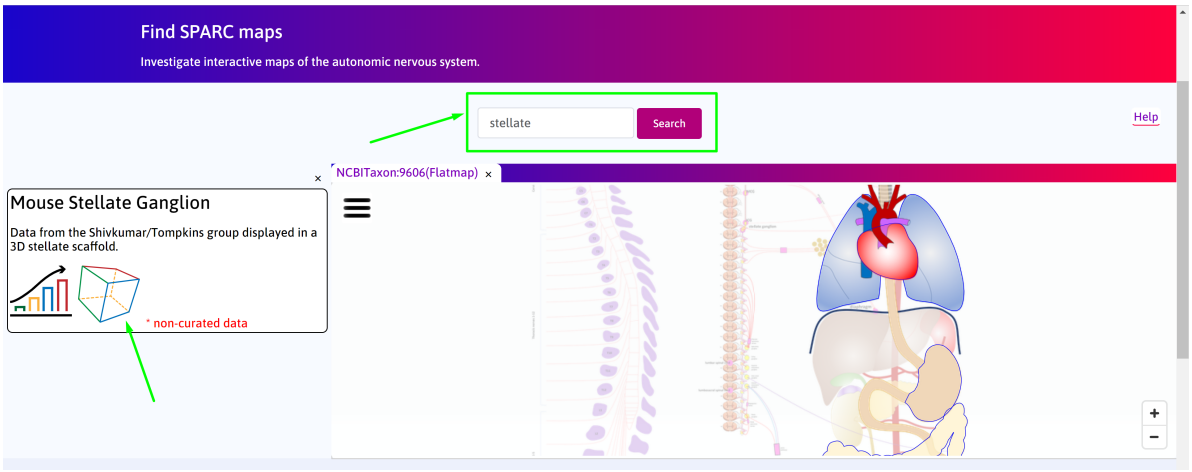
This document guides a user of the SPARC Data Portal through the steps required to discover a collection of segmented cell bodies from the stellate ganglion which have been mapped to a common coordinate framework for visualization purposes. The user is able to discover any electrophysiological data that has been recorded for each of the cell bodies.

2.2 Step-by-step instructions

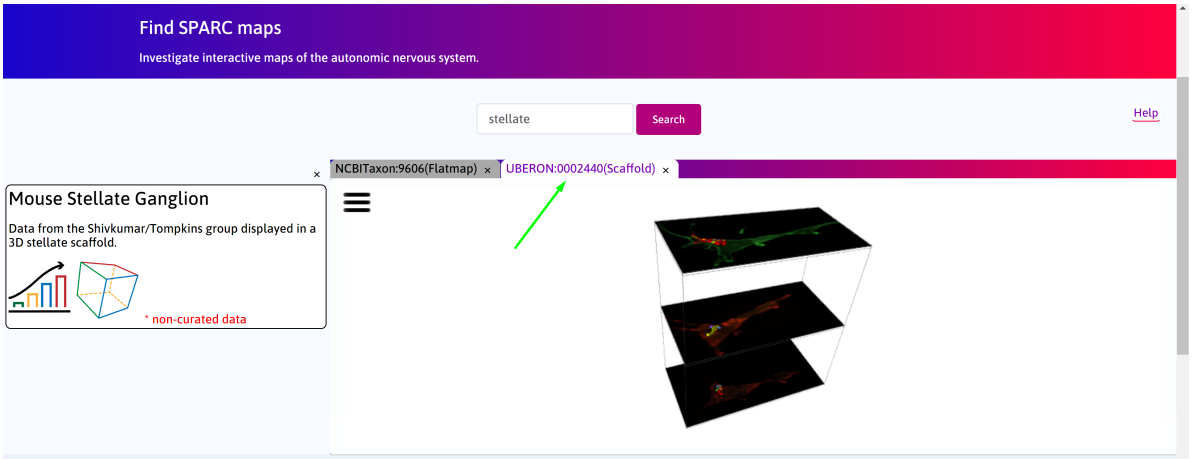
Follow these step-by-step instructions to familiarise yourself with the flow of the web interface.

Step 1. Perform a search using keywords **stellate** or **stellate ganglion** and click on  icon.

Step 1. The default **Result** column displays the use cases available on the portal. Click on the *Cell Body Segmentation and Electrophysiology Data: Stellate Ganglion* box.

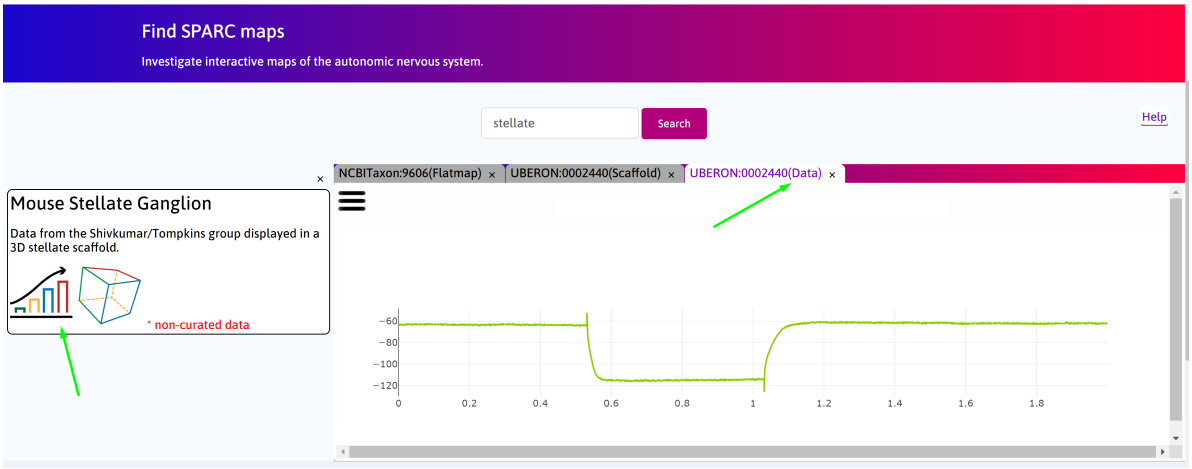


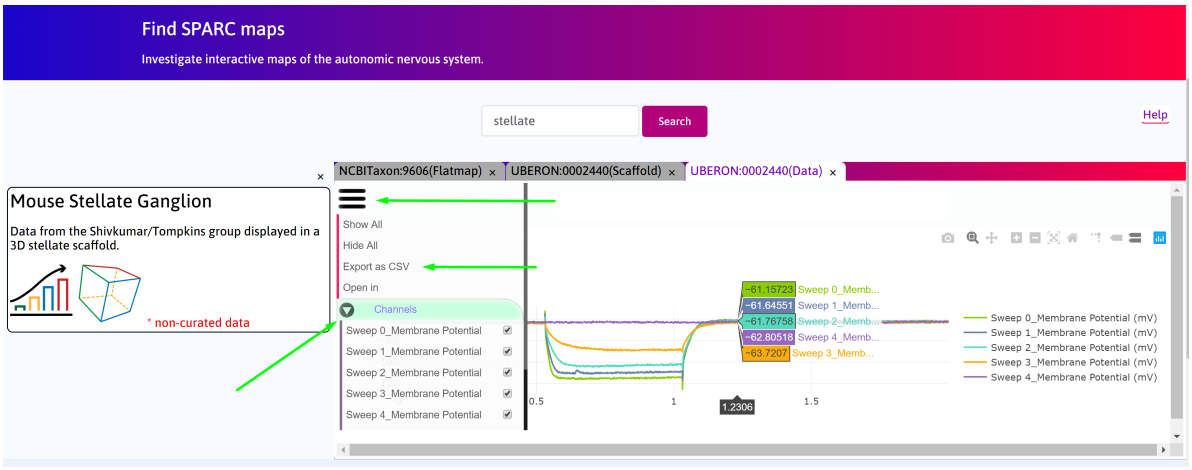
Step 2. A new tab called Scaffold Viewer will open to display the anatomical organ scaffold of the stellate. The current scaffold is a rectangular cube with slots to contain the stellate image stacks using texture mapping techniques within the scaffold elements. Segmented cells (soma) with associated axon and dendrites have been mapped and embedded in the image-scaffold structure. Each cell will have electrophysiological data properly registered.



Step 3. Click on  icon on the search result to visualise the electrophysiological data associated with the samples.

Step 4. Click on  to open the control panel. You can select different sweep or channel data for that cell in this tab to visualise both simultaneously. You can also export the data as a CSV format file.


Find SPARC maps
Investigate interactive maps of the autonomic nervous system.
stellate
Search
Help
NCBITaxon:9606(Flatmap)
UBERON:0002440(Scaffold)
UBERON:0002440(Data)
Mouse Stellate Ganglion
Data from the Shivkumar/Tompkins group displayed in a 3D stellate scaffold.
* non-curated data
−60
−80
−100
−120
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8


Find SPARC maps
Investigate interactive maps of the autonomic nervous system.
stellate
Search
Help
NCBITaxon:9606(Flatmap)
UBERON:0002440(Scaffold)
UBERON:0002440(Data)
Mouse Stellate Ganglion
Data from the Shivkumar/Tompkins group displayed in a 3D stellate scaffold.
* non-curated data
Show All
Hide All
Export as CSV
Open in
Channels
Sweep 0_Membrane Potential
Sweep 1_Membrane Potential
Sweep 2_Membrane Potential
Sweep 3_Membrane Potential
Sweep 4_Membrane Potential
−61.15723 Sweep 0_Memb...
−61.64551 Sweep 1_Memb...
−61.76758 Sweep 2_Memb...
−62.80518 Sweep 4_Memb...
−63.7207 Sweep 3_Memb...
Sweep 0_Membrane Potential (mV)
Sweep 1_Membrane Potential (mV)
Sweep 2_Membrane Potential (mV)
Sweep 3_Membrane Potential (mV)
Sweep 4_Membrane Potential (mV)
0.5
1
1.2306
1.5

CHAPTER 3

Mapping Cardiac Electromechanics in the Pig

Contents:

3.1 Overview

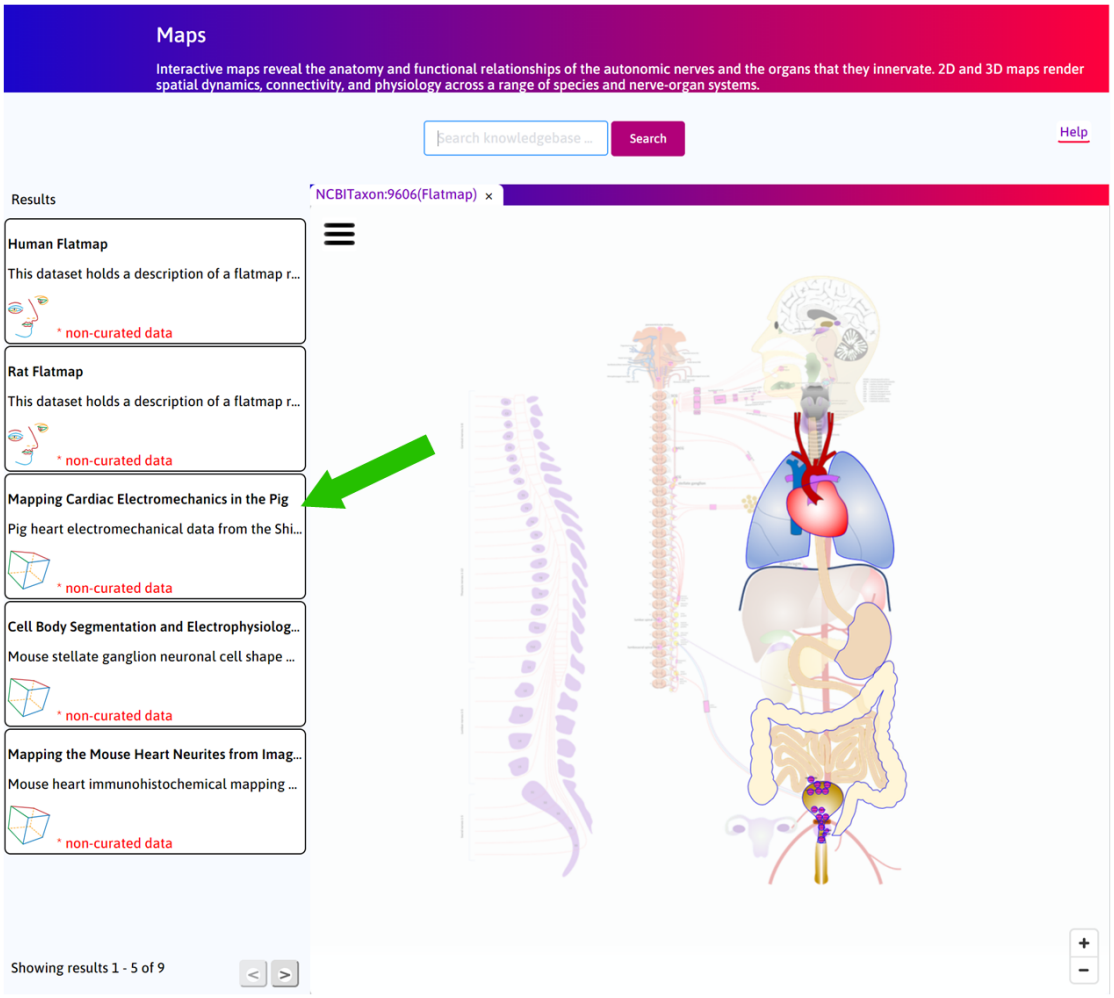
Pig heart electromechanical data from the Shivkumar/Ardell group is displayed on a 3D pig heart scaffold. The deforming geometry of the pig heart is fitted through the cardiac cycle with the pig heart scaffold. Electrophysiological measurements from two 64-electrode patches, one on the left ventricle (LV) and one on the right ventricle (RV), are fitted as time-varying fields via scaffold parameters and shown on the LV and RV epicardial surfaces, respectively, of the beating heart model. *Note* that these electromechanical data, fitted to the 3D scaffold, are from the same pig heart and include both physiological normal contracting heart beats and the whole heart response to stellate stimulation. This use-case demonstrates the use of the scaffold to merge two types of data set (one mechanical and one electrophysiological) and begins to illustrate the connection between stimulation of the peripheral nervous system and the response at the whole heart level.

This document guides a user of the SPARC Data Portal through the steps required to discover some data looking at autonomic control of the heart.

3.2 Step-by-step instructions

Follow these step-by-step instructions to familiarise yourself with the flow of the web interface.

Step 1: The default **Result** column displays some of the use cases available on the portal. Click on the *Mapping Cardiac Electromechanics in the Pig* box.



Step 2: Click on the  to open the **Scaffold Viewer** tab to visualise the heart scaffold.

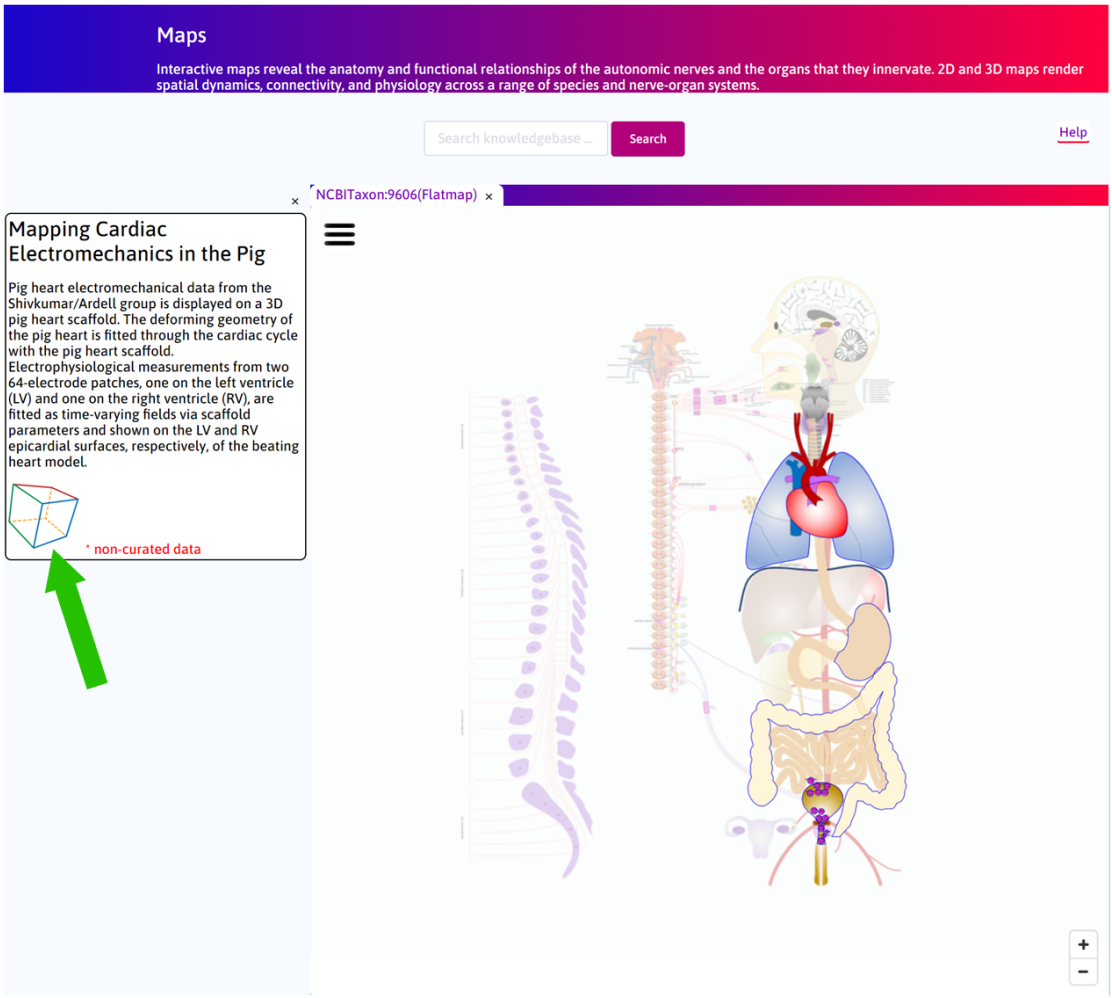
Step 3: In the **Scaffold Viewer** tab, a 3D pig heart scaffold has been fitted to the 2D video data. In addition a 64-electrode patch mesh has been constructed from the original electrode patch on the surface of the left ventricular epicardium. Electro-physiological data recorded from this patch has been registered on the mesh and a field is displayed on the surface of this mesh. This mesh is then *embedded* on the corresponding surface of the scaffold.

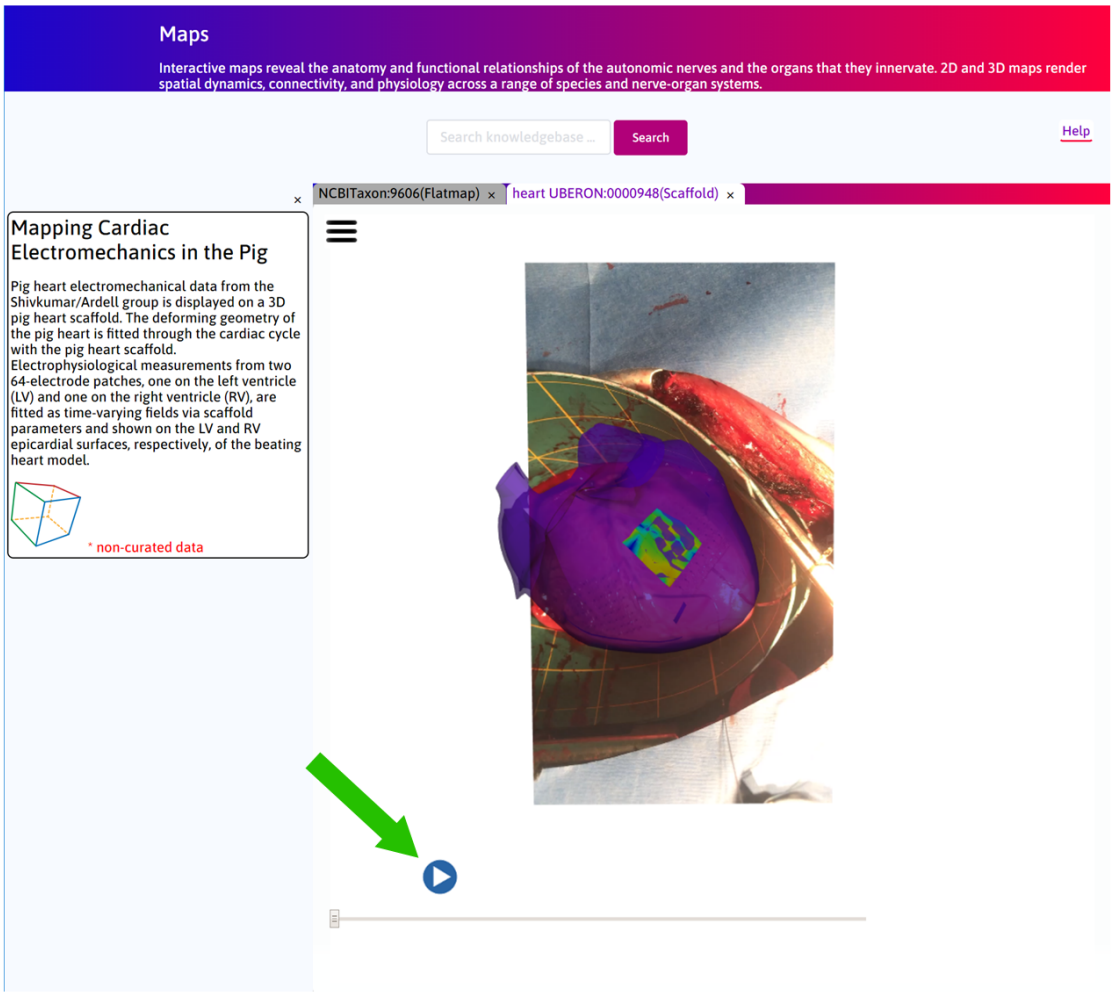
Press **play** to see the video.

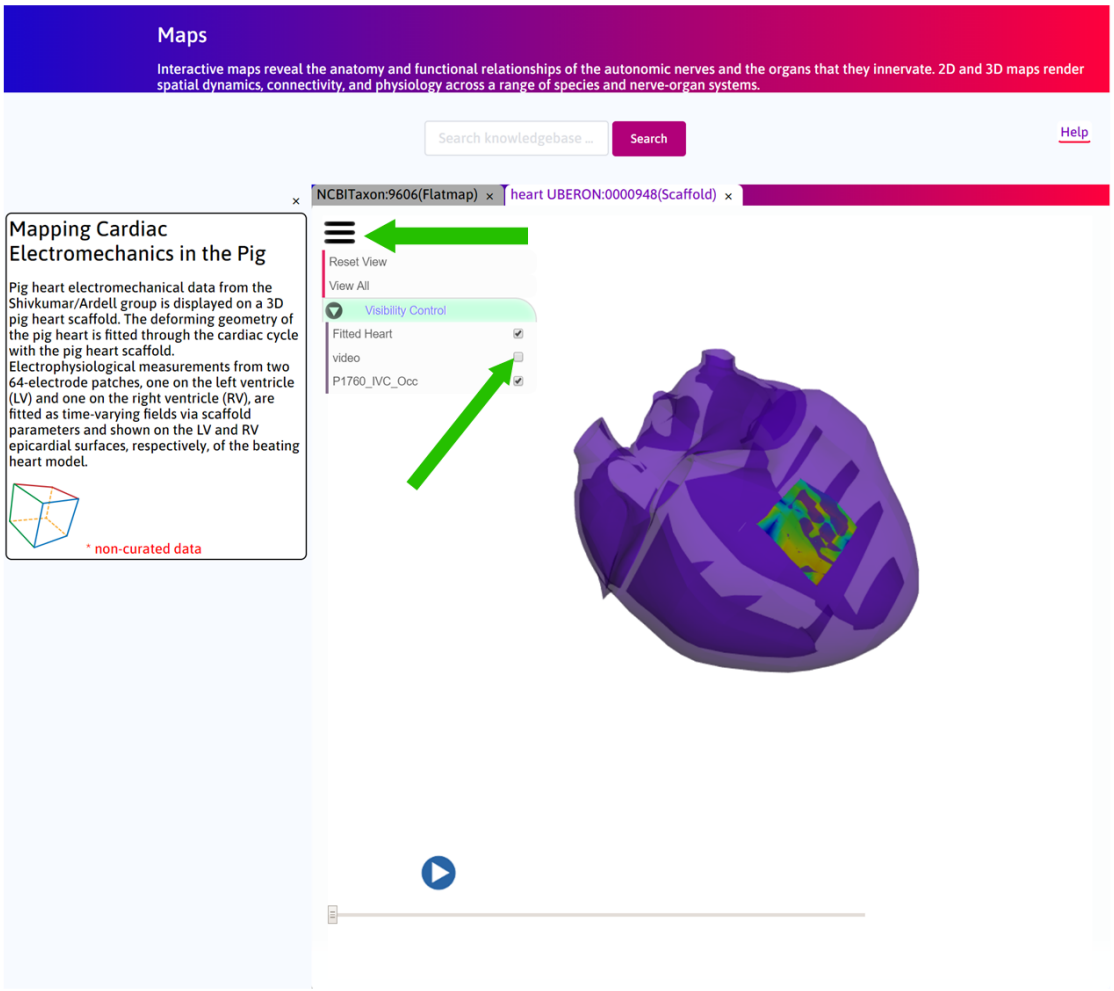
Step 4: By clicking on  you can control visibility of each of the graphical objects in the scene.

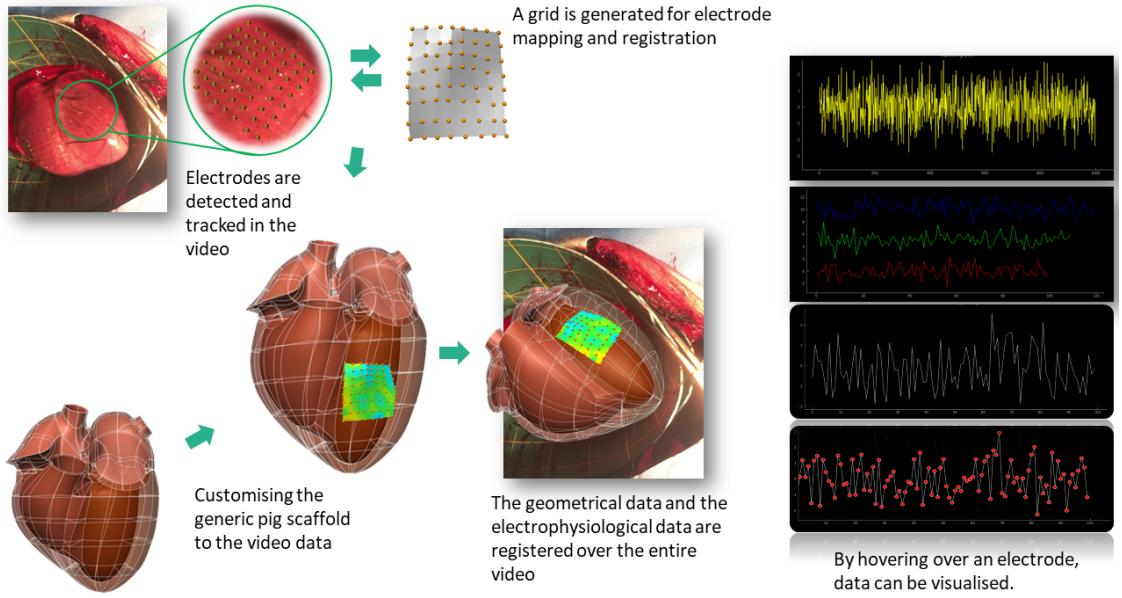
3.3 Scaffold Generation

The following Figure depicts the workflow for the generation of the 3D scaffold.


Maps
Interactive maps reveal the anatomy and functional relationships of the autonomic nerves and the organs that they innervate. 2D and 3D maps render spatial dynamics, connectivity, and physiology across a range of species and nerve-organ systems.
Search knowledgebase ...
Search
Help
NCBITaxon:9606(Flatmap)
Mapping Cardiac Electromechanics in the Pig
Pig heart electromechanical data from the Shivkumar/Ardell group is displayed on a 3D pig heart scaffold. The deforming geometry of the pig heart is fitted through the cardiac cycle with the pig heart scaffold. Electrophysiological measurements from two 64-electrode patches, one on the left ventricle (LV) and one on the right ventricle (RV), are fitted as time-varying fields via scaffold parameters and shown on the LV and RV epicardial surfaces, respectively, of the beating heart model.
* non-curated data


Maps
Interactive maps reveal the anatomy and functional relationships of the autonomic nerves and the organs that they innervate. 2D and 3D maps render spatial dynamics, connectivity, and physiology across a range of species and nerve-organ systems.
Search knowledgebase ...
Search
Help
NCBITaxon:9606(Flatmap)
heart UBERON:0000948(Scaffold)
Mapping Cardiac Electromechanics in the Pig
Pig heart electromechanical data from the Shivkumar/Ardell group is displayed on a 3D pig heart scaffold. The deforming geometry of the pig heart is fitted through the cardiac cycle with the pig heart scaffold.
Electrophysiological measurements from two 64-electrode patches, one on the left ventricle (LV) and one on the right ventricle (RV), are fitted as time-varying fields via scaffold parameters and shown on the LV and RV epicardial surfaces, respectively, of the beating heart model.
* non-curated data


Maps
Interactive maps reveal the anatomy and functional relationships of the autonomic nerves and the organs that they innervate. 2D and 3D maps render spatial dynamics, connectivity, and physiology across a range of species and nerve-organ systems.
Search knowledgebase ...
Search
Help
NCBITaxon:9606(Flatmap)
heart UBERON:0000948(Scaffold)
Mapping Cardiac Electromechanics in the Pig
Pig heart electromechanical data from the Shivkumar/Ardell group is displayed on a 3D pig heart scaffold. The deforming geometry of the pig heart is fitted through the cardiac cycle with the pig heart scaffold.
Electrophysiological measurements from two 64-electrode patches, one on the left ventricle (LV) and one on the right ventricle (RV), are fitted as time-varying fields via scaffold parameters and shown on the LV and RV epicardial surfaces, respectively, of the beating heart model.
* non-curated data
Reset View
View All
Visibility Control
Fitted Heart
video
P1760_IVC_Occ



3.4 Future Steps

In the current version, the scaffold has only been fitted to the video data through anisotropic scaling and some shear. This was a limitation as only one view angle was available. In future, a stereo camera system will be installed to reconstruct a 3D view of the beating heart in order to accurately fit the scaffold and capture the deformation of cardiac tissue.

CHAPTER 4

Mapping the Mouse Heart Neurites from Image to Scaffold

Contents:

4.1 Overview

Immunohistochemical mapping of neural pathways in cleared heart (sham heart 4) stained with PGP9.5 (glycoprotein surface axonal antibody labelling) from the Shivkumar/Pradeep group is displayed in a 3D mouse heart scaffold that has been fitted to the segmented heart surface data from Sham Heart 44, which provides a more extensive geometric dataset. Future experiments are likely to provide much better quality mouse data for both the heart's anatomy and its embedded neurons.

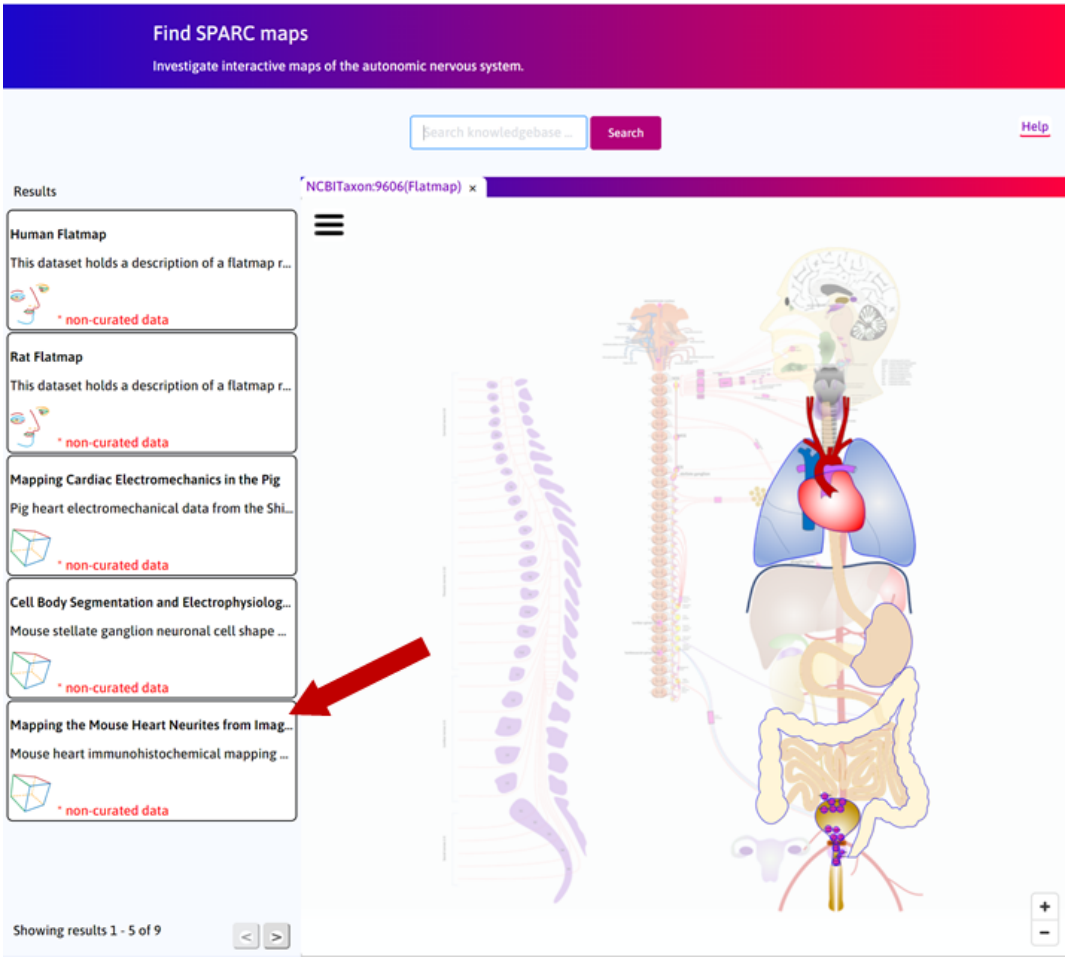
4.2 Step-by-step instructions

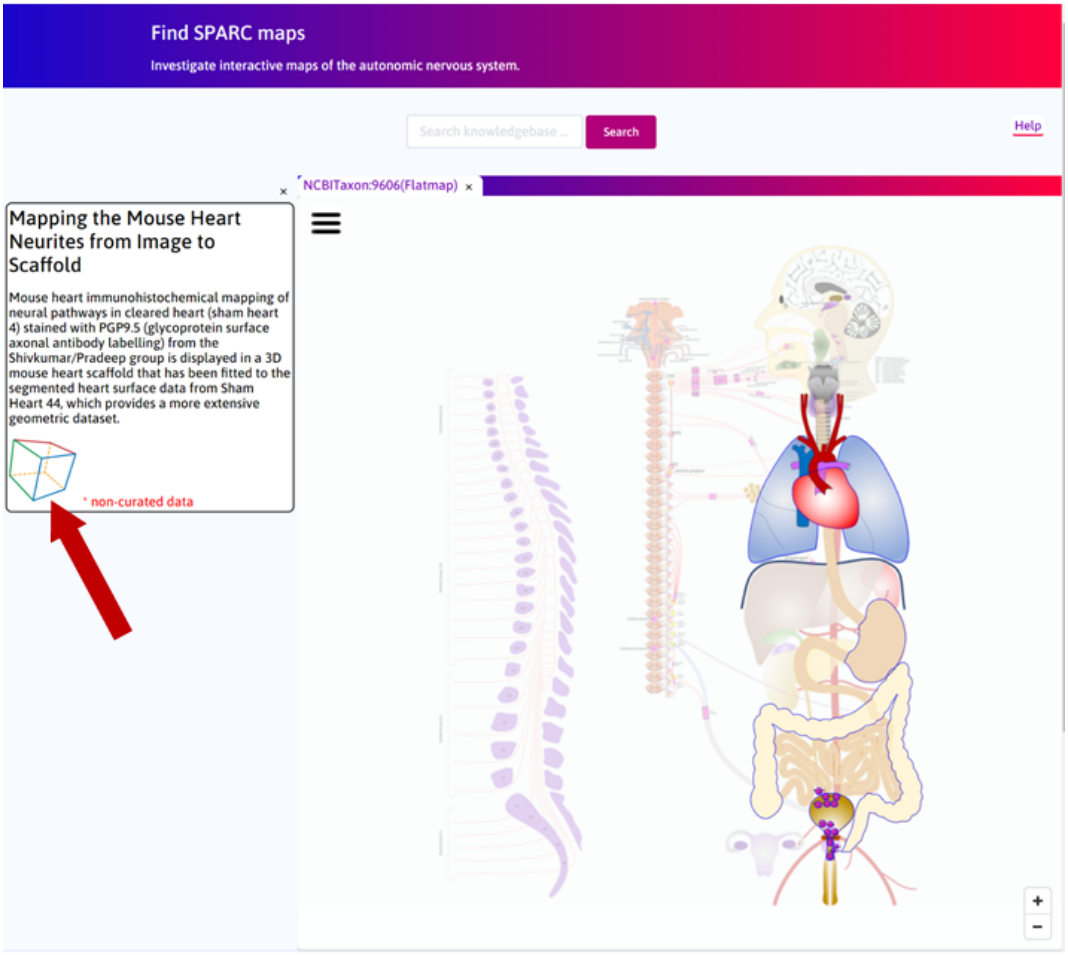
Follow these step-by-step instructions to familiarise yourself with the flow of the web interface.

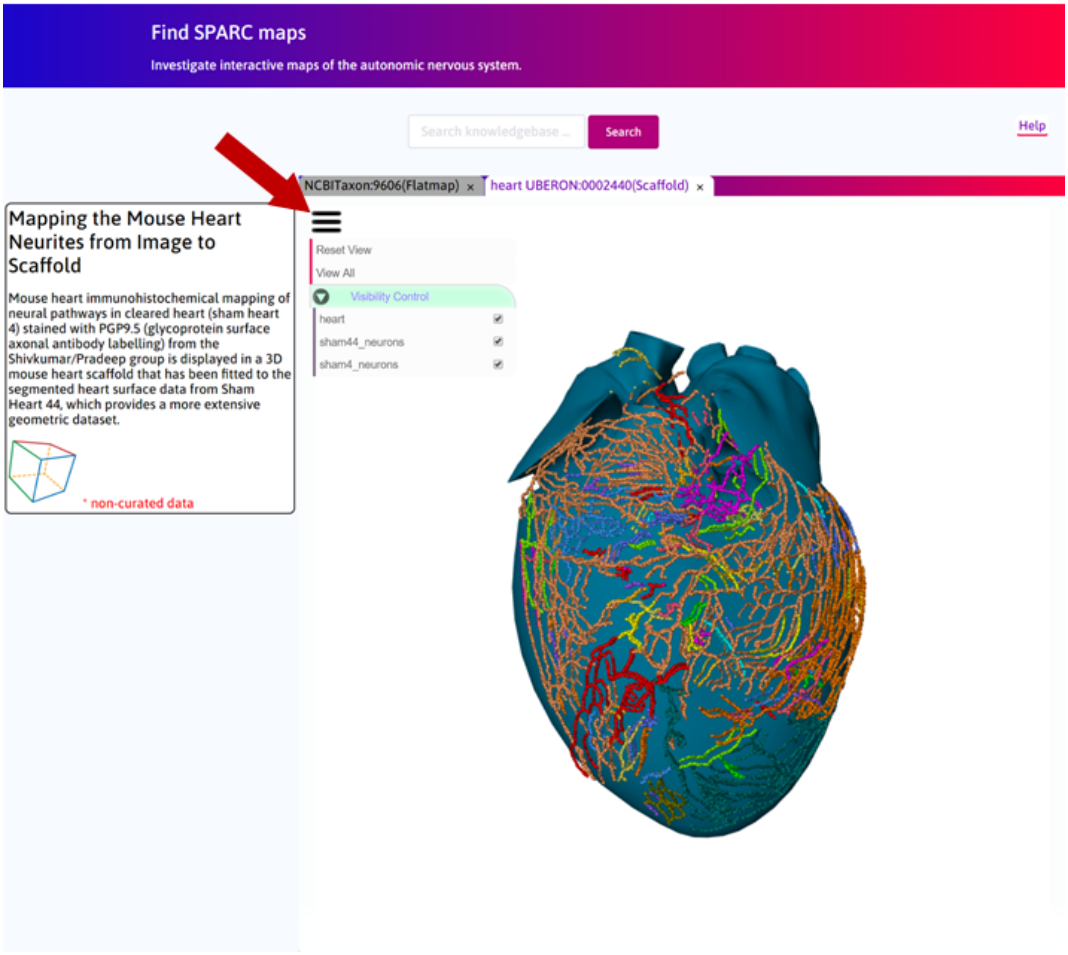
Step 1. The default **Result** column displays the use cases available on the portal. Click on the *Mapping the Mouse Heart Neurites from Image to Scaffold* box.

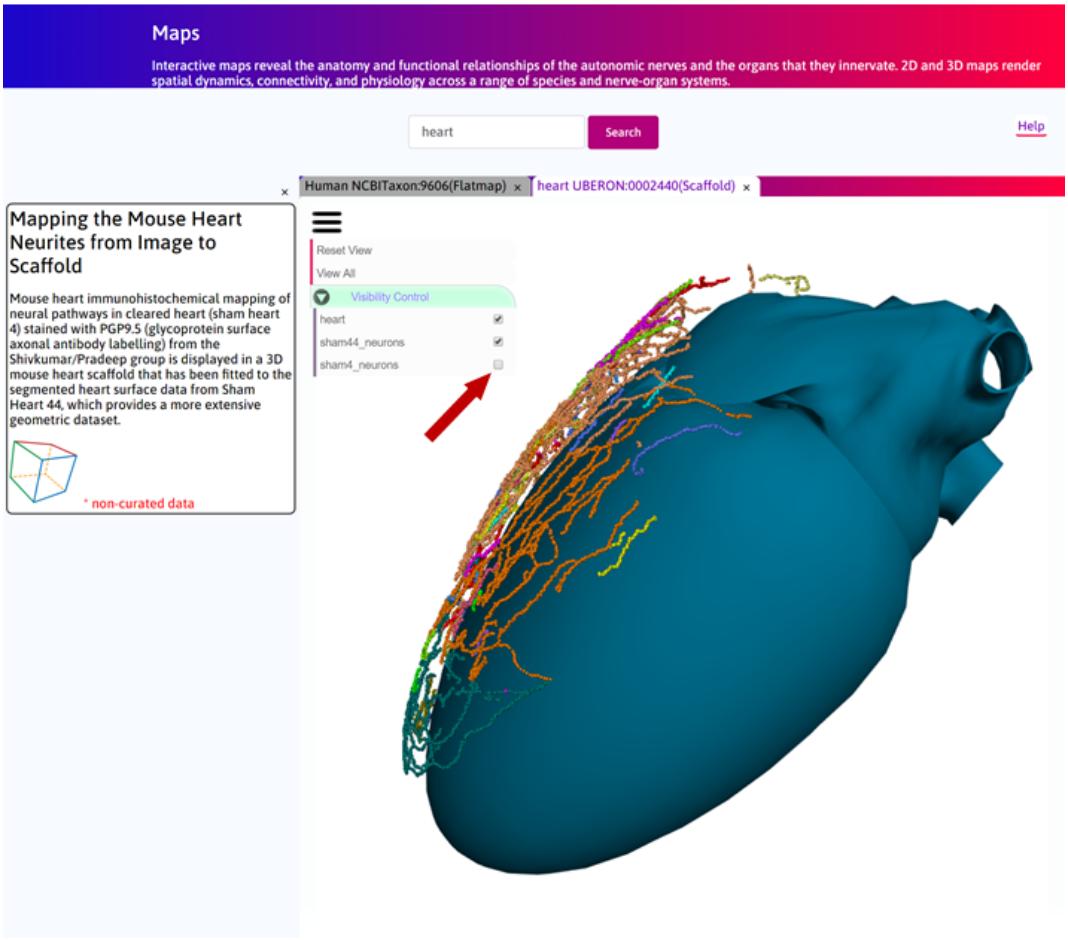
Step 2 Click on the  to open the **Scaffold Viewer** tab to visualise the heart scaffold.

Step 3. In the **Scaffold Viewer** tab, click on  to open the control panel. There are three objects visible: 1) fitted heart scaffold, 2) sham heart 44 neurite tracing, 3) sham heart 4 neurite tracing.


Find SPARC maps
Investigate interactive maps of the autonomic nervous system.
Search knowledgebase ...
Search
Help
Results
NCBITaxon:9606(Flatmap)
Human Flatmap
This dataset holds a description of a flatmap r...
* non-curated data
Rat Flatmap
This dataset holds a description of a flatmap r...
* non-curated data
Mapping Cardiac Electromechanics in the Pig
Pig heart electromechanical data from the Shi...
* non-curated data
Cell Body Segmentation and Electrophysiolog...
Mouse stellate ganglion neuronal cell shape ...
* non-curated data
Mapping the Mouse Heart Neurites from Imag...
Mouse heart immunohistochemical mapping ...
* non-curated data
Showing results 1 - 5 of 9
< >
+
−

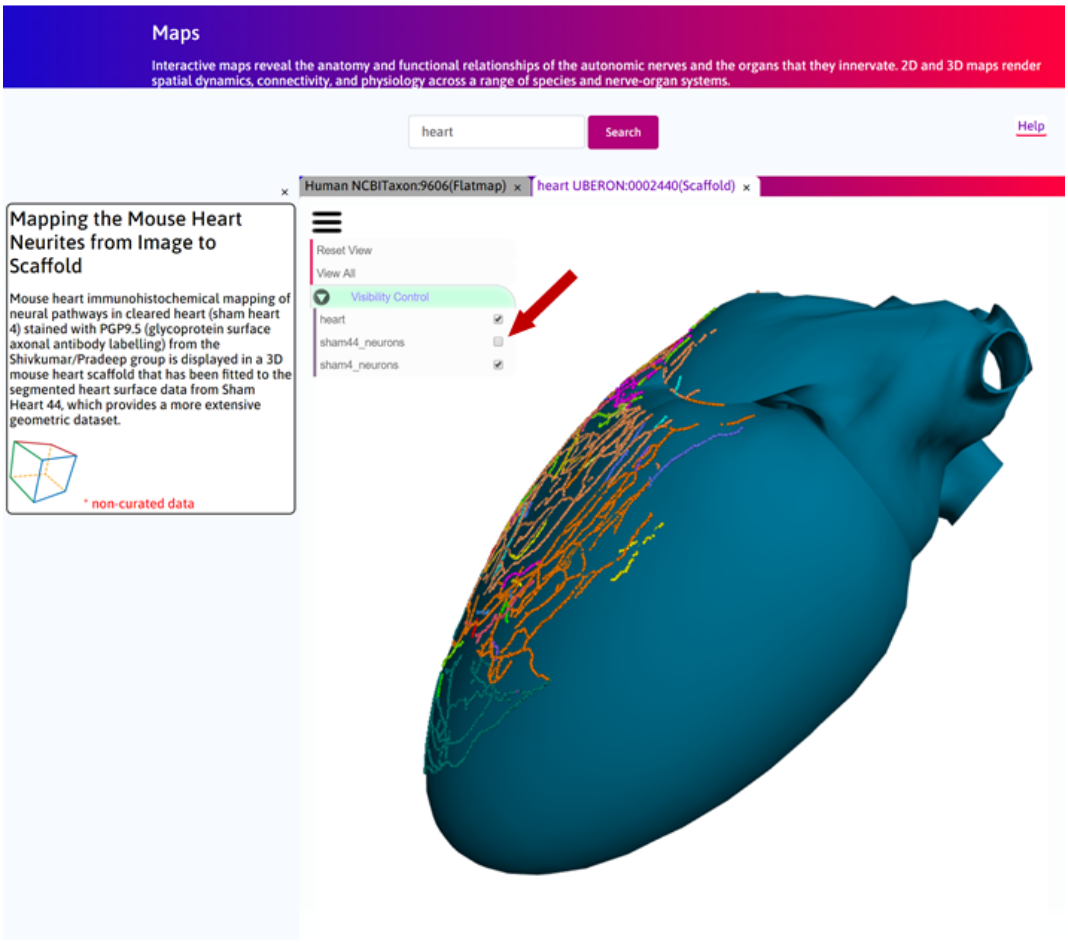

Find SPARC maps
Investigate interactive maps of the autonomic nervous system.
Search knowledgebase ...
Search
Help
NCBITaxon:9606(Flatmap)
Mapping the Mouse Heart Neurites from Image to Scaffold
Mouse heart immunohistochemical mapping of neural pathways in cleared heart (sham heart 4) stained with PGP9.5 (glycoprotein surface axonal antibody labelling) from the Shivkumar/Pradeep group is displayed in a 3D mouse heart scaffold that has been fitted to the segmented heart surface data from Sham Heart 44, which provides a more extensive geometric dataset.
* non-curated data


Find SPARC maps
Investigate interactive maps of the autonomic nervous system.
Search knowledgebase ...
Search
Help
NCBITaxon:9606(Flatmap)
heart UBERON:0002440(Scaffold)
Mapping the Mouse Heart Neurites from Image to Scaffold
Mouse heart immunohistochemical mapping of neural pathways in cleared heart (sham heart 4) stained with PGP9.5 (glycoprotein surface axonal antibody labelling) from the Shivkumar/Pradeep group is displayed in a 3D mouse heart scaffold that has been fitted to the segmented heart surface data from Sham Heart 44, which provides a more extensive geometric dataset.
* non-curated data
Reset View
View All
Visibility Control
heart
sham44_neurons
sham4_neurons


Maps
Interactive maps reveal the anatomy and functional relationships of the autonomic nerves and the organs that they innervate. 2D and 3D maps render spatial dynamics, connectivity, and physiology across a range of species and nerve-organ systems.
heart
Search
Help
Human NCBITaxon:9606(Flatmap)
heart UBERON:0002440(Scaffold)
Mapping the Mouse Heart Neurites from Image to Scaffold
Mouse heart immunohistochemical mapping of neural pathways in cleared heart (sham heart 4) stained with PGP9.5 (glycoprotein surface axonal antibody labelling) from the Shivkumar/Pradeep group is displayed in a 3D mouse heart scaffold that has been fitted to the segmented heart surface data from Sham Heart 44, which provides a more extensive geometric dataset.
* non-curated data
Reset View
View All
Visibility Control
heart
sham44_neurons
sham4_neurons

Step 4. **Turn off Sham 4 neurons** to only visualise the scaffold and Sham 44 neurons.

Step 5. **Turn Sham 4 neurons back on** and now **turn off Sham 44 neurons** to visualise the registered neurons on the scaffold surface.

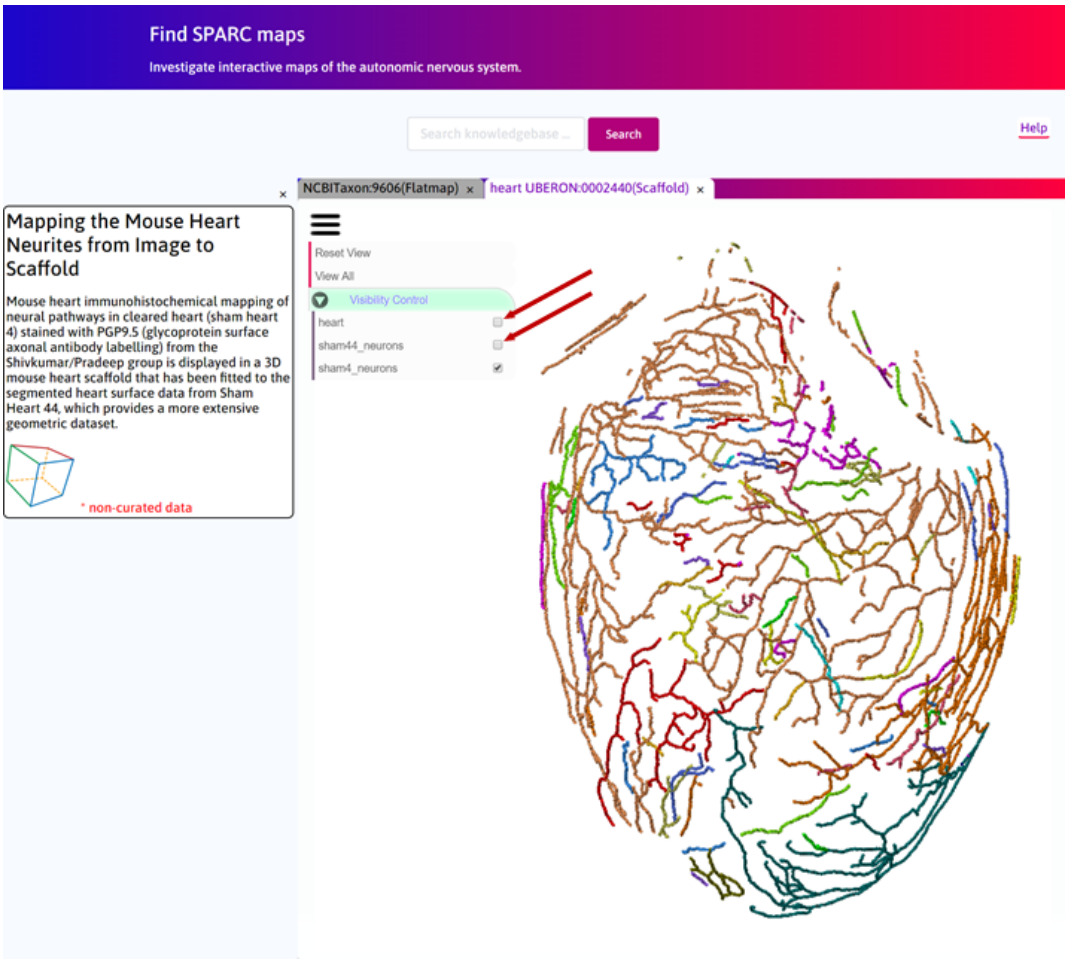


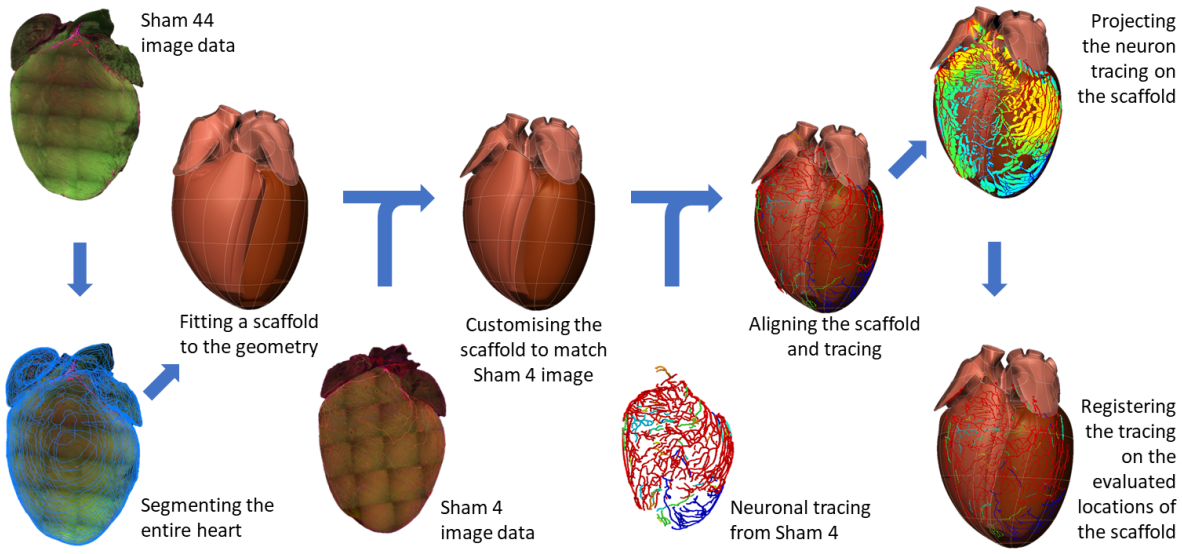
Step 6. To visualise only the neurons, **turn off the scaffold**.

4.3 Scaffold Generation

The following figure illustrates an overview of the workflow for the generation of the 3D scaffold.

Below is an **introductory video** which explains the mapping of the mouse heart neurites from image to scaffold.


Find SPARC maps
Investigate interactive maps of the autonomic nervous system.
Search knowledgebase ...
Search
Help
NCBITaxon:9606(Flatmap)
heart UBERON:0002440(Scaffold)
Mapping the Mouse Heart Neurites from Image to Scaffold
Mouse heart immunohistochemical mapping of neural pathways in cleared heart (sham heart 4) stained with PGP9.5 (glycoprotein surface axonal antibody labelling) from the Shivkumar/Pradeep group is displayed in a 3D mouse heart scaffold that has been fitted to the segmented heart surface data from Sham Heart 44, which provides a more extensive geometric dataset.
* non-curated data
Reset View
View All
Visibility Control
heart
sham44_neurons
sham4_neurons


Sham 44 image data
Fitting a scaffold to the geometry
Customising the scaffold to match Sham 4 image
Aligning the scaffold and tracing
Projecting the neuron tracing on the scaffold
Segmenting the entire heart
Sham 4 image data
Neuronal tracing from Sham 4
Registering the tracing on the evaluated locations of the scaffold

CHAPTER 5

Mapping Cellular Gene Expression in the Rat Heart from Image to Scaffold

Contents:

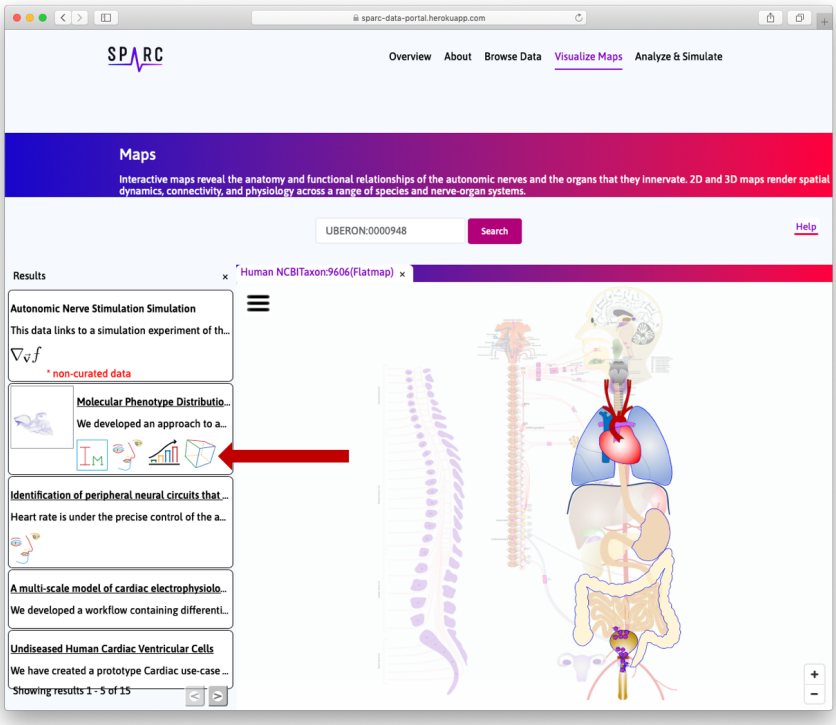
5.1 Overview

Rat heart geometric 3Scan data for both ventricles and both atria from the Schwaber/Vadigepalli/Cheng group has been fitted with a 3D rat heart scaffold. The location of a cluster of 151 intrinsic cardiac neuron (ICN) samples, which have been lifted for RNA-Seq analysis (molecular cell body transcript data) from a region of the left atrium (from a different animal), are indicated on the 3D scaffold. To click on one of these tissue locations displays the RNA message level for the 154 genes examined. To visualize the spatial distribution of the RNA message, the 151 samples have been fitted with a continuous field description using scaffold nodal parameters. Any one of the 154 genes can be selected to show the spatial variation of that transcript as a heat map. Rat heart neural pathway data showing the efferent connectome linking ICN cells in the left atrium and the SA node cells on the right atrium are visualized in the next iteration of this use case.

5.2 Step-by-step instructions

Follow these step-by-step instructions to familiarize yourself with the flow of the Web interface.

Step 1. The default **Result** column displays the use cases available on the portal. Click on the *Mapping Cellular Gene Expression in the Rat Heart from Image to Scaffold* box, then click on icon.



The Scaffold Viewer tab opens and the fitted heart scaffold can be visualized. A number of lifted neuronal cells have been mapped and registered on the scaffold (purple spheres).

Step 2. Click on the ☰ icon to pop up the drop-down menu. Visibility can be turned *on* or *off* for each item.

Step 3. Hover on the different regions to highlight the chambers separately.

Each cell has been lifted and assayed for the expression of 154 genes selected as associated with neuromodulation and cardiac function using qPCR or RNASeq. These have been mapped on the registered cells on the scaffold. Each cell has a unique ID.

Step 4. Now, click on the  icon.

The Data Viewer tab opens to view the gene expression data. At this point, the data can only viewed using a bar chart. However, additional visualization capabilities, such as heatmap and clustering, will be available in the future.

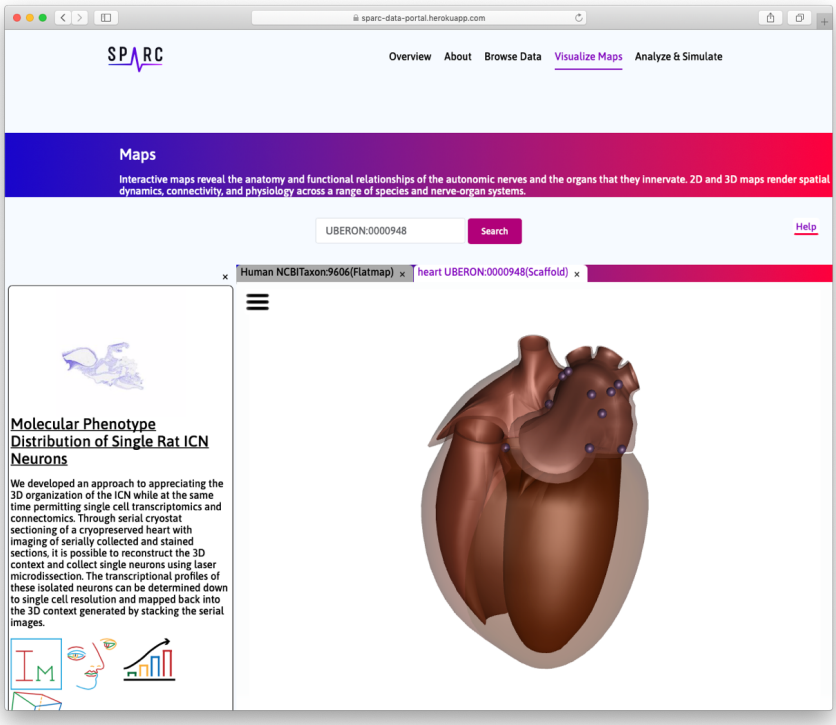
Step 5. Add more genes to the bar chart by expanding the drop-down menu.

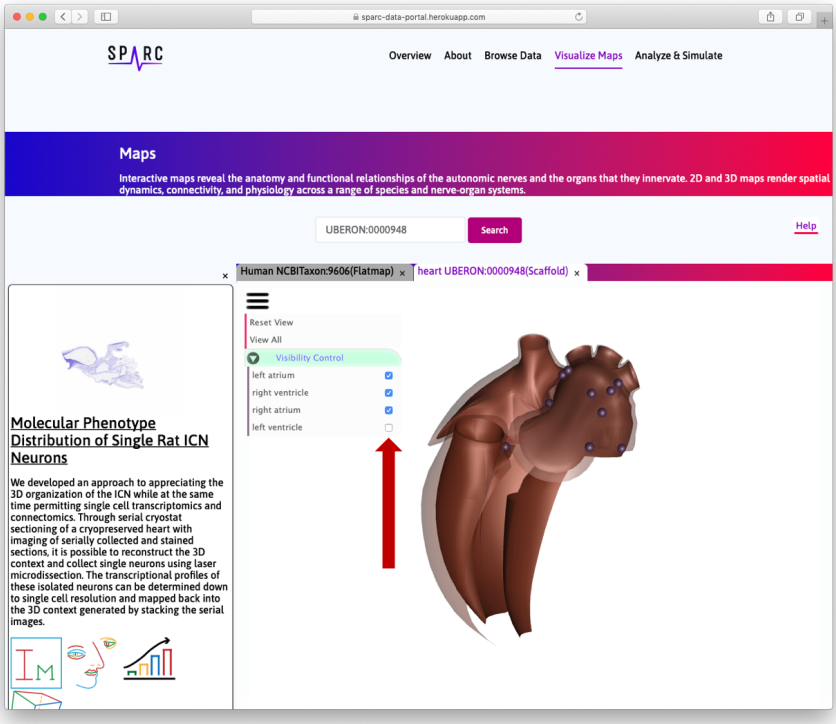
The bar chart will show the expression of each gene using a unique color for all the registered cells on the scaffold.

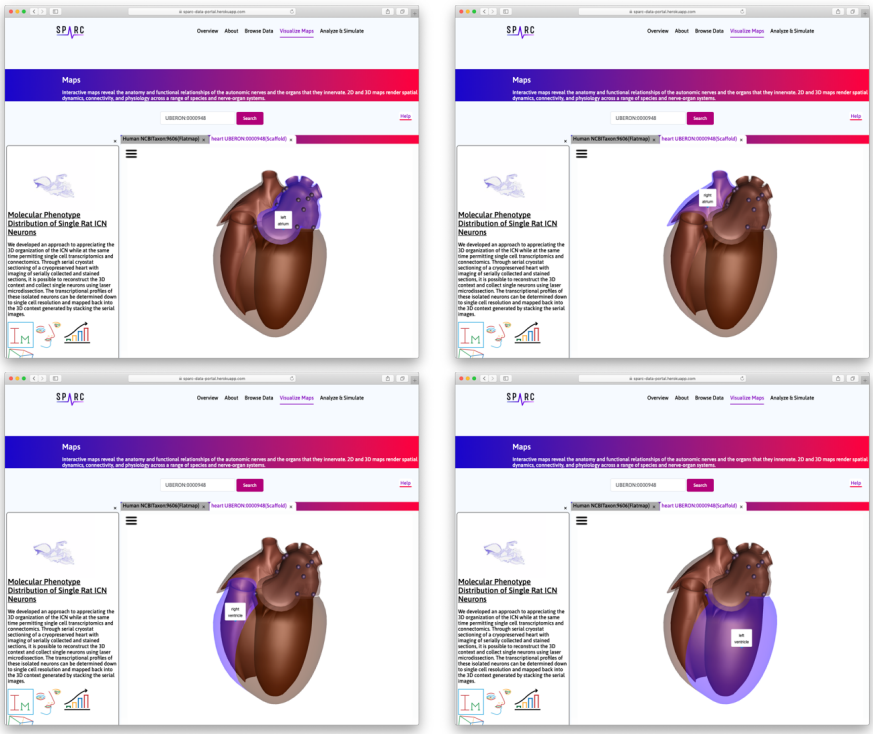
5.3 Scaffold Generation

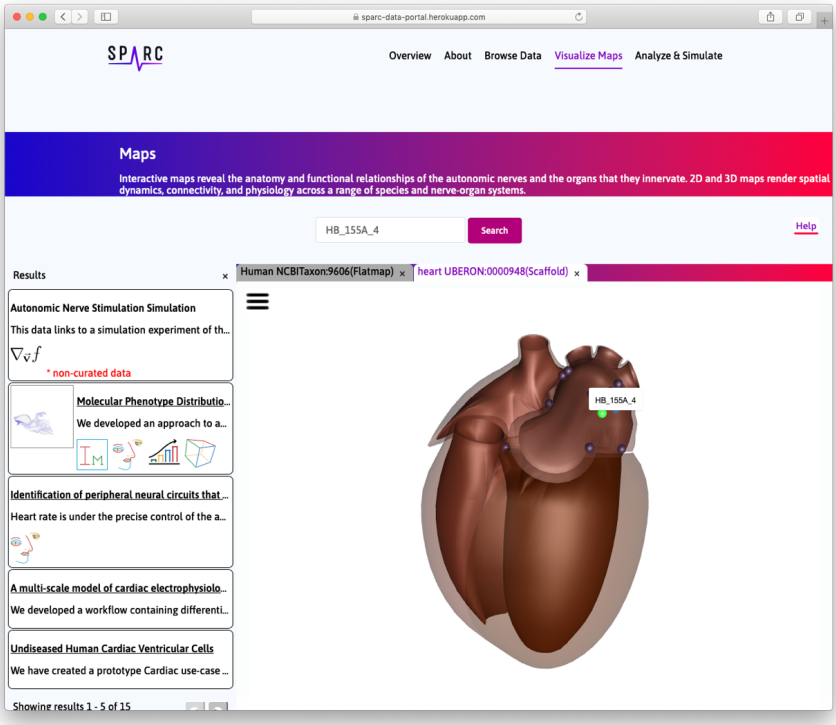
The following Figure depicts the workflow for the generation of the 3D scaffold.

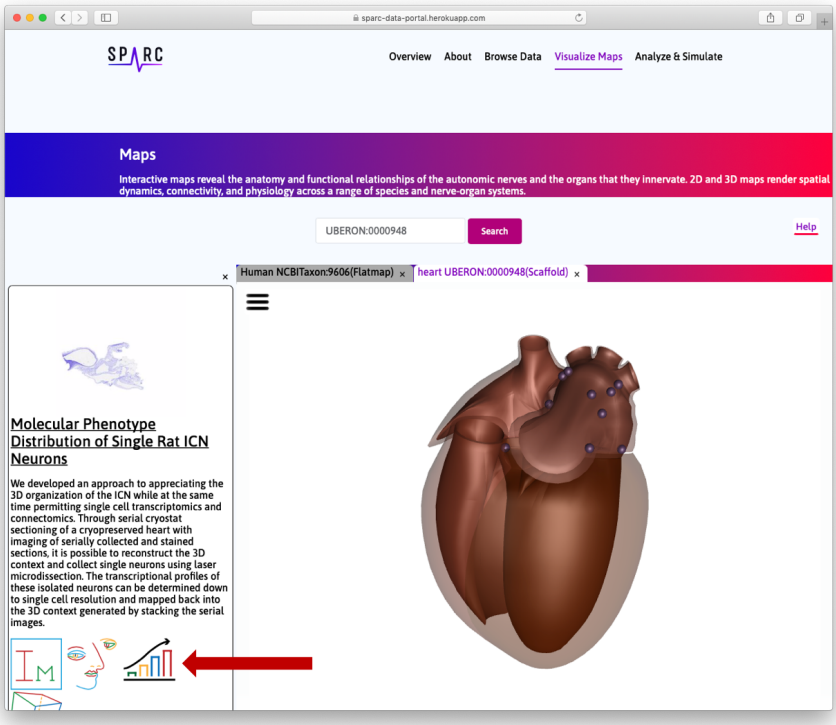
The treatment process needed to extract the cells for RNA-Seq analysis left that rat heart in a very distorted state and was therefore not fitted with a scaffold. Instead, corresponding locations of the ICN cells in the much less distorted 3Scan-processed heart were identified by eye and the cell information was transferred to that heart.


sparc-data-portal.herokuapp.com
SPARC
Overview
About
Browse Data
Visualize Maps
Analyze & Simulate
Maps
Interactive maps reveal the anatomy and functional relationships of the autonomic nerves and the organs that they innervate. 2D and 3D maps render spatial dynamics, connectivity, and physiology across a range of species and nerve-organ systems.
UBERON:0000948
Search
Help
Human NCBITaxon:9606(Flatmap)
heart UBERON:0000948(Scaffold)
Molecular Phenotype Distribution of Single Rat ICN Neurons
We developed an approach to appreciating the 3D organization of the ICN while at the same time permitting single cell transcriptomics and connectomics. Through serial cryostat sectioning of a cryopreserved heart with imaging of serially collected and stained sections, it is possible to reconstruct the 3D context and collect single neurons using laser microdissection. The transcriptional profiles of these isolated neurons can be determined down to single cell resolution and mapped back into the 3D context generated by stacking the serial images.


sparc-data-portal.herokuapp.com
SPARC
Overview
About
Browse Data
Visualize Maps
Analyze & Simulate
Maps
Interactive maps reveal the anatomy and functional relationships of the autonomic nerves and the organs that they innervate. 2D and 3D maps render spatial dynamics, connectivity, and physiology across a range of species and nerve-organ systems.
UBERON:0000948
Search
Help
Human NCBITaxon:9606(Flatmap)
heart UBERON:0000948(Scaffold)
Reset View
View All
Visibility Control
left atrium
right ventricle
right atrium
left ventricle
Molecular Phenotype Distribution of Single Rat ICN Neurons
We developed an approach to appreciating the 3D organization of the ICN while at the same time permitting single cell transcriptomics and connectomics. Through serial cryostat sectioning of a cryopreserved heart with imaging of serially collected and stained sections, it is possible to reconstruct the 3D context and collect single neurons using laser microdissection. The transcriptional profiles of these isolated neurons can be determined down to single cell resolution and mapped back into the 3D context generated by stacking the serial images.

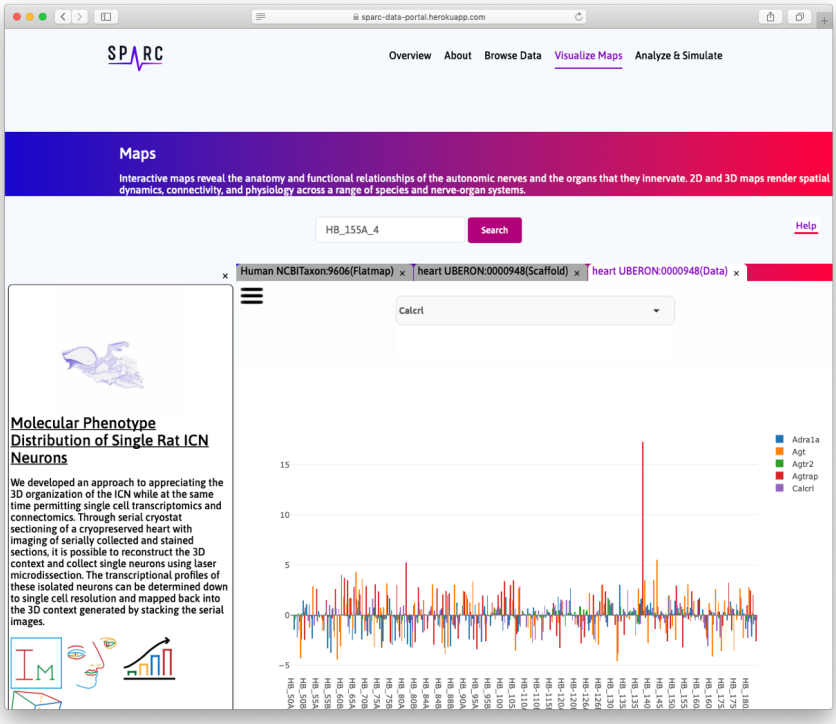


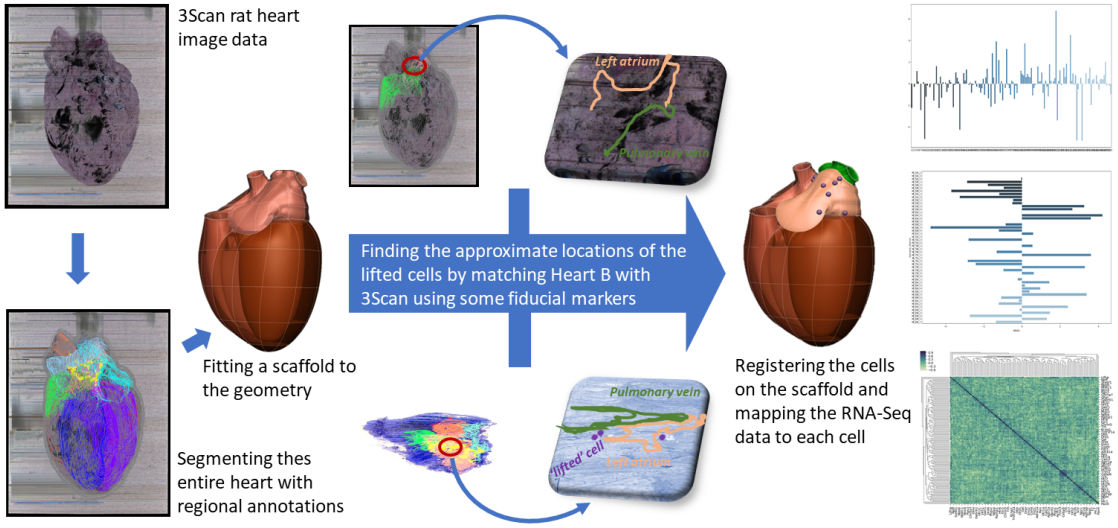

sparc-data-portal.herokuapp.com
SPARC
Overview
About
Browse Data
Visualize Maps
Analyze & Simulate
Maps
Interactive maps reveal the anatomy and functional relationships of the autonomic nerves and the organs that they innervate. 2D and 3D maps render spatial dynamics, connectivity, and physiology across a range of species and nerve-organ systems.
HB_155A_4
Search
Help
Results
Human NCBITaxon:9606(Flatmap)
heart UBERON:0000948(Scaffold)
Autonomic Nerve Stimulation Simulation
This data links to a simulation experiment of th...
* non-curated data
Molecular Phenotype Distributio...
We developed an approach to a...
Identification of peripheral neural circuits that...
Heart rate is under the precise control of the a...
A multi-scale model of cardiac electrophysiolo...
We developed a workflow containing differenti...
Undiseased Human Cardiac Ventricular Cells
We have created a prototype Cardiac use-case ...
Showing results 1 - 5 of 15
HB_155A_4


sparc-data-portal.herokuapp.com
SPARC
Overview
About
Browse Data
Visualize Maps
Analyze & Simulate
Maps
Interactive maps reveal the anatomy and functional relationships of the autonomic nerves and the organs that they innervate. 2D and 3D maps render spatial dynamics, connectivity, and physiology across a range of species and nerve-organ systems.
UBERON:0000948
Search
Help
Human NCBITaxon:9606(Flatmap)
heart UBERON:0000948(Scaffold)
Molecular Phenotype Distribution of Single Rat ICN Neurons
We developed an approach to appreciating the 3D organization of the ICN while at the same time permitting single cell transcriptomics and connectomics. Through serial cryostat sectioning of a cryopreserved heart with imaging of serially collected and stained sections, it is possible to reconstruct the 3D context and collect single neurons using laser microdissection. The transcriptional profiles of these isolated neurons can be determined down to single cell resolution and mapped back into the 3D context generated by stacking the serial images.


sparc-data-portal.herokuapp.com
SPARC
Overview
About
Browse Data
Visualize Maps
Analyze & Simulate
Maps
Interactive maps reveal the anatomy and functional relationships of the autonomic nerves and the organs that they innervate. 2D and 3D maps render spatial dynamics, connectivity, and physiology across a range of species and nerve-organ systems.
HB_155A_4
Search
Help
Human NCBITaxon:9606(Flatmap)
heart UBERON:0000948(Scaffold)
heart UBERON:0000948(Data)
Adra1a
Molecular Phenotype Distribution of Single Rat ICN Neurons
We developed an approach to appreciating the 3D organization of the ICN while at the same time permitting single cell transcriptomics and connectomics. Through serial cryostat sectioning of a cryopreserved heart with imaging of serially collected and stained sections, it is possible to reconstruct the 3D context and collect single neurons using laser microdissection. The transcriptional profiles of these isolated neurons can be determined down to single cell resolution and mapped back into the 3D context generated by stacking the serial images.


sparc-data-portal.herokuapp.com
SPARC
Overview
About
Browse Data
Visualize Maps
Analyze & Simulate
Maps
Interactive maps reveal the anatomy and functional relationships of the autonomic nerves and the organs that they innervate. 2D and 3D maps render spatial dynamics, connectivity, and physiology across a range of species and nerve-organ systems.
HB_155A_4
Search
Help
Human NCBITaxon:9606(Flatmap)
heart UBERON:0000948(Scaffold)
heart UBERON:0000948(Data)
Adra1a
Adra2a
Adrb1
Agt
Press to select
Agtr1a
Agtr2
Agtrap
Ar
Molecular Phenotype Distribution of Single Rat ICN Neurons
We developed an approach to appreciating the 3D organization of the ICN while at the same time permitting single cell transcriptomics and connectomics. Through serial cryostat sectioning of a cryopreserved heart with imaging of serially collected and stained sections, it is possible to reconstruct the 3D context and collect single neurons using laser microdissection. The transcriptional profiles of these isolated neurons can be determined down to single cell resolution and mapped back into the 3D context generated by stacking the serial images.


sparc-data-portal.herokuapp.com
SPARC
Overview
About
Browse Data
Visualize Maps
Analyze & Simulate
Maps
Interactive maps reveal the anatomy and functional relationships of the autonomic nerves and the organs that they innervate. 2D and 3D maps render spatial dynamics, connectivity, and physiology across a range of species and nerve-organ systems.
HB_155A_4
Search
Help
Human NCBITaxon:9606(Flatmap)
heart UBERON:0000948(Scaffold)
heart UBERON:0000948(Data)
Calcrl
Adra1a
Agt
Agtr2
Agtrap
Calcrl
Molecular Phenotype Distribution of Single Rat ICN Neurons
We developed an approach to appreciating the 3D organization of the ICN while at the same time permitting single cell transcriptomics and connectomics. Through serial cryostat sectioning of a cryopreserved heart with imaging of serially collected and stained sections, it is possible to reconstruct the 3D context and collect single neurons using laser microdissection. The transcriptional profiles of these isolated neurons can be determined down to single cell resolution and mapped back into the 3D context generated by stacking the serial images.


3Scan rat heart image data
Left atrium
Pulmonary vein
Finding the approximate locations of the lifted cells by matching Heart B with 3Scan using some fiducial markers
Fitting a scaffold to the geometry
Segmenting thes entire heart with regional annotations
Pulmonary vein
Lifted cell
Left atrium
Registering the cells on the scaffold and mapping the RNA-Seq data to each cell

CHAPTER 6

Mapping Gene Expression in the Mouse Lungs from Images to Scaffold

Contents:

6.1 Overview

A 3D scaffold of the mouse thoracic cavity created using segmentation of longitudinal microCT scans from the SIMBA VIA (Vision and Image Analysis) public database is visualized. The trachea and main bronchi are also shown as rings of segmented points. Confocal stained images from Taylor-Clark group for mouse lungs are embedded into the scaffold. The confocal images were obtained from the right middle lobe (RML). The scaffold was registered to ensure alignment with the airway branch visible on the confocal. This use-case is one of many that link an organ systems with the brainstem.

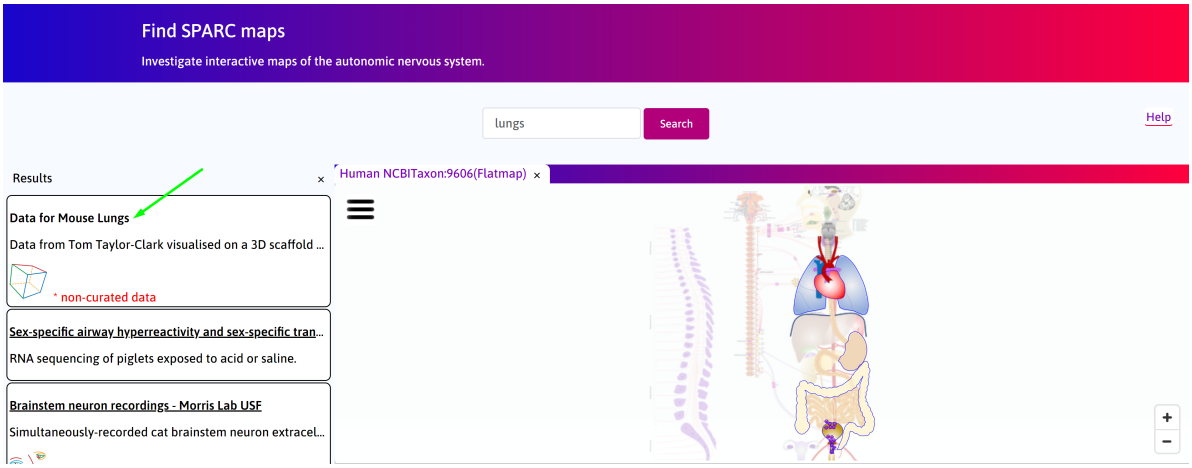
6.2 Step-by-step instructions

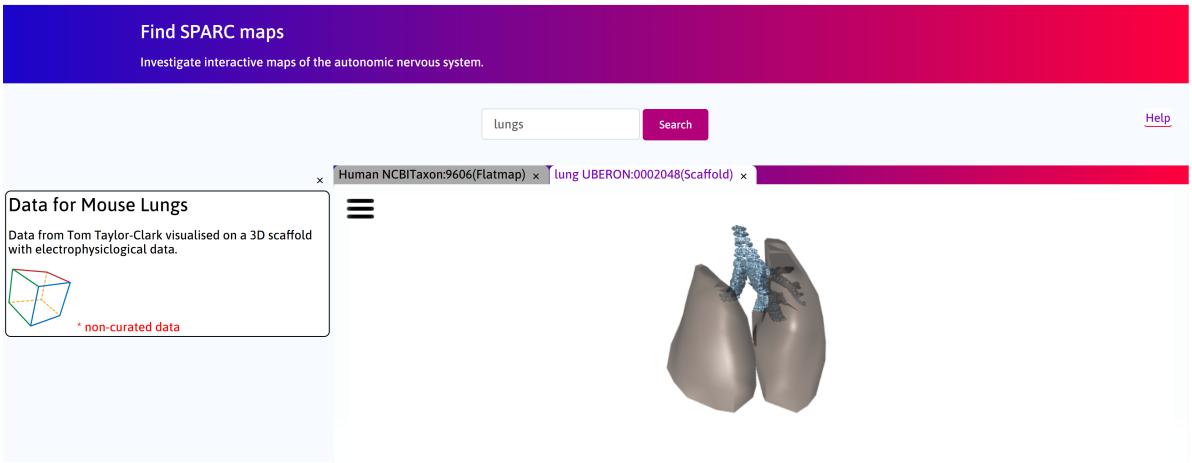
Follow these step-by-step instructions to familiarise yourself with the flow of the web interface.

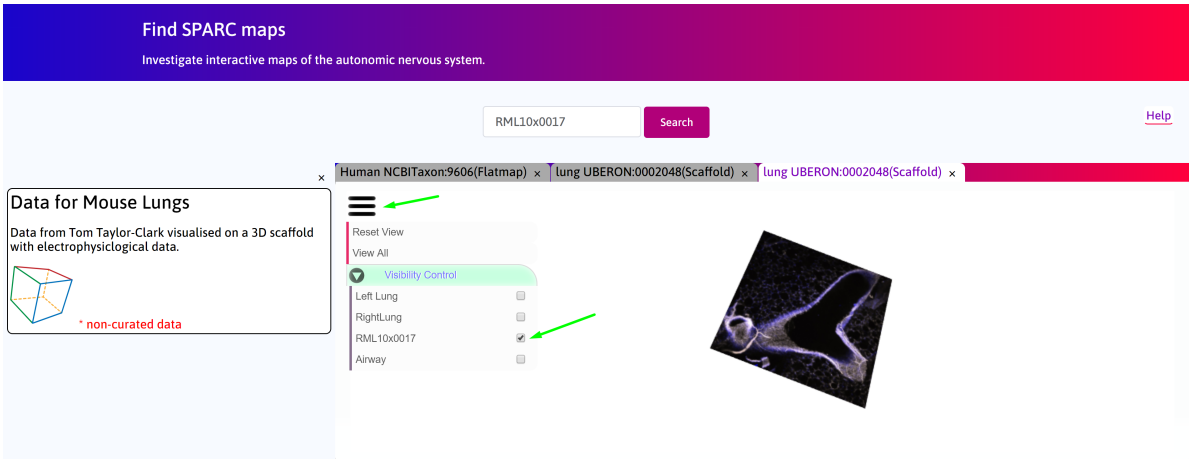
Step 1. The default **Result** column displays the use cases available on the portal. Click on the *Mapping Gene Expression in the Mouse Lungs from Images to Scaffold* box, then on  icon.

Step 2. Allow model to load.

Step 3. To view only the confocal image in the right middle lobe (RML), select only RML10x007 checkbox after clicking on ☰ icon for drop-down menu.

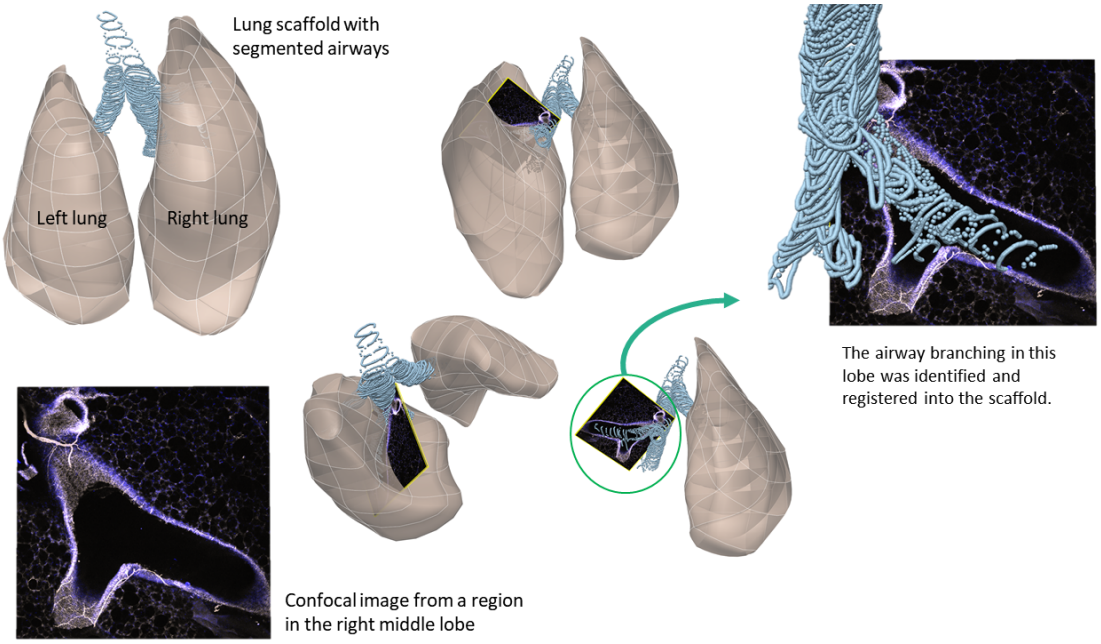

Find SPARC maps
Investigate interactive maps of the autonomic nervous system.
lungs
Search
Help
Results
Human NCBITaxon:9606(Flatmap)
Data for Mouse Lungs
Data from Tom Taylor-Clark visualised on a 3D scaffold ...
* non-curated data
Sex-specific airway hyperreactivity and sex-specific tran...
RNA sequencing of piglets exposed to acid or saline.
Brainstem neuron recordings - Morris Lab USF
Simultaneously-recorded cat brainstem neuron extracel...


Find SPARC maps
Investigate interactive maps of the autonomic nervous system.
lungs
Search
Help
Human NCBITaxon:9606(Flatmap)
lung UBERON:0002048(Scaffold)
Data for Mouse Lungs
Data from Tom Taylor-Clark visualised on a 3D scaffold with electrophysiclogical data.
* non-curated data


Find SPARC maps
Investigate interactive maps of the autonomic nervous system.
RML10x0017
Search
Help
Human NCBITaxon:9606(Flatmap)
lung UBERON:0002048(Scaffold)
lung UBERON:0002048(Scaffold)
Data for Mouse Lungs
Data from Tom Taylor-Clark visualised on a 3D scaffold with electrophysiclogical data.
* non-curated data
Reset View
View All
Visibility Control
Left Lung
RightLung
RML10x0017
Airway

6.3 Scaffold Generation

A diagram and video are below, detailing the workflow for the generation of an anatomically-based 3D thoracic shape of the lungs.



CHAPTER 7

3D Mapping and Visualization of 2D Experimental Data Stomach Afferents and Efferents

Contents:

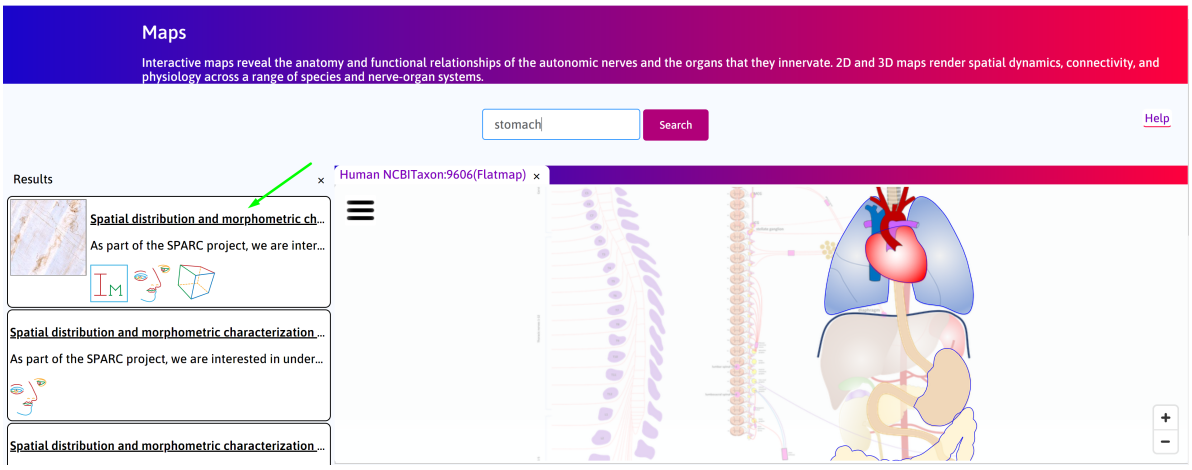
7.1 Overview

A 3D scaffold of the rat stomach created using segmented microCT data from the Powley group is shown. The neurites including nerve endings (both intraganglionic laminar endings (IGLEs) and longitudinal intramuscular arrays (IMAs) are displayed on the 3D scaffold. The scaffold can be cut and opened out flat to match the experimental whole-mount preparation, and to then display the experimental data. Note that 152 neurite maps (from 152 different rats) were each registered to a fitted scaffold for each rat and then morphed into the average flat mount scaffold. At specific locations on the scaffold, the corresponding microscopy image of the neurite can be seen via Biolucida. This use-case demonstrates both the application of neural pathway data to the stomach and the use of a transformation between the normal 3D stomach anatomy and the 2D whole-mount preparation.

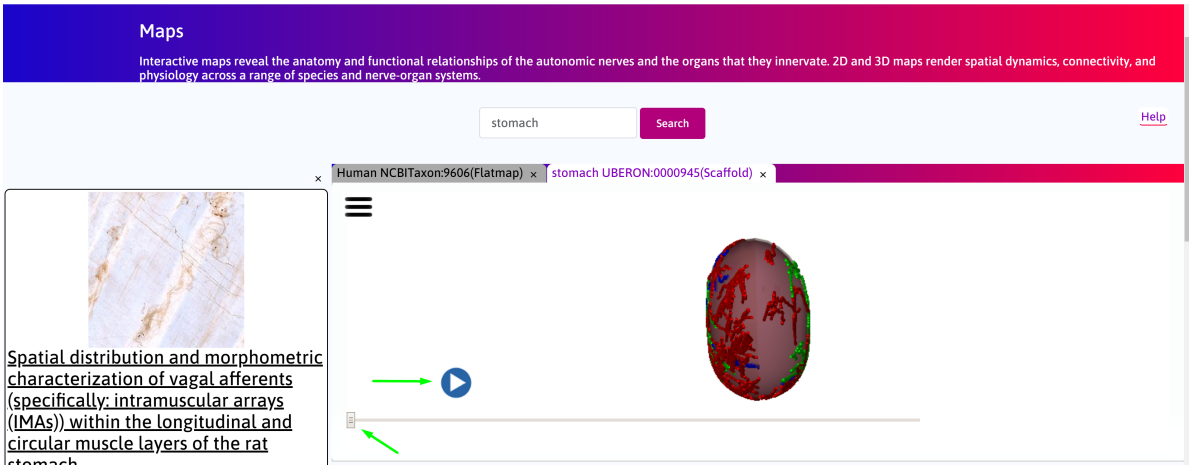
7.2 Step-by-step instructions

Follow these step-by-step instructions to familiarise yourself with the flow of the web interface.

Step 1. The default **Result** column displays the use cases available on the portal. Click on the *3D Mapping and Visualization of 2D Experimental Data Stomach Afferents and Efferents* box. Click on the scaffold icon ().



Step 2. Allow a few seconds for the scaffold to load. Navigate between the 3D scaffold and layers view using the slider. Click on the play button to automate toggle between the configurations.



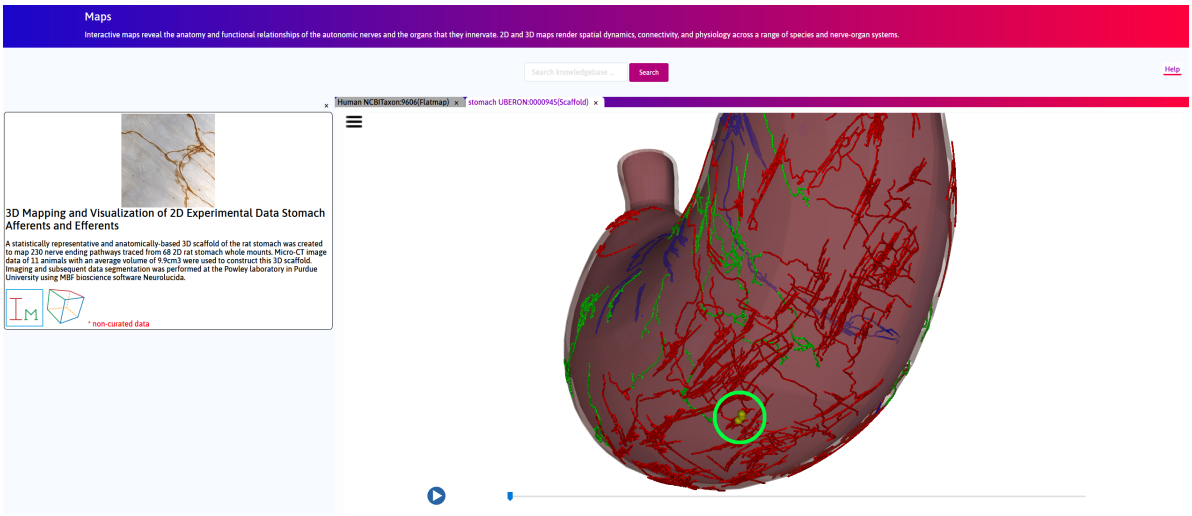
Step 3. Under unexpanded view, right-click and drag to rotate the scaffold. On the longitudinal ventral surface, locate 3 yellow spheres, which represent distinct neurites.

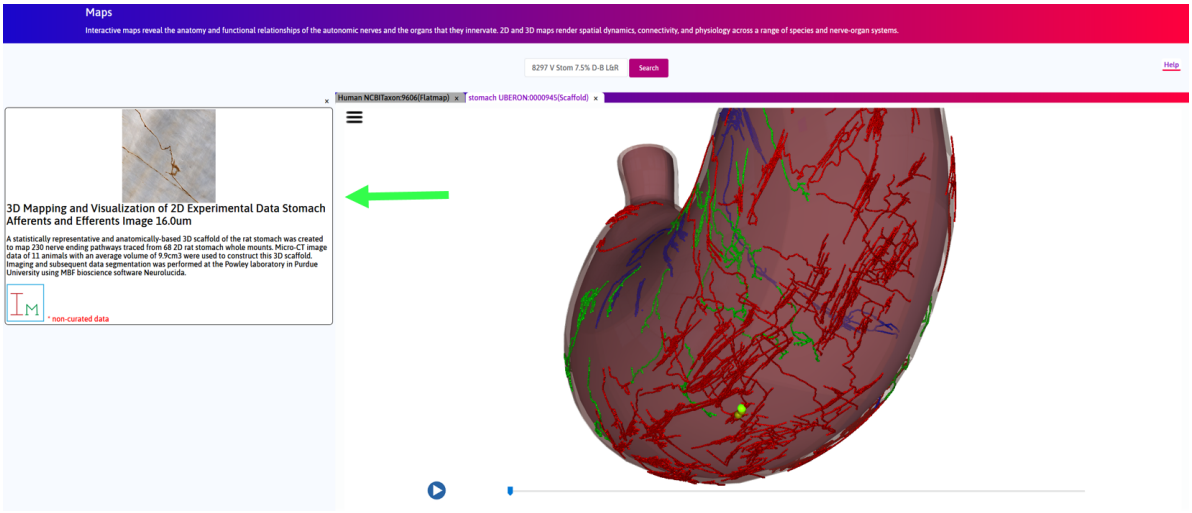
Step 4. Click on a yellow sphere. In the left panel inset, a link to a light microscopy image of the neurites in the corresponding location on the fitted scaffold is visible.

7.3 Scaffold Generation

A statistically representative and anatomically-based 3D scaffold of the rat stomach was created to map nerve ending pathways. Micro-CT image data of 11 animals were used to construct this 3D scaffold. Imaging and data segmentation was performed at the Powley laboratory using Neurolucida (MBF Bioscience). An approximate surface was generated for each case using gross morphometric measurements of the organ. These surfaces were then fitted to the segmented data (Fig. 1). The fitted scaffolds surfaces were combined to form an average stomach surface of representative thickness to generate the 3D scaffold, which was subsequently split into three anatomically-distinct tissue layers.

230 neurite pathways imaged and segmented from whole mounts of 68 different rats were then mapped into the multi-layered 3D scaffold. Each neurite was first deformed in the X-Y plane to match its standard contour using a free-form deformation technique (Fig 6(a)). The standard contour was then transformed with its contents to its 3D counterpart (b).





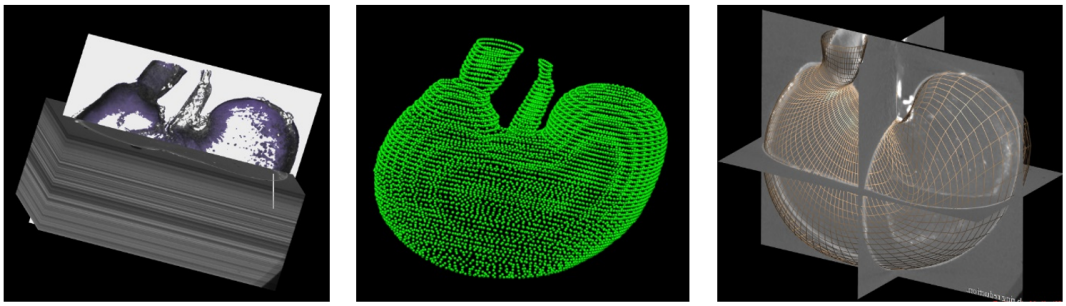


Fig. 1 (a) Micro-CT of rat stomach (b) Segmented data (c) Fitted scaffold surface

Fig. 6 Mapping 2D experimentally determined nerve ending to representative 3D scaffold (a) Actual 2D ventral contour with neurite tracing (b) Deformed to match standard 2D ventral contour (c) Transformed to 3D ventral scaffold

The neurites consisted of three types of afferents- IMAs, IGLEs and circular IMAs; efferents were mapped from their standard 2D contour to the 3D scaffold. The afferent IGLEs and efferents were placed between smooth muscle layers (myenteric plexus layer) while IMAs were included between respective smooth muscle layers (Fig. 7).

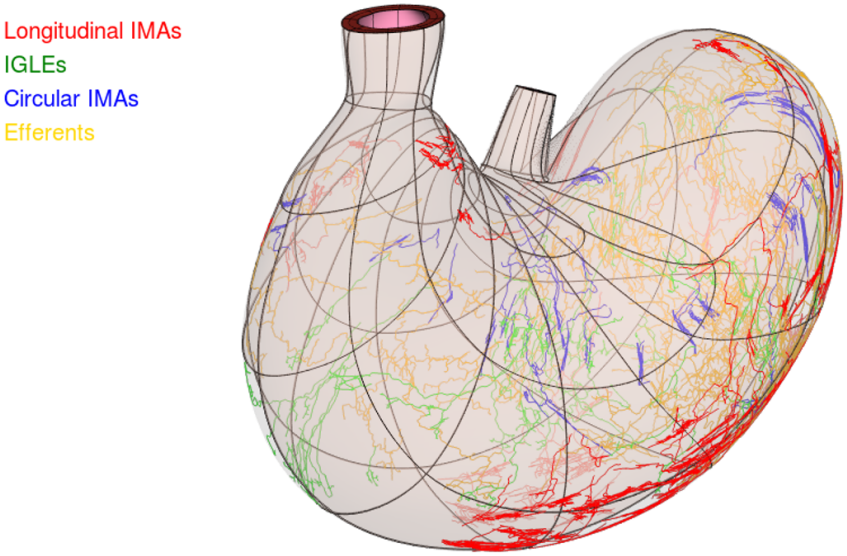


Fig. 7. Mapped 2D neurite pathways in 3D scaffold (230 neurites – 68 stomachs)

7.4 Future Steps

Plans are under way to acquire more detailed high-resolution images to better understand the tissue structural composition and vasculature. Once available, the 3D scaffold's tissue layers will be updated accordingly. This includes having the data and models being visualized at varying levels of stomach fills i.e. empty to full states.

CHAPTER 8

Rat Superior Cervical Ganglion

Contents:

8.1 Overview

Mapping of neuroanatomical connectivity is illustrated using rat superior cervical ganglion (SCG) data from Steve Lewis' group at CWRU and rat brainstem data from Don Bolser's group at UFL. This knowledge is assimilated into the SPARC SciGraph, to demonstrate cross-domain data linkage. The Bolser and Lewis work has three major areas of physiological complementarity:

Larynx/Trachea: The sensory (Bolser) and motor (Lewis) limbs of protective mechanisms for the upper respiratory tract are captured in the connectivity model.

Carotid Body: Chemosensing for oxygen partial pressure by the Carotid Body is key to respiratory control (Bolser). The SCG (Lewis) sends effector projections to the Carotid Body that modulate its chemosensing.

Carotid Sinus: Non-intuitively, blood pressure sensing by the carotid sinus is also key to respiratory control (Bolser). The SCG (Lewis) sends effector projections to the Carotid Sinus that modulate its barosensing.

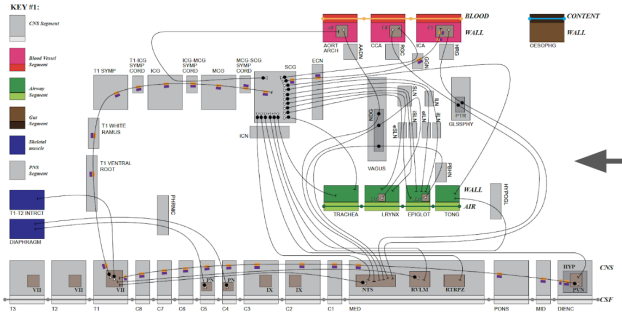
Knowledge that links the above pathways provides a key means to discover multiple datasets (usually siloed behind institutional and collaborative divides) in these diverse physiology domains.

8.2 Step-by-step instructions

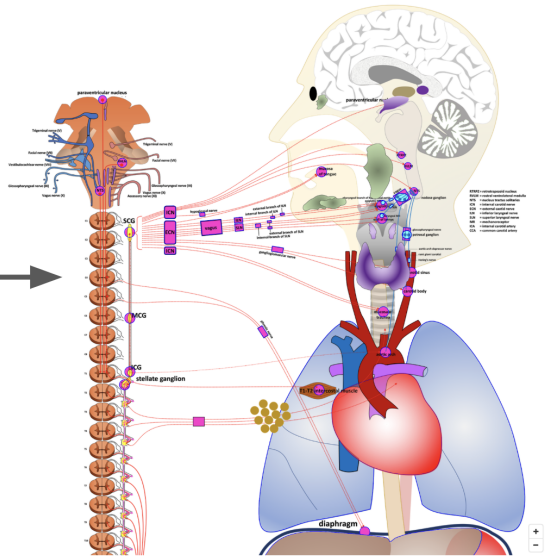
Follow these step-by-step instructions to familiarise yourself with the flow of the web interface.

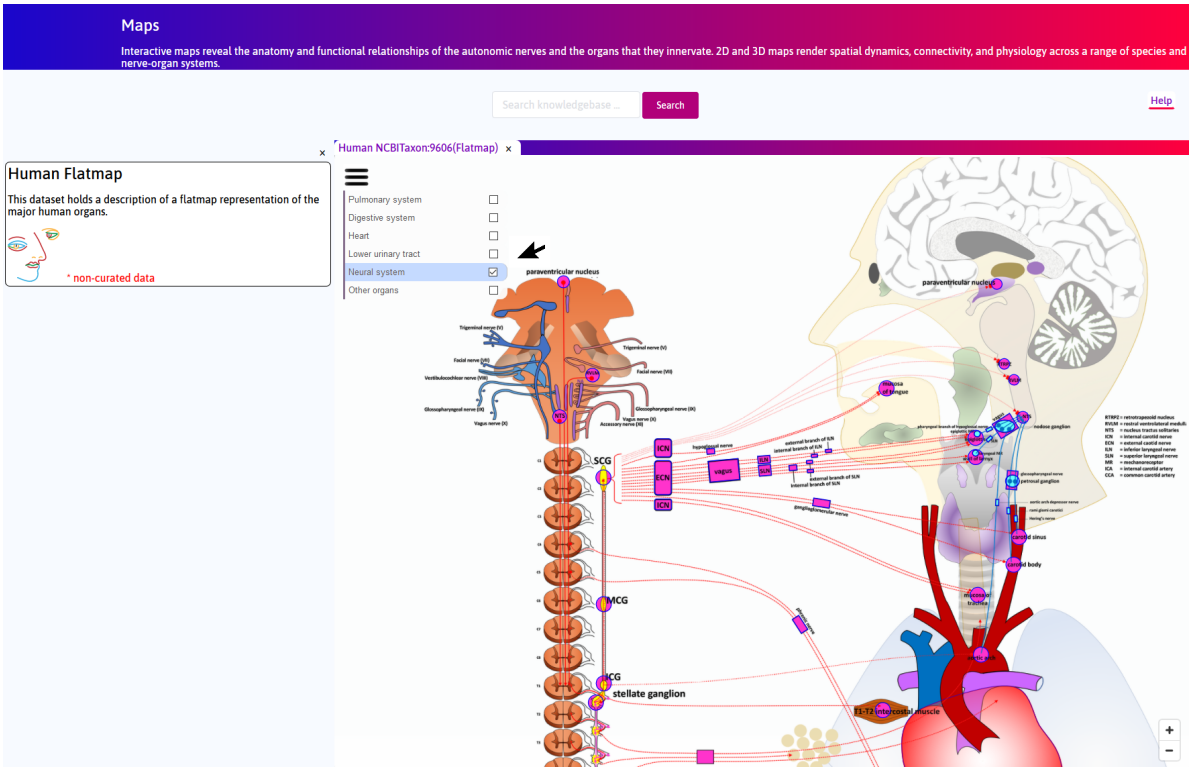
Step 1. Select **Neural system** from the drop-down menu |open-control| on the human flatmap.

ApiNATOMY connectivity model

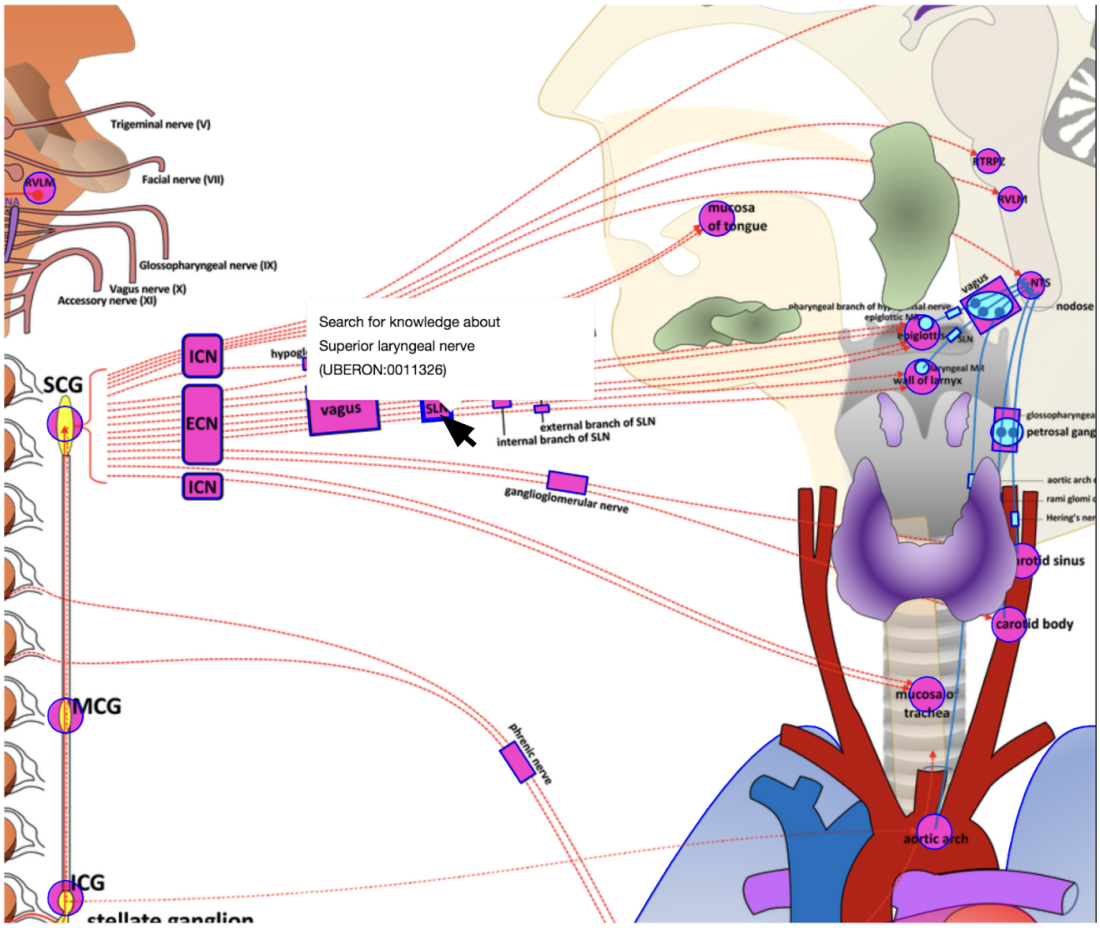


Flatmap graphical depiction





Step 2. *Right-click* on **pink rectangles** that symbolizes portion of nerve.

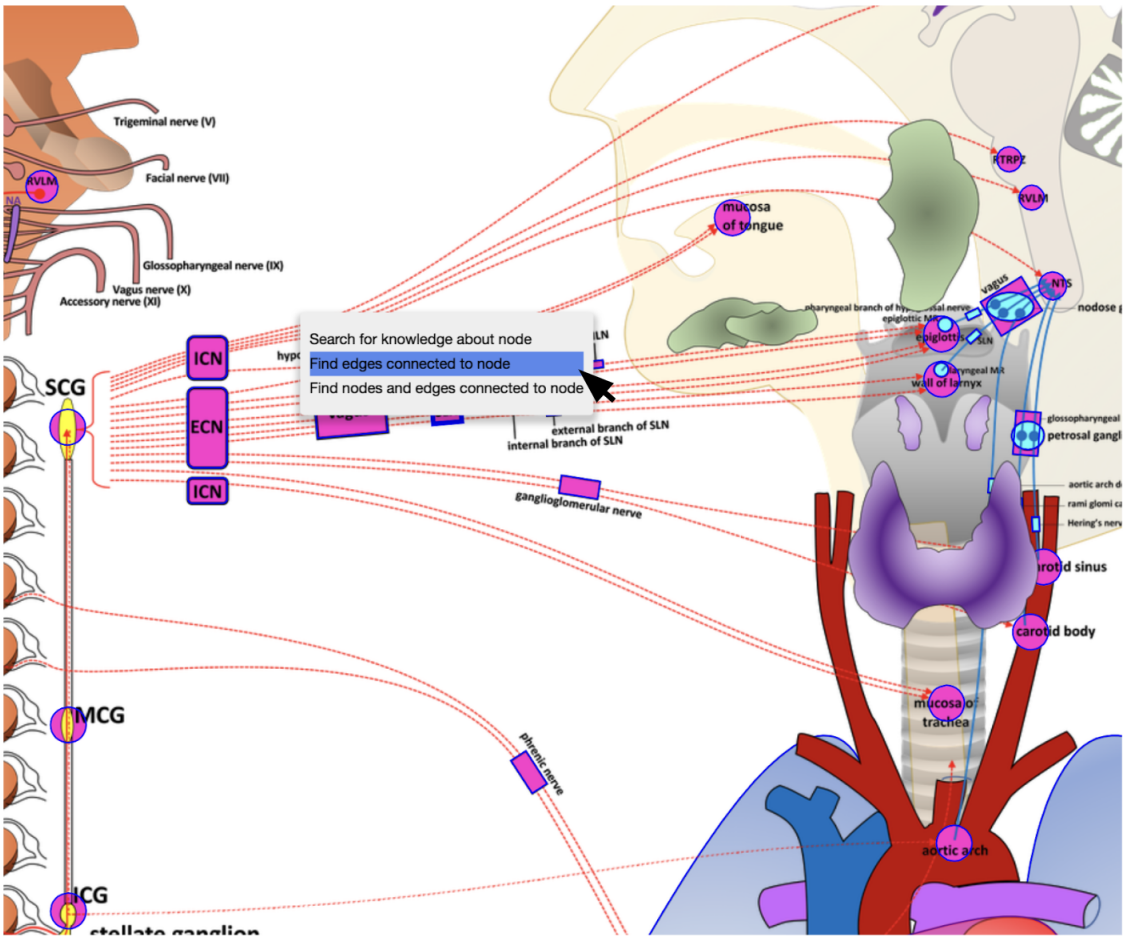


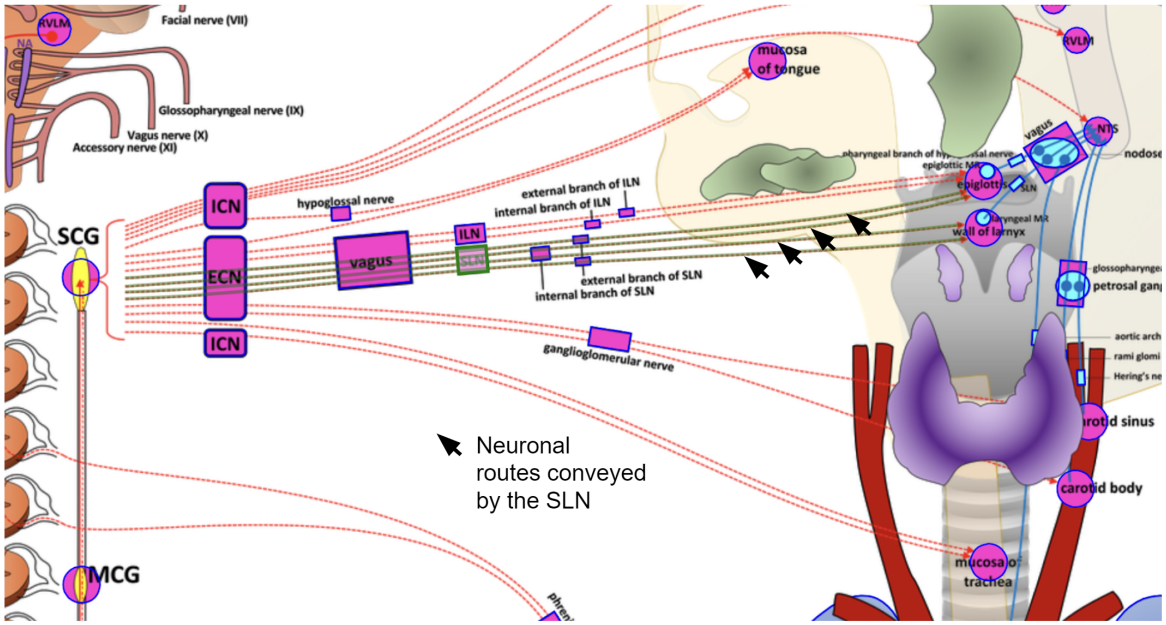
Step 3. *Left-click* on 'Find edges connected to node' to find neuronal routes conveyed by the selected nerve.

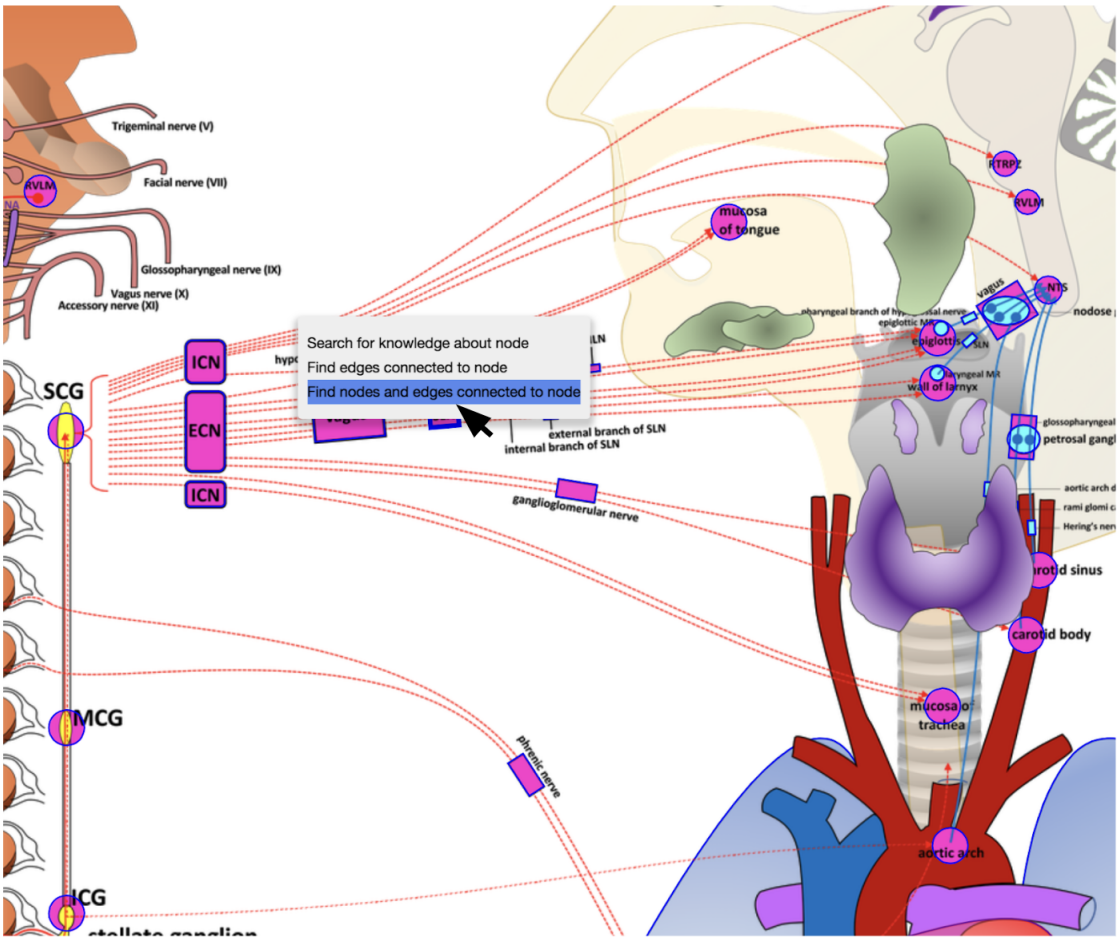
For example, neuronal routes conveyed by the SLN as shown below.

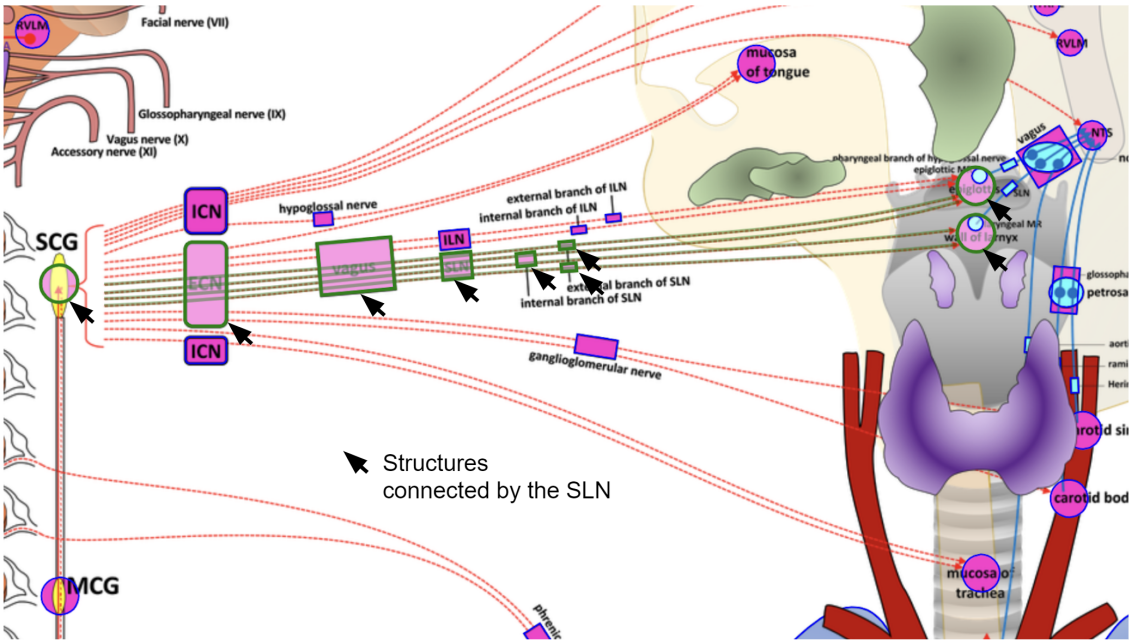
Step 4. *Left-click* on 'Find nodes and edges connected to node' to find data relevant to structures connected by the selected nerve.

For example, structures connected by the SLN as shown below.


Trigeminal nerve (V)
Facial nerve (VII)
Glossopharyngeal nerve (IX)
Vagus nerve (X)
Accessory nerve (XI)
RVLM
NA
SCG
ICN
ECN
ICN
MCG
ICG
Search for knowledge about node
Find edges connected to node
Find nodes and edges connected to node
external branch of SLN
internal branch of SLN
ganglioglomerular nerve
phrenic nerve
mucosa of tongue
RTRPZ
RVLM
vagus
NTS
epiglottis
wall of larynx
glossopharyngeal
petrosal gangl
carotid sinus
carotid body
mucosa of trachea
aortic arch


Facial nerve (VII)
Glossopharyngeal nerve (IX)
Vagus nerve (X)
Accessory nerve (XI)
RVLM
NA
SCG
ICN
ECN
ICN
MCG
hypoglossal nerve
ILN
vagus
external branch of ILN
internal branch of ILN
external branch of SLN
internal branch of SLN
ganglioglomerular nerve
Neuronal routes conveyed by the SLN
mucosa of tongue
RVLM
NTS
vagus
epiglottis
wall of larynx
petrosal gang
carotid sinus
carotid body
mucosa of trachea
aortic arch


Trigeminal nerve (V)
Facial nerve (VII)
Glossopharyngeal nerve (IX)
Vagus nerve (X)
Accessory nerve (XI)
RVLM
SCG
ICN
ECN
ICN
MCG
ICG
Search for knowledge about node
Find edges connected to node
Find nodes and edges connected to node
external branch of SLN
internal branch of SLN
ganglioglomerular nerve
phrenic nerve
mucosa of tongue
RTRPZ
RVLM
Vagus
NTS
nodose
epiglottis
SLN
wall of larnyx
glossopharyngeal
petrosal gangl
aortic arch
carotid body
mucosa o
trachea
aortic arch


Facial nerve (VII)
Glossopharyngeal nerve (IX)
Vagus nerve (X)
Accessory nerve (XI)
RVLM
SCG
ICN
ECN
ICN
MCG
hypoglossal nerve
ILN
external branch of ILN
internal branch of ILN
external branch of SLN
internal branch of SLN
ganglioglomerular nerve
Structures
connected by the SLN
mucosa of tongue
RVLM
Vagus
NTS
SLN
wall of larnyx
petrosa
carotid bod
mucosa o
trachea

CHAPTER 9

Mapping Image Data in Mouse Colon

Contents:

9.1 Overview

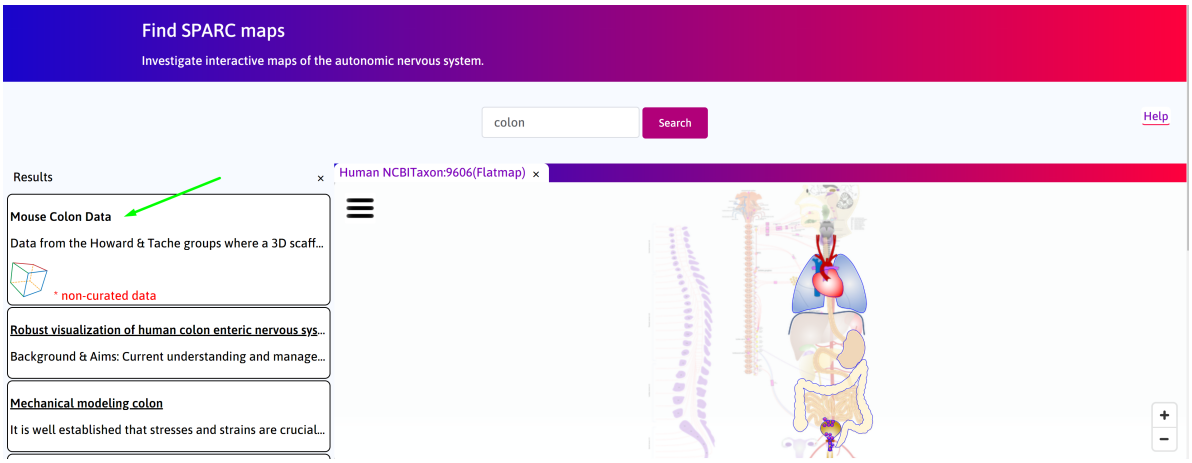
A 3D scaffold fitted to the structural data of mouse colon is visualized. Apart from its 3D configuration, the scaffold is displayed as a flat preparation which represents the state where a colon is stretched out, cut open and laid flat on a surface for imaging purposes. Segmented image data of enteric neurons and nerve fibers (Tache group) and vasculature (Howard group) of mouse tissue samples are mapped onto the flat scaffold based on the locations where the tissue samples were obtained from. This allows image and experimental data to be embedded and displayed at labelled material points on the scaffold in both its 3D and flat configuration.

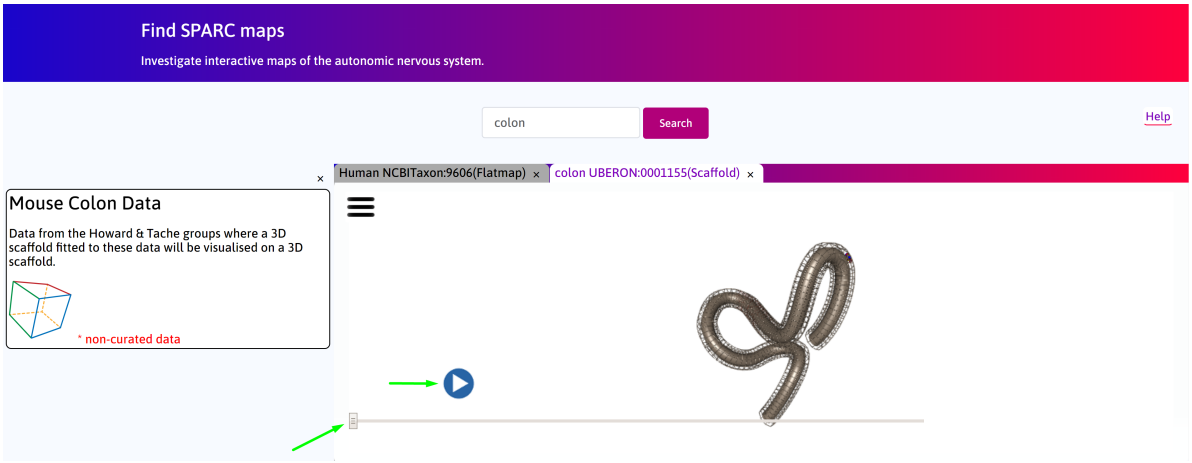
9.2 Step-by-step instructions

Follow these step-by-step instructions to familiarise yourself with the flow of the web interface.

Step 1. The default **Result** column displays the use cases available on the portal. Click on the *Mapping Image Data in Mouse Colon* box. Click on the scaffold icon (**|scaffold-icon|**). Click on the scaffold icon ().

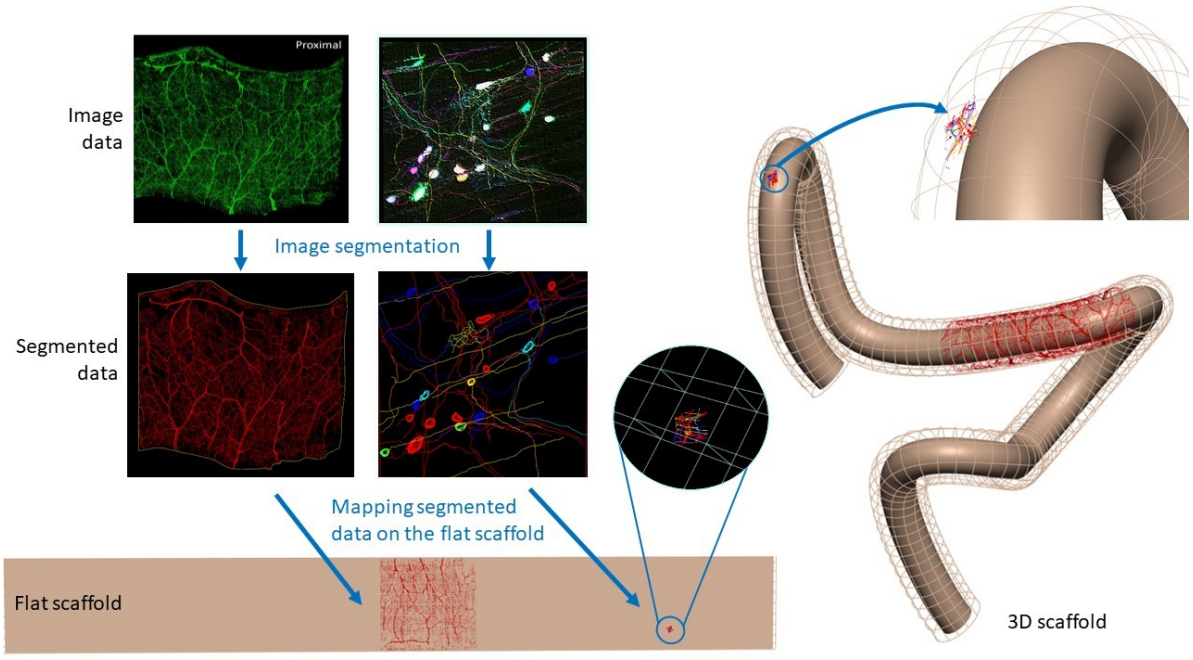
Step 2. Allow a few seconds for the scaffold to load. Navigate between the 3D and flat scaffold using the slider. Click on the **play** button to automate toggle between the two configurations.


Find SPARC maps
Investigate interactive maps of the autonomic nervous system.
colon
Search
Help
Results
Mouse Colon Data
Data from the Howard & Tache groups where a 3D scaff...
* non-curated data
Robust visualization of human colon enteric nervous sys...
Background & Aims: Current understanding and manage...
Mechanical modeling colon
It is well established that stresses and strains are crucial...
Human NCBITaxon:9606(Flatmap)


Find SPARC maps
Investigate interactive maps of the autonomic nervous system.
colon
Search
Help
Human NCBITaxon:9606(Flatmap)
colon UBERON:0001155(Scaffold)
Mouse Colon Data
Data from the Howard & Tache groups where a 3D scaffold fitted to these data will be visualised on a 3D scaffold.
* non-curated data

9.3 Scaffold Generation

The Figure below illustrates an overview of the workflow.



Below is an **introductory video** which explains how the structural data of mouse colon are mapped onto a 3D scaffold.

CHAPTER 10

Interactive Graphics Controls

The table below describes the effect of different mouse buttons in manipulating the view.

Mouse Button	Transformation
Left	Rotate
Middle	Zoom
Right	Pan