

# Segment

<b>Introduction</b>	<b>page 178</b>
<b>Segmentation Options</b>	<b>page 181</b>
Cursor Link	page 196
Toggle Region Display	page 197
Notes	page 199
<b>Edge Strength</b>	<b>page 203</b>
1. Using Edge Strength In Segmentation	page 204
<b>Walls</b>	<b>page 210</b>
2. Using Walls with Semi-Automatic Segmentation	page 211
<b>Subregion</b>	<b>page 216</b>
3. Setting a Subregion	page 217
<b>Semi-Automatic Tools</b>	<b>page 218</b>
Threshold Volume	page 219
4. Threshold Volume and Segmentation	page 220
Region Grow	page 223
5. Segmentation with Region Grow	page 224
6. Adjusting Connected Neighbors	page 226
7. 2D Region Grow	page 229
Connected Components	page 233
8. Segmenting Multiple Objects Using Connected Components	page 234
Object Extractor	page 235
9. Segmentation of a Single Object Using Object Extractor	page 236

10. Segmentation of Multiple Objects Using Object Extractor	page 239
Object Separator	page 242
11. Separating Objects	page 243
12. Editing Objects via Oblique Cutting	page 245
Fill Holes	page 249
13. Filling Holes in Objects	page 250
14. Using Fill Holes for Segmentation	page 253
Morph Objects	page 256
15. Using Morphological Operations to Improve Segmentation	page 257
Filter Objects	page 261
Propagate Objects	page 264
16. Propagate Objects	page 265
<b>Manual Tools</b>	<b>page 268</b>
Freehand Draw	page 269
17. Using Freehand Draw to Define a 2D Region	page 270
18. Using Freehand Draw to Define a Single Shape on a 2D Slice	page 273
19. Using Freehand Draw to Define a Single Shape in 3D	page 274
Painting Regions of Interest	page 276
20. Using Freehand Draw to Paint Regions of Interest	page 277
Manual Trace	page 281
21. Manual Contour Tracing and Editing	page 281
Auto Trace	page 284
22. Using Auto Trace to Define a 2D Region of Interest	page 285
Spline Trace	page 289

23. Using Spline Trace to Define a Region of Interest	page 290
Smart Trace	page 291
24. Smart Trace Region Definition	page 292
Reassign Object	page 294
25. Reassigning Objects	page 295
Nudge Edit	page 303
26. Editing Object Borders	page 304
27. Using the Nudge Tool with Locked Objects	page 307
Divide Regions	page 310
28. Grid Division of an Object	page 311
29. Radial Division of an Object	page 314
Dividing Regions Between Borders	page 316
30. Dividing Regions Between Borders – Interpolating Between Objects	page 317
31. Dividing Regions Between Borders – Interpolating Within an Object	page 319
Adjust Regions	page 321
Fabricate Shape(s)	page 333
32. Creating a Shape	page 333
33. Creating Objects from a Text File	page 336
<b>Manual Tools for 3D Editing</b>	<b>page 339</b>
34. 2D Manual Trace Editing of Object Maps	page 339
35. 2D Freehand Draw Editing of Object Maps	page 342
<b>Dual Input Segmentation</b>	<b>page 343</b>
<b>4D Segmentation</b>	<b>page 346</b>
<b>Generating Surface Files from Objects</b>	<b>page 350</b>

# Introduction

The goal of segmentation is to partition an image into regions, or objects, that are homogeneous with respect to one or more characteristics or features. Segmentation is a critically important tool for the processing of image data and is often the precursor to other applications such as measurement, visualization, surface-based registration and surface extraction.

## Object Maps

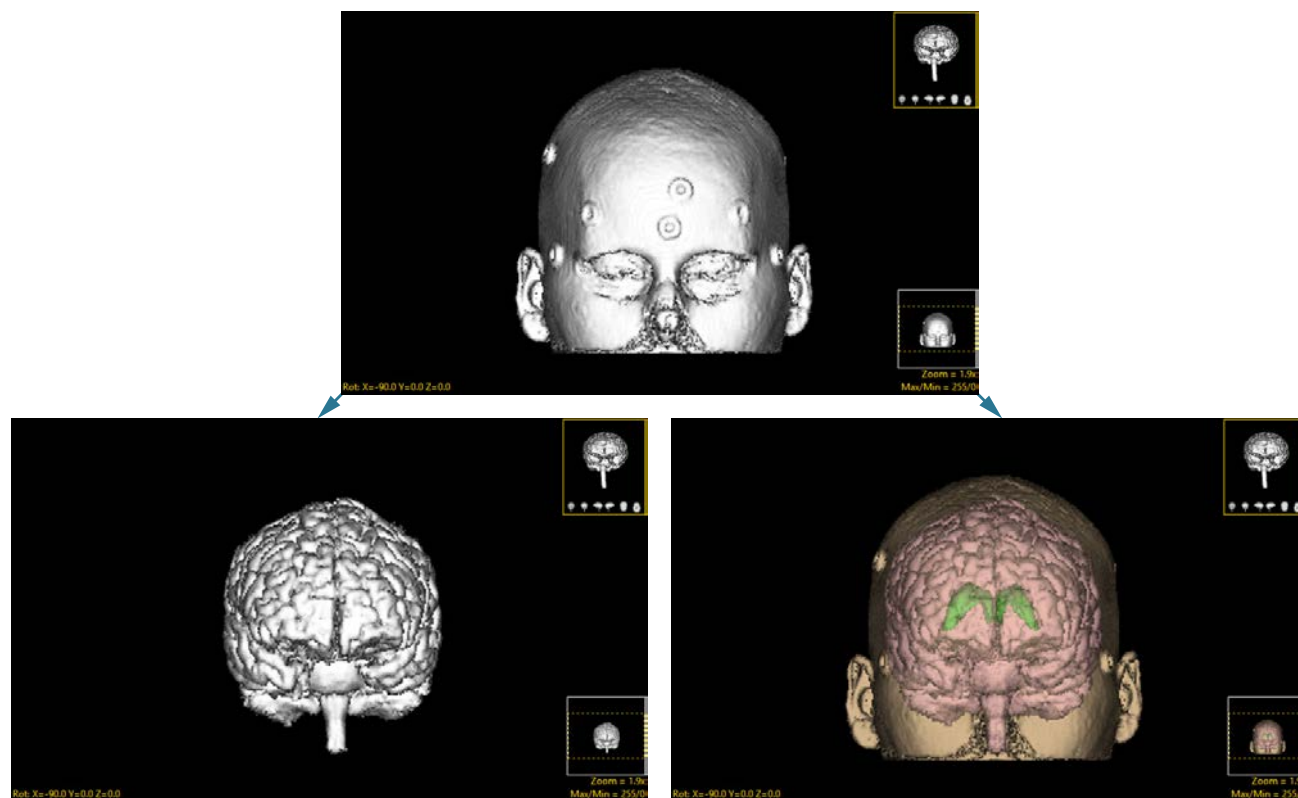
AnalyzePro uses a file called an object map to partition image data into groups of voxels within a segmentation component map. After creation of the object map through segmentation, it can be used to drive visualization, registration, surface generation and statistical analysis.



The object map is an associated volume with the same dimensions as the image data. Each voxel of the object map contains an 8-bit value which encodes it as belonging to 1 of 256 total possible objects. Every voxel in the data set is initially assigned to the first object (Original), leaving 255 additional objects that can be used for 2D region or 3D volume of interest definition.

Object maps are loaded separately from the image data to which they are associated using the File > Load Object Map option in each functional module. When the object map is loaded, the objects defined in it are overlaid on the image data.

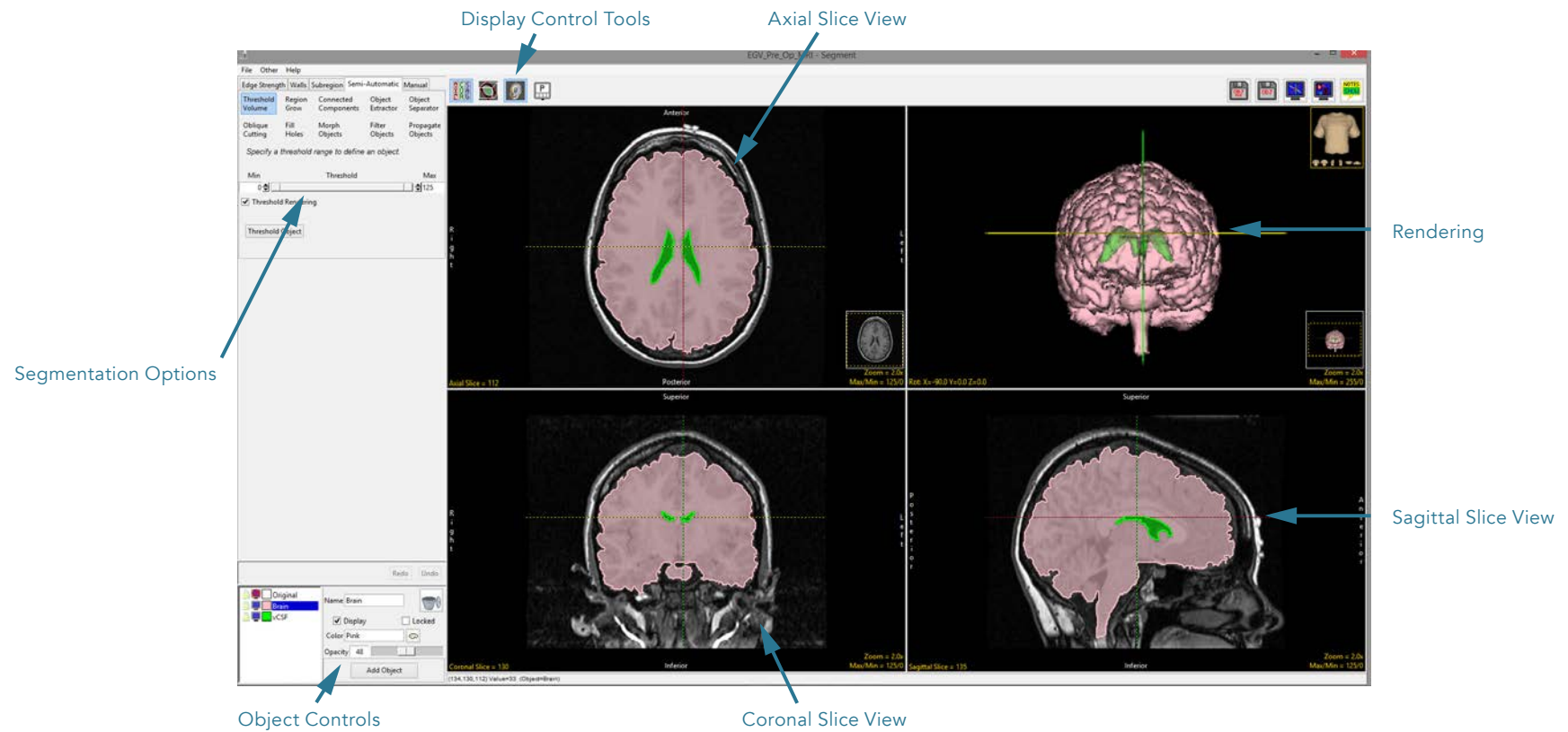
## Object Map Segmentation vs. Grayscale Segmentation



Grayscale segmentation destroys all voxels that are not part of the object of interest.

Object maps preserve the original data by assigning the segmented voxels to objects.

## Segment Overview





# Segmentation Options

The segmentation options are provided in five tabs:

- Edge Strength
- Walls
- Subregion
- Semi-Automatic
- Manual

These five tabs provide access to all the segmentation tools in Segment. The segmentation tools within each tab will be discussed in this section.

## Rendering

The render window provides an interactive 3D display of the segmented image data. For more information about the render window, refer to [Display](#).

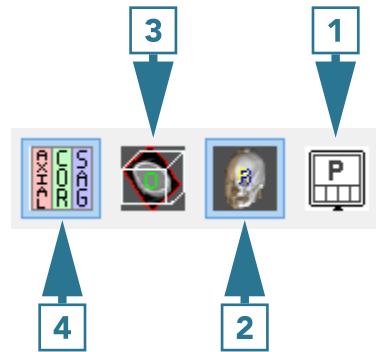
## Slice

The orthogonal slice display windows provide an interactive 2D review tool of the slice data in the axial, coronal and sagittal planes. For more information about the slice display windows, refer to [Display](#).



### Display Control Tools

The Display Control tools allow users to control and customize the layout of the Segment display area. Some of these control options are unique to Segment.



- 1 Controls Layout
- 2 Toggle Rendering
- 3 Toggle Oblique
- 4 Toggle All Orientations

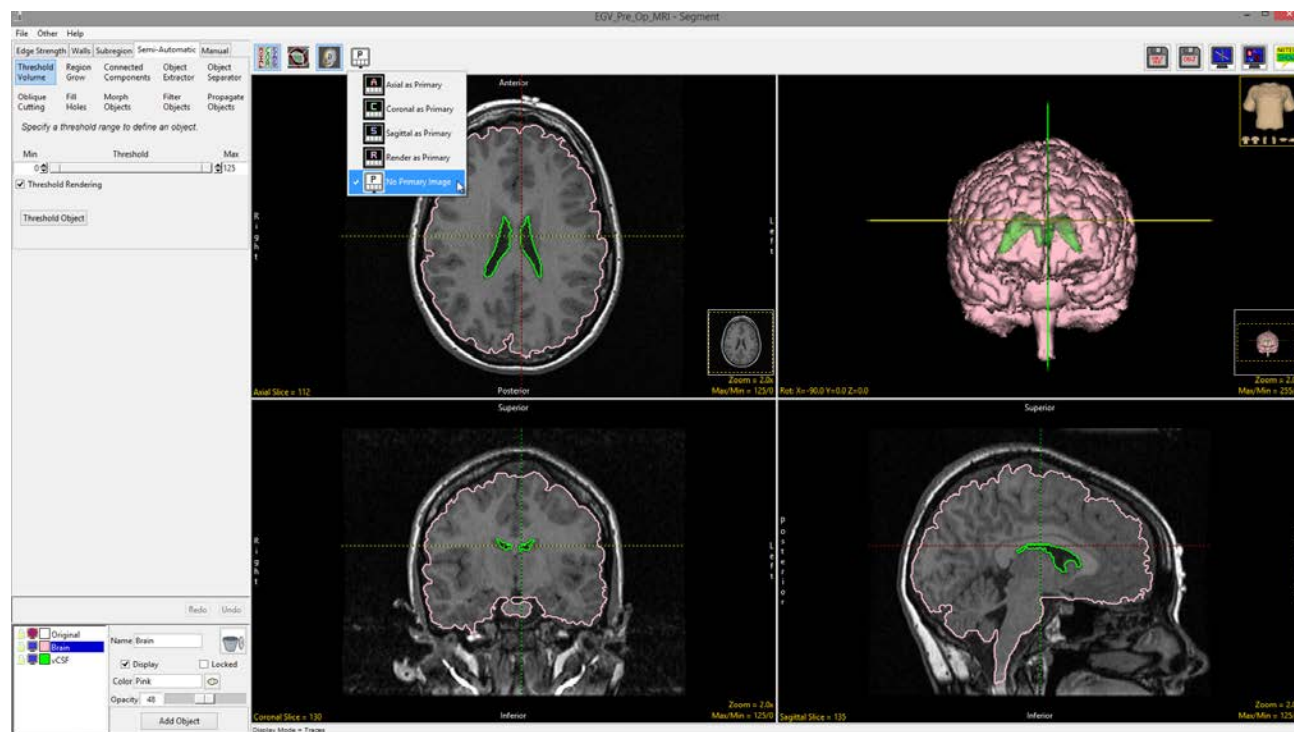


## Control Layout

This option allows users to control the layout of the display. Choose from Axial as Primary, Coronal as Primary, Sagittal as Primary, Render as Primary or No Primary image.

## No Primary Image

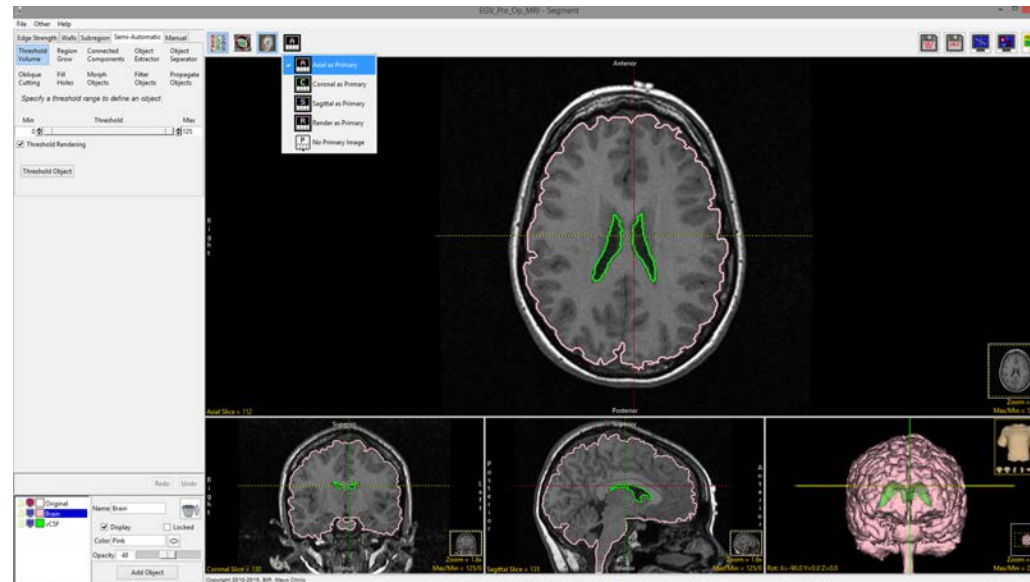
This is the default selection. This option displays the rendering and three orthogonal views in four equally sized windows.





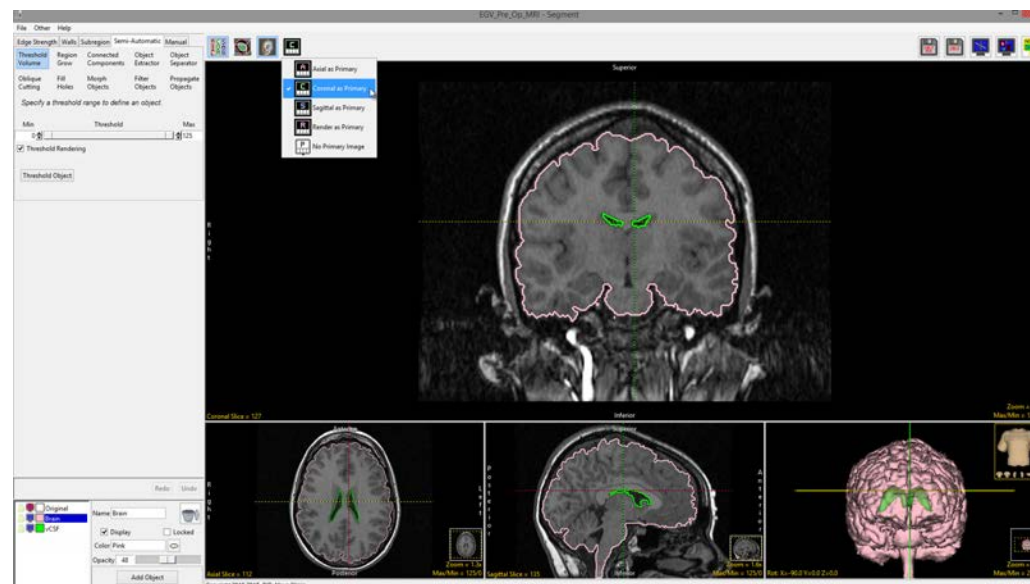
### Axial as Primary

Focuses the display on the axial image. The coronal, sagittal and rendering windows are displayed below the axial window.



### Coronal as Primary

Focuses the display on the coronal image. The axial, sagittal and rendering windows are displayed below the coronal window.

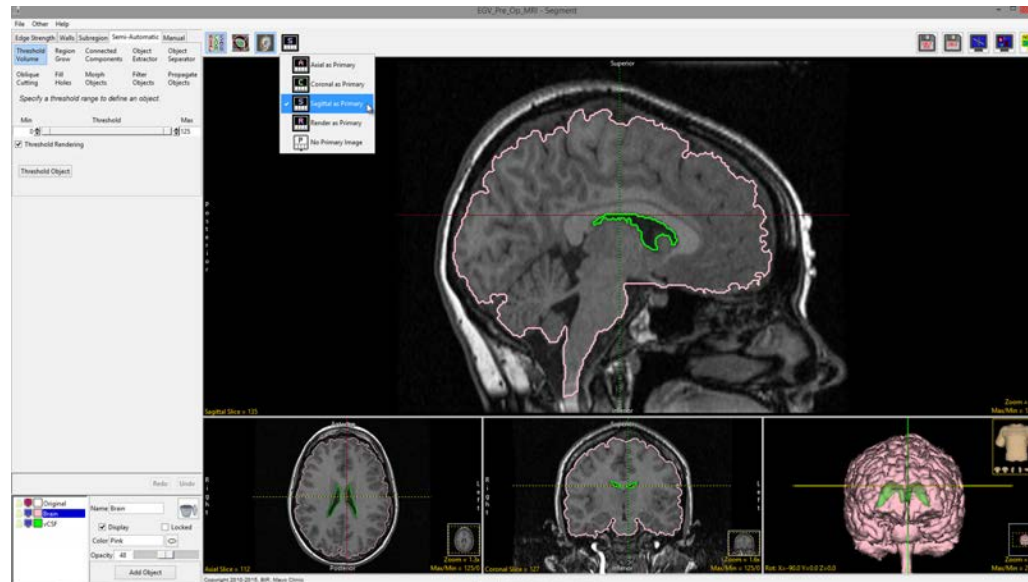






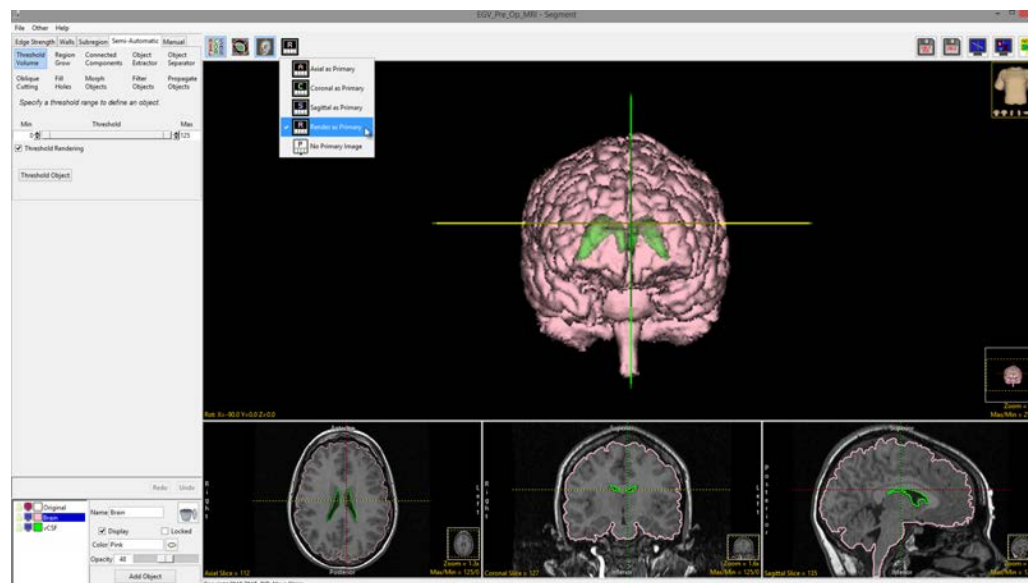
## Sagittal as Primary

Focuses the display on the sagittal image. The axial, coronal and rendering windows are displayed below the sagittal window.



## Render as Primary

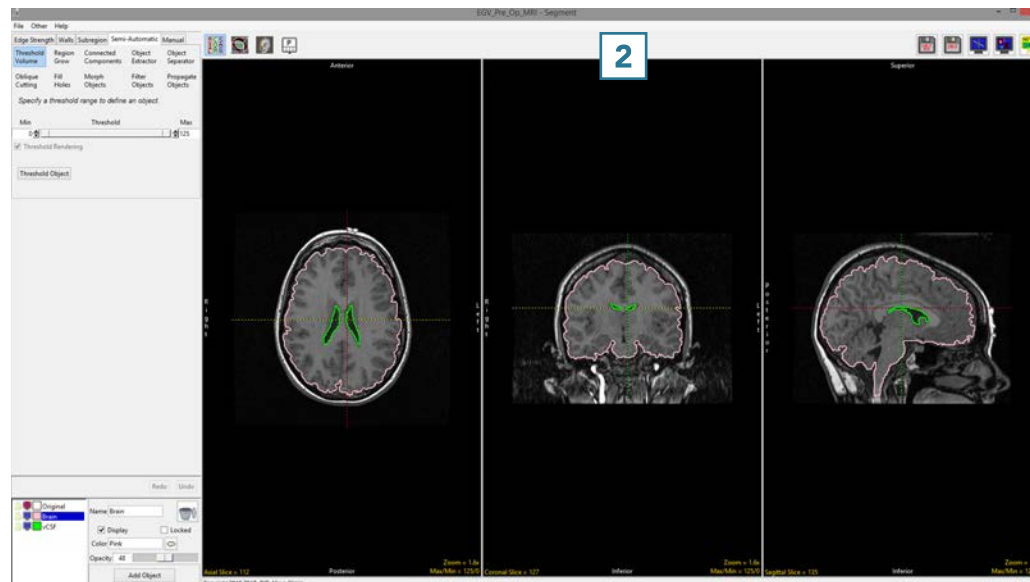
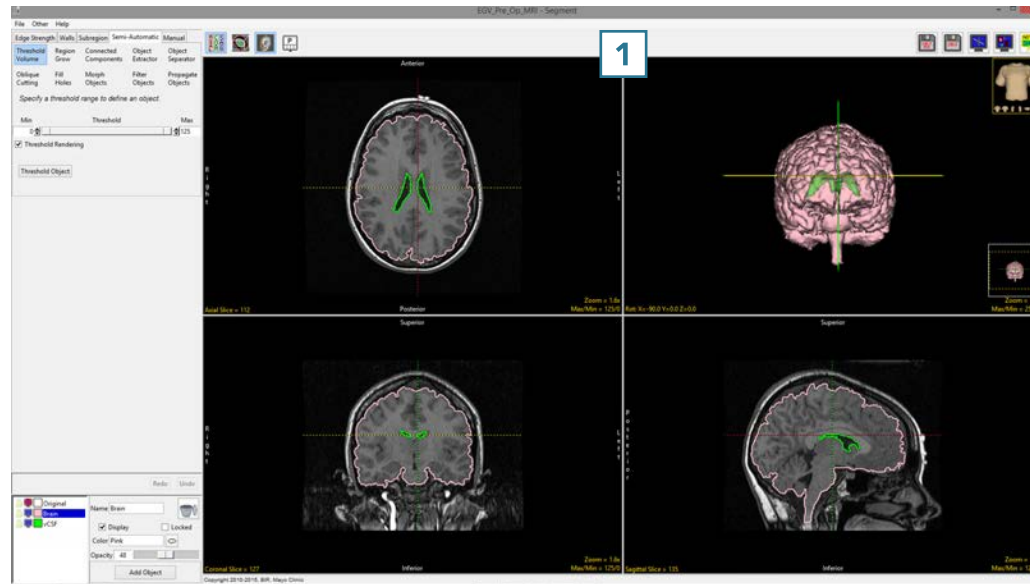
Focuses the display on the rendering. The axial, coronal and sagittal windows are displayed below the rendering.





## Toggle Rendering

The Toggle Rendering options allows users to switch the Render window on and off. **1** and off. **2**







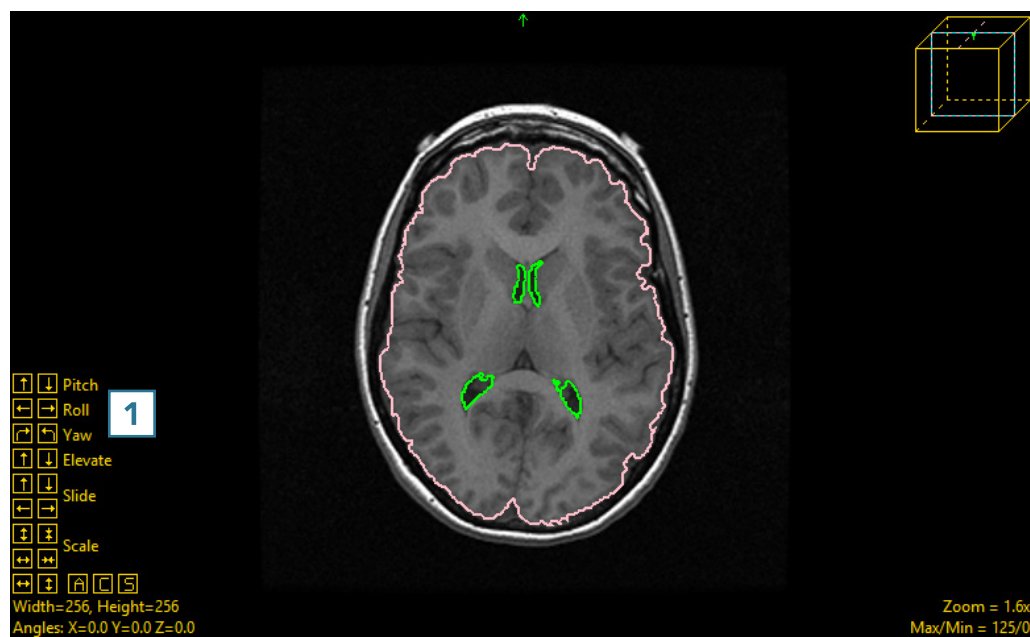
## Toggle Oblique

The Toggle Oblique option allows users to switch the oblique display window **1** on and off.





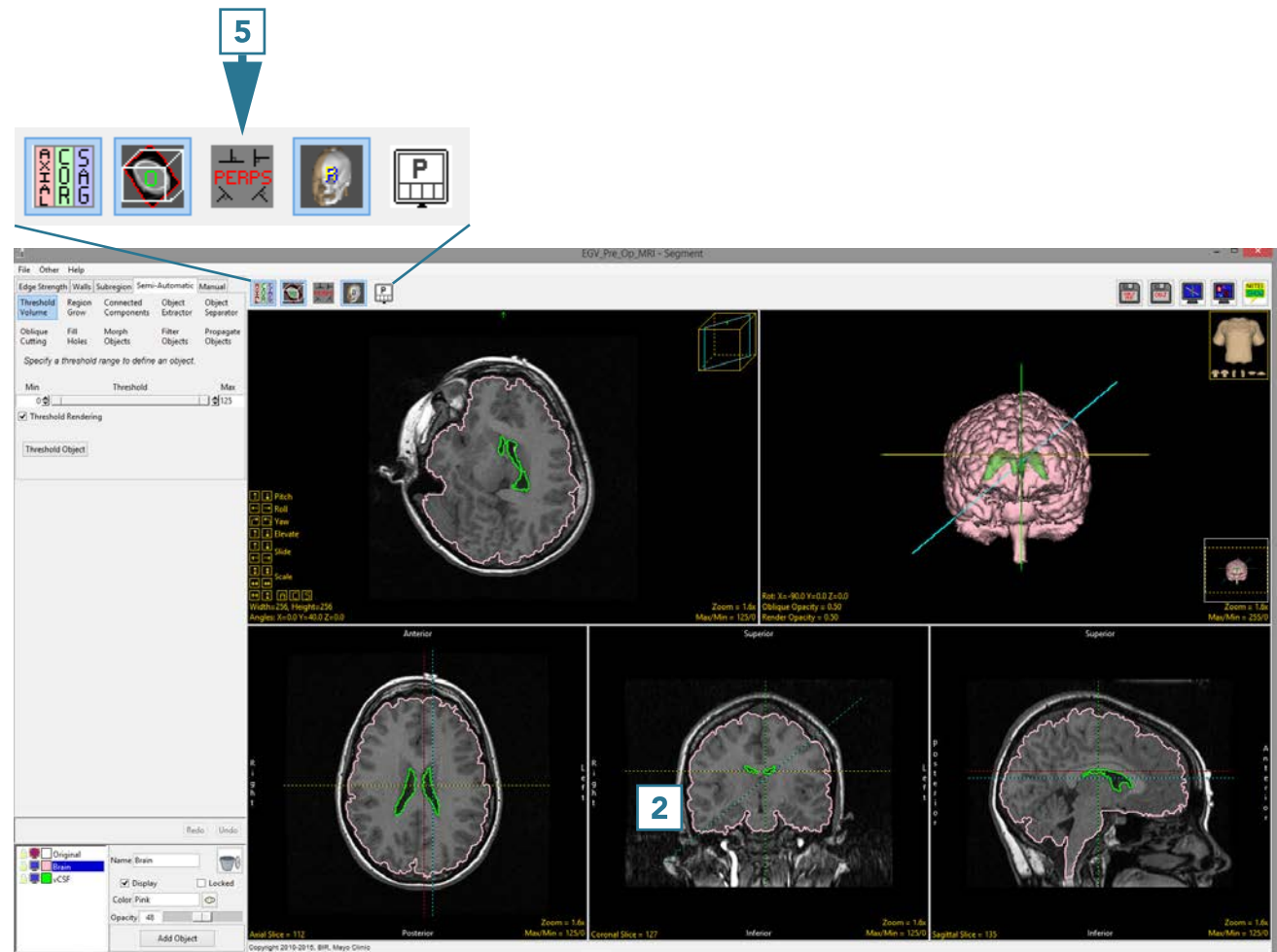
The oblique window provides users with the ability to create any arbitrary oblique plane on the fly, using the control tools in the oblique window. **1**





The oblique image can also be generated using the blue oblique reference line that appears in all of the other enabled windows. **2**

When the oblique image is enabled, an additional option becomes available: Toggle Perpendicular. **5**



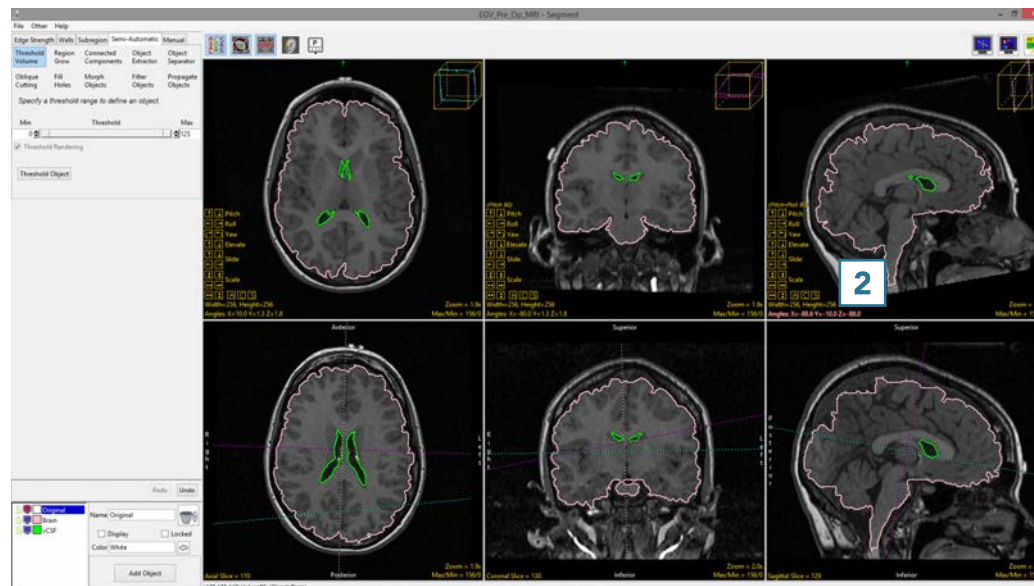
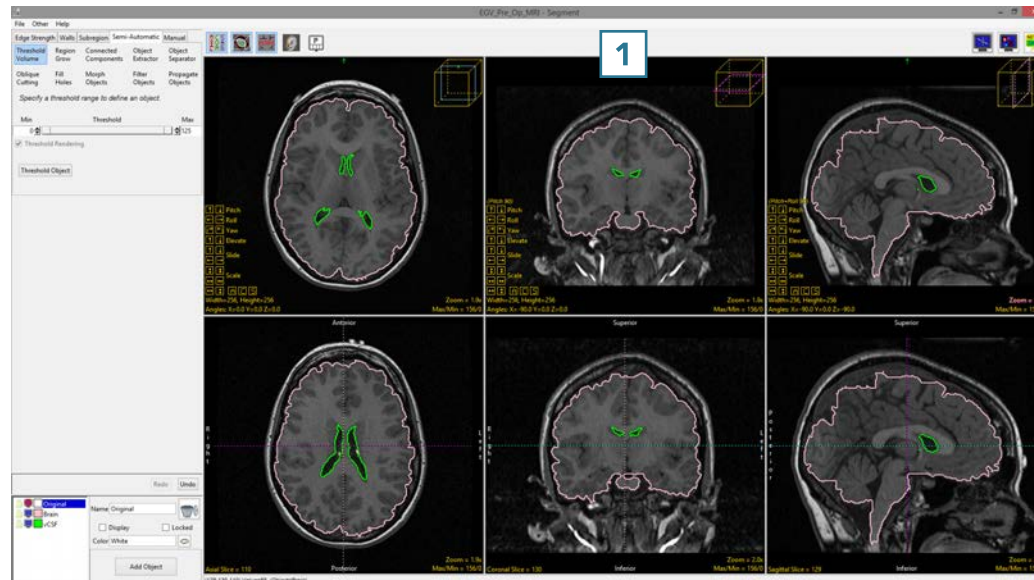


## Toggle Perpendicular

The Toggle Perpendicular window provides an oblique control window for each orientation. **1**



The control tools **2** can be used to manipulate each orientation to aid users with the generation of the desired oblique plane.

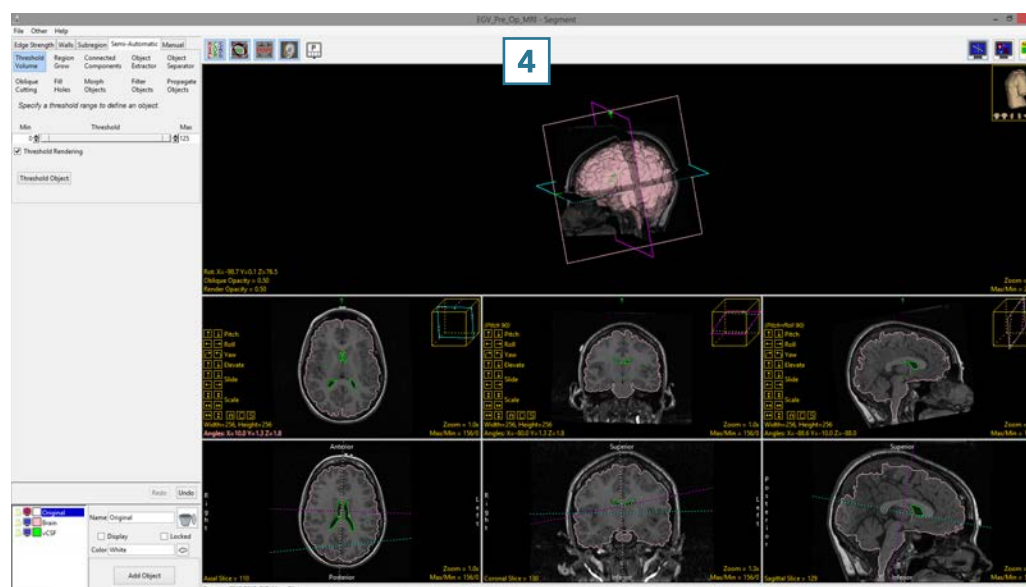
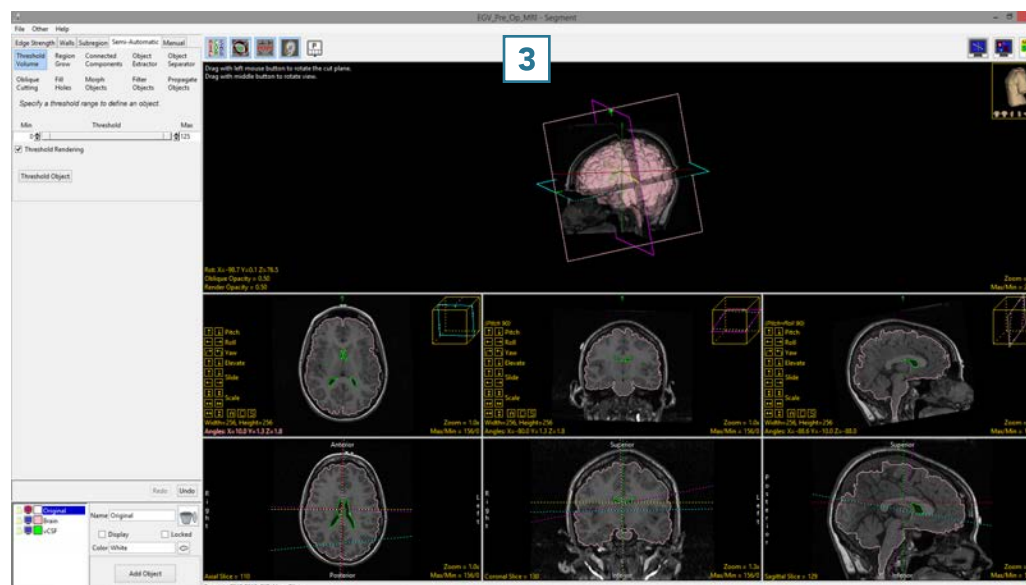




When enabled, the perpendicular displays can be viewed with the Rendering toggled on. **3** While this option is up to the user, some users find the oblique reference lines displayed on the 3D rendering helpful when manipulating the oblique plane in 2D.

Users may also find it useful to switch off the linked cursor tool **4** when using the oblique reference lines.

For more information about creating oblique planes, refer to the [Apply Matrix exercise](#) in the Transform section.

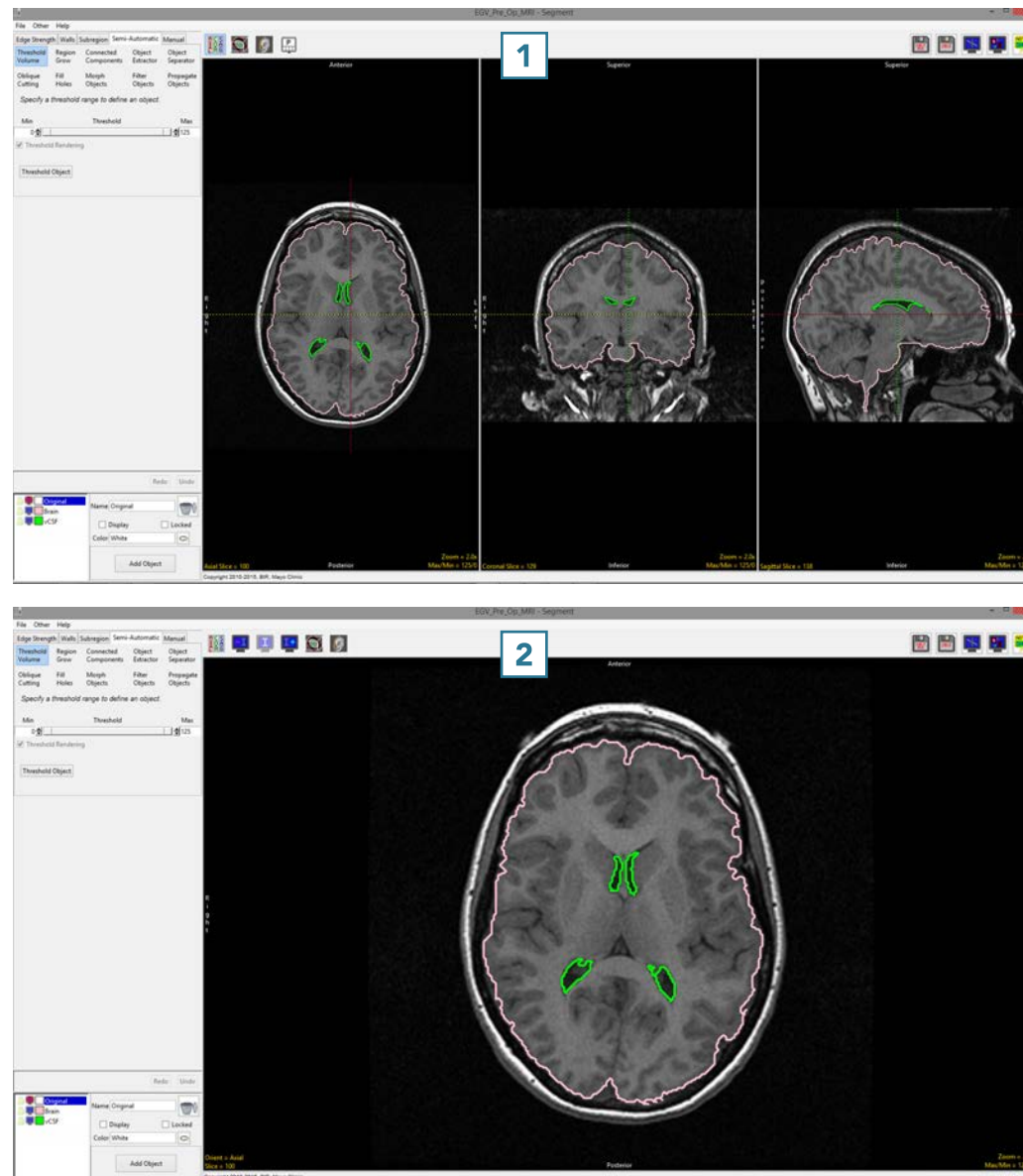






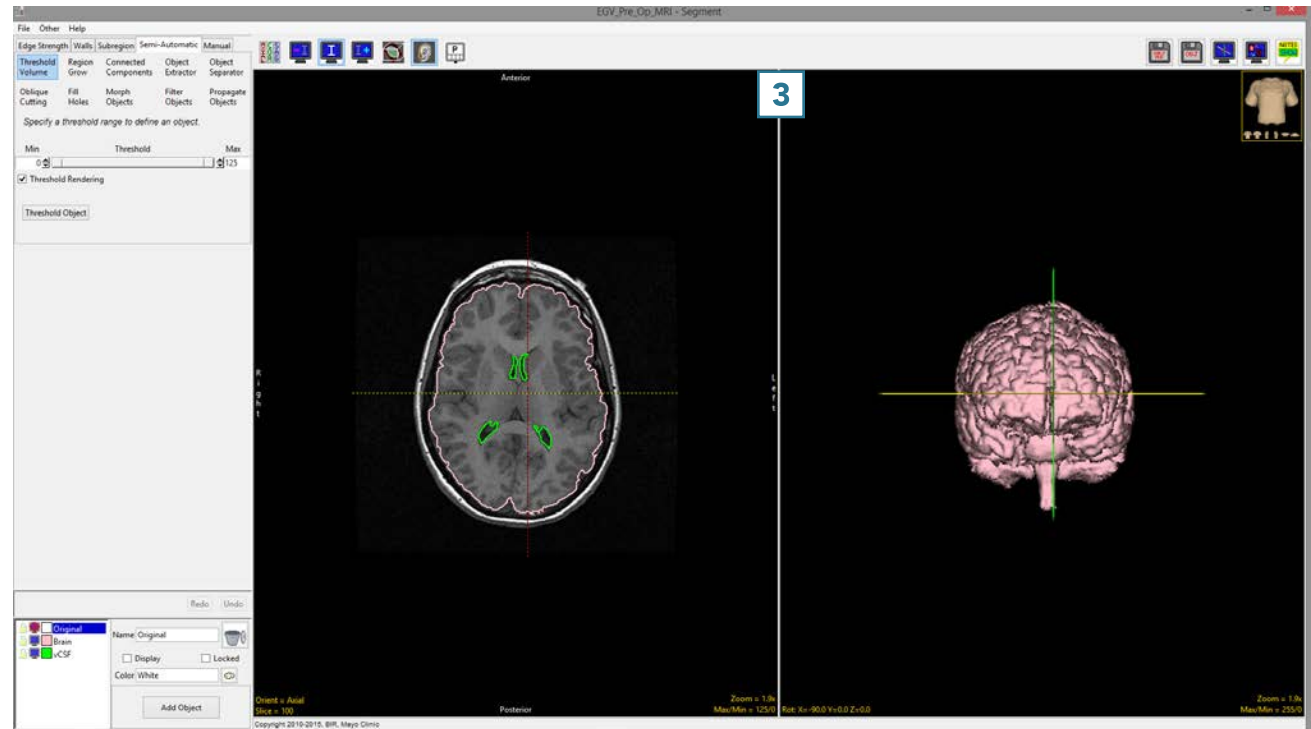
## Toggle All Orientations

The Toggle All Orientations option allows users to switch between the display of the axial, coronal and sagittal **1** windows to a single image window. **2**



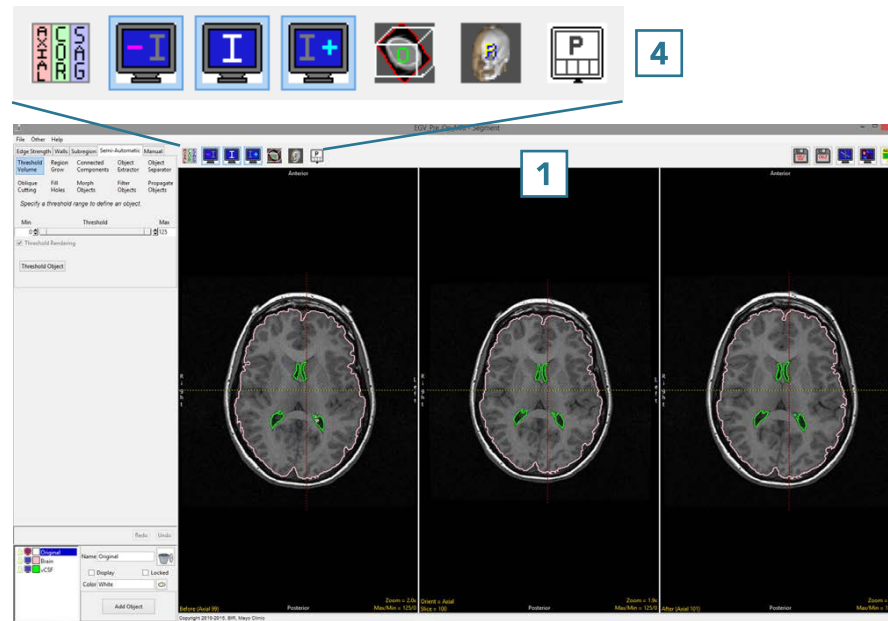


When the rendering is enabled, the 3D rendering will also be displayed. **3**





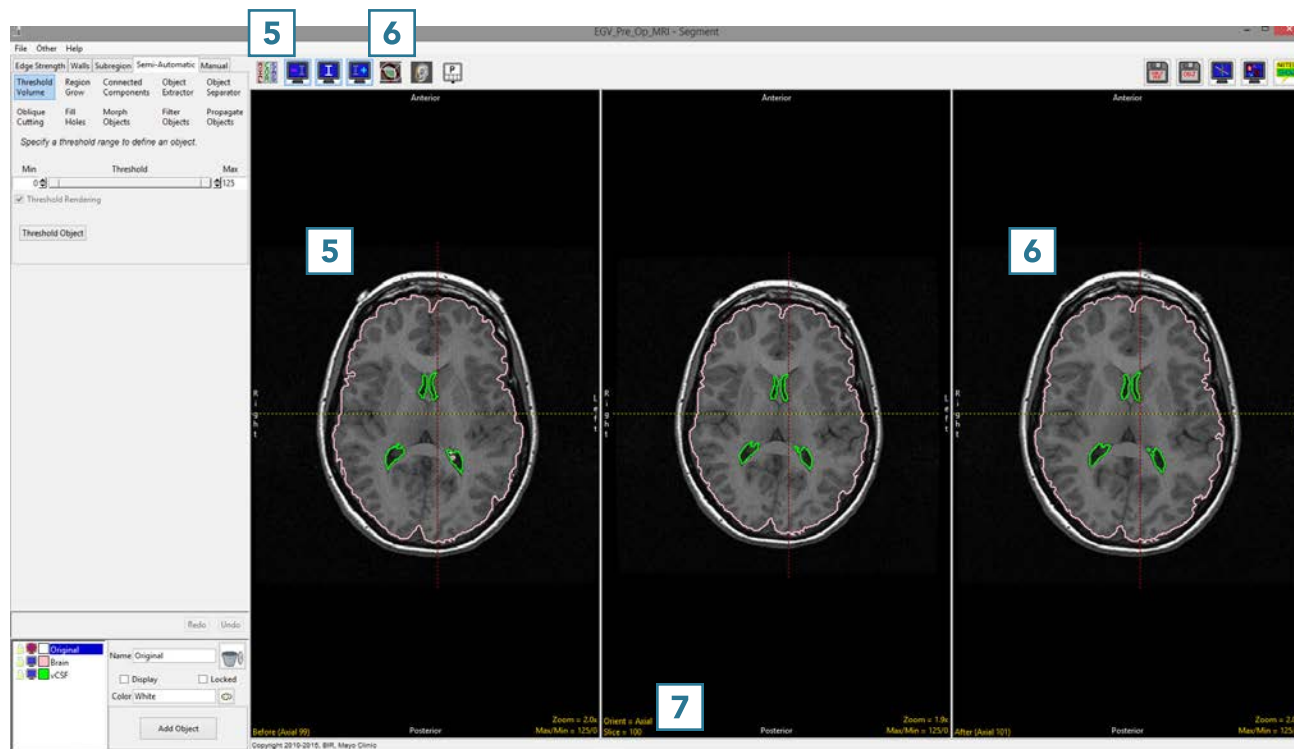
When display is toggled to single display mode, **1** additional display options are enabled. **4**







The additional options allow users to display the image before **5** and after **6** the current slice. To display another orientation, click on the Orient text **7** to cycle through the orthogonal orientation displays.

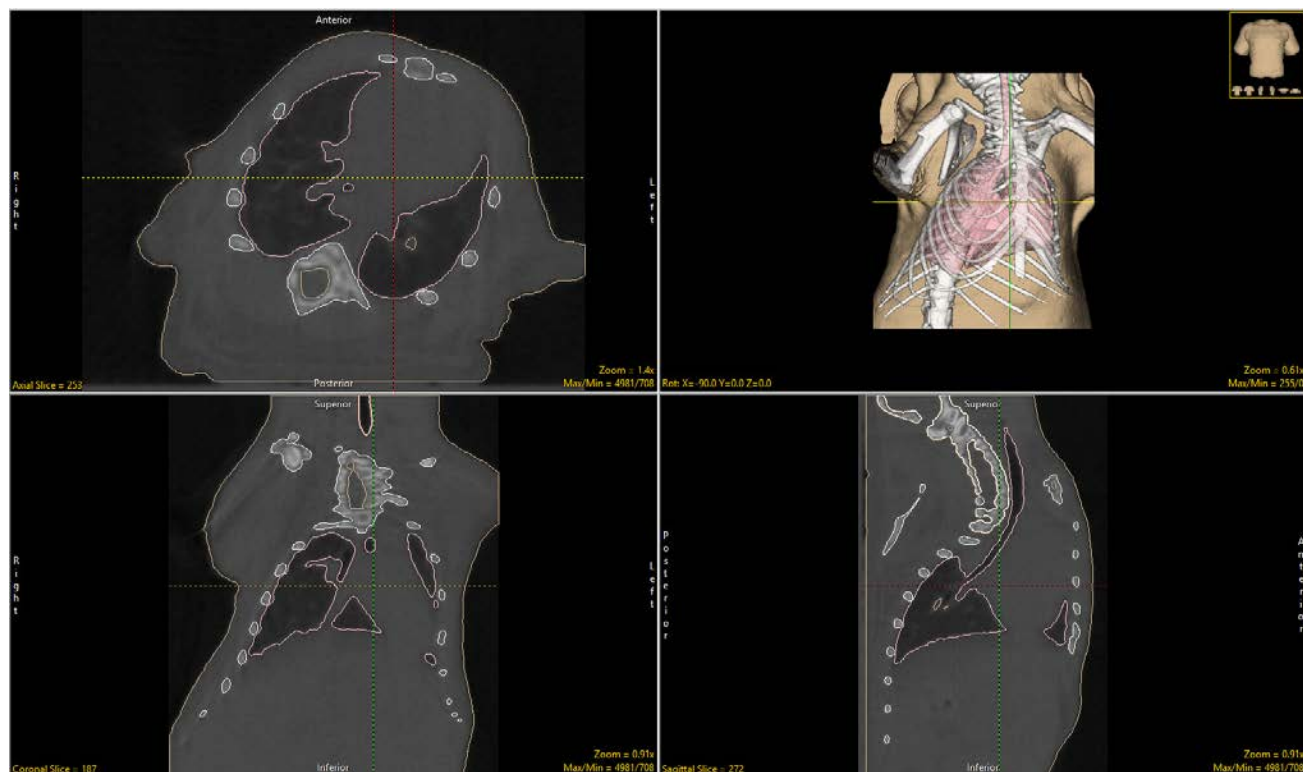




## Cursor Link

The cursor link allows users to interactively navigate through the image data. The tool can be controlled from any of the 2D orientations or from the 3D rendering. Moving the tool will interactively update the corresponding slice displays.

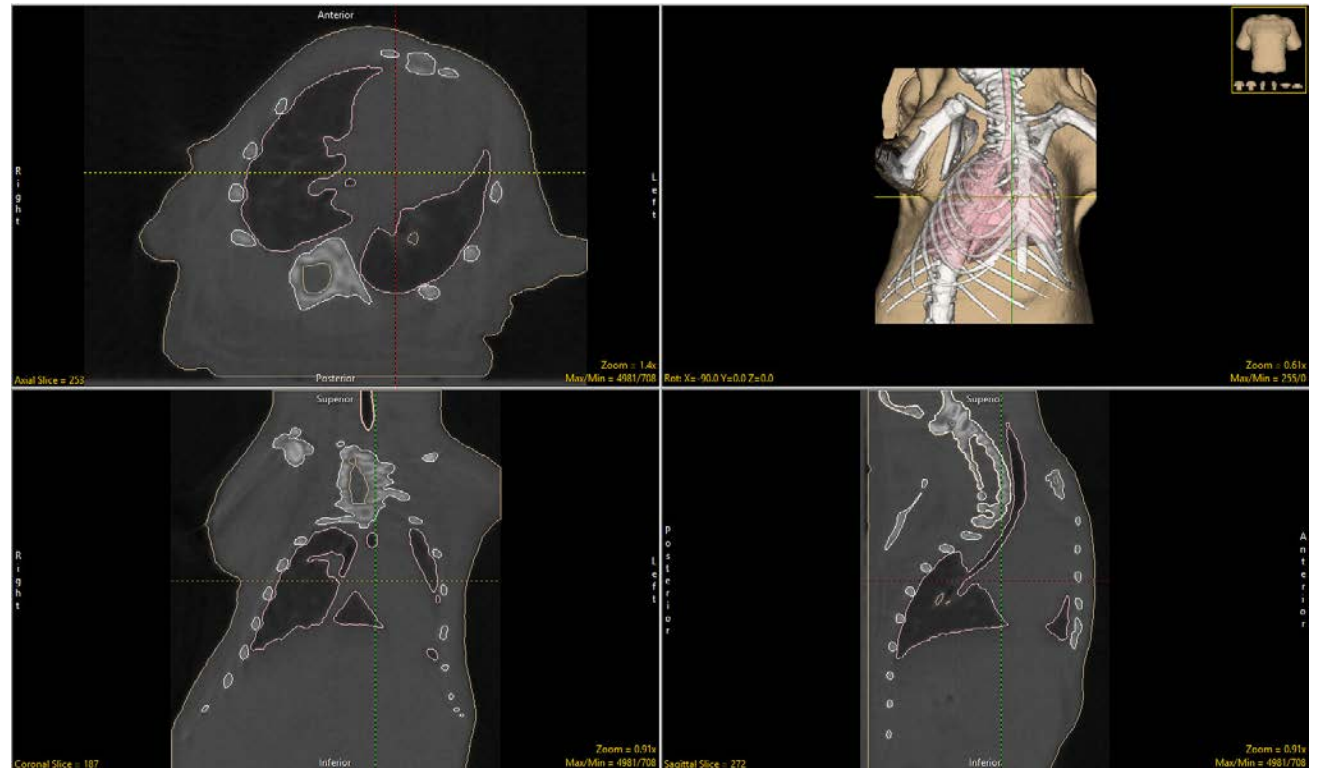
The linked cursor can be enabled or disabled using the Toggle Cursor Link button.





## Toggle Region Display

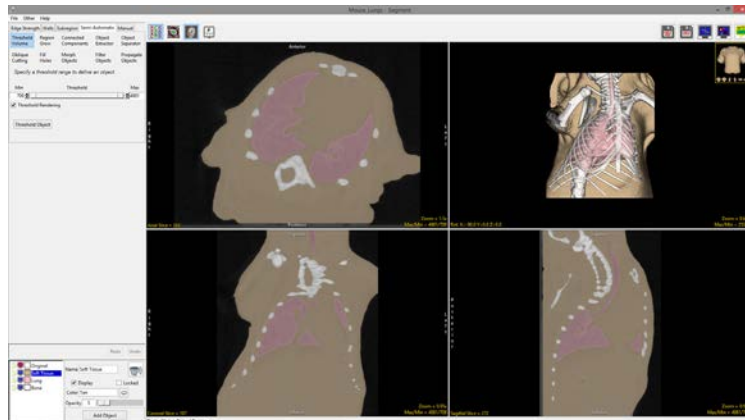
Users have the option to change the display of objects on the 2D slices. Users can cycle through the various object display options using the Toggle Region Display button or using the t key.



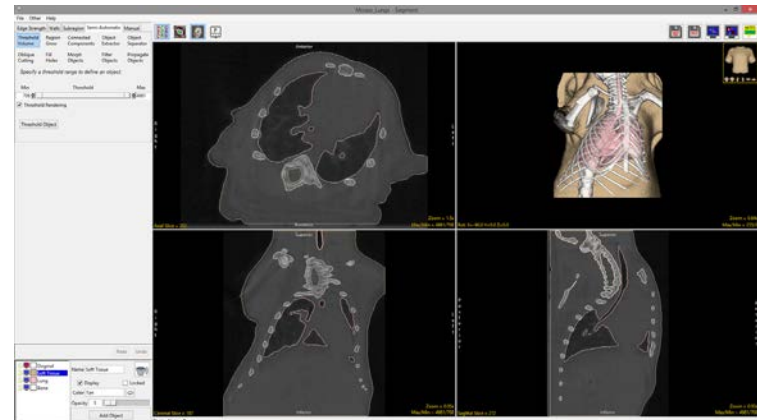


## There are four object display options:

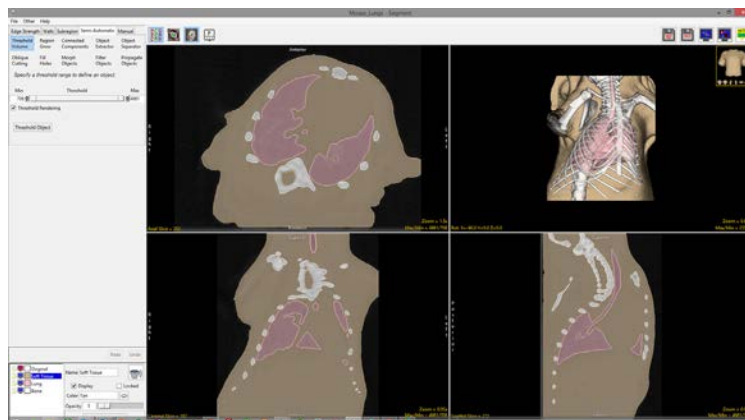
### Filled Regions



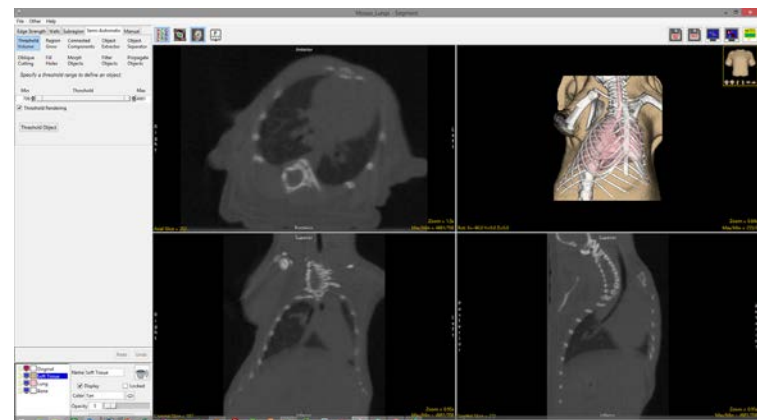
### Edges



### Both



### Off





## Notes

The Notes tool in AnalyzePro allows users to annotate image data in 2D or 3D. Notes will be associated with the data set and can be loaded into other modules. Notes can be hidden or deleted at any time.



Shows notes (default).



Allows users to make and edit notes.



Hides notes.

To annotate a data set using notes click on the Notes button in the toolbar. (Note that the Edit mode will be activated.) Click on any 2D slice or the 3D rendering to create a note.





### Save Object Map As

Allows users to save an object map as a new object map. This is helpful for creating copies of the original object map for editing.

### Save Object Map

Allows users to quickly save edits made to the current object map. This option will overwrite the loaded object map. Use caution when using Save Object Map.



## Object Controls

The AnalyzePro object controls allow users to edit object properties on the fly. The object control window allows users to edit the following object attributes:

The Name field **1** allows users to rename objects from the default assigned names.

The Color option **2** allows object color to be changed from the default color assigned to the object. The color can be edited by typing a color name in the text entry field or by selecting a color using the color picker, which can be reached by clicking the colored square next to the object name in the object list.

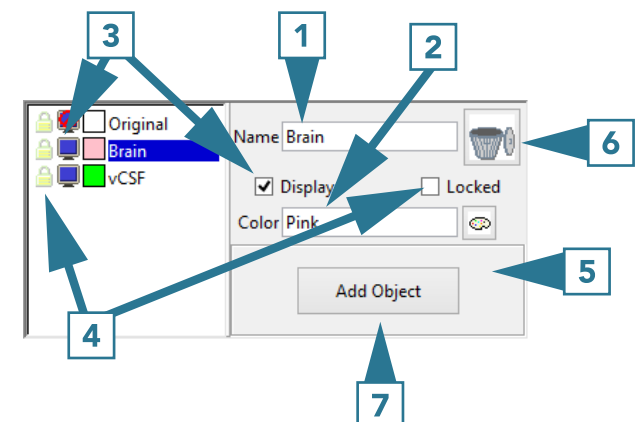
Object Display **3** can be switched on or off by checking or unchecking the Display checkbox or the monitor icon next to the object in the object list.

Object Lock **4** provides the ability to lock objects, which is a powerful segmentation technique. Locking an object protects objects from being written over. When an object is locked, the boundary of the object acts as a limit. This can be leveraged to help with the segmentation of objects that are spatially connected. Some semi-automatic tools do not observe locked objects. Before such a tool is used, a dialog box will appear notifying the user of this.

Opacity: **5** Right-clicking on the rendering and choosing Transparency allows the opacity of each object to be manipulated to enhance display of objects. Object opacity can be manipulated by using the opacity slider or by entering a value in the text field.

Delete **6** allows users to remove objects. Voxels assigned to an object that is deleted are reassigned back to the Original object.

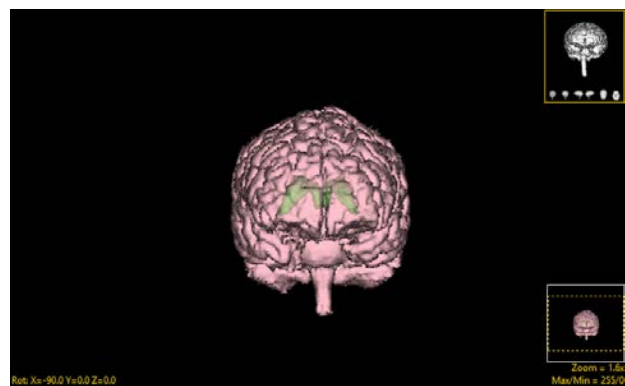
Add Object **7** button allows users to add new objects to the object map.



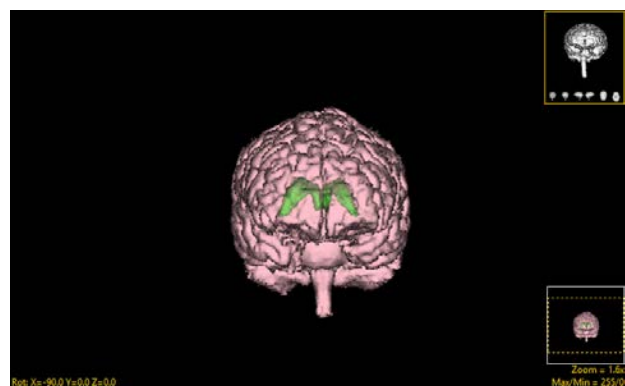




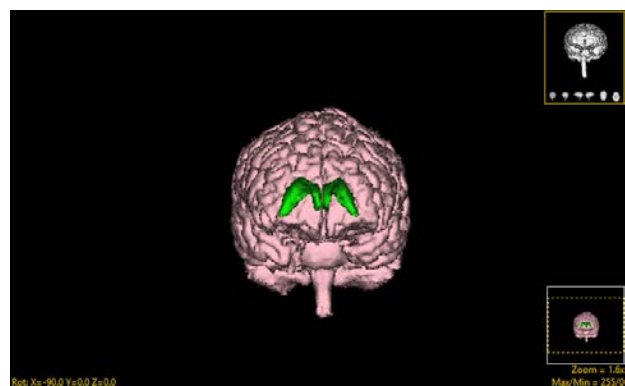
The effect of changing the opacity level of the brain parenchyma object.



70%



50%



5%





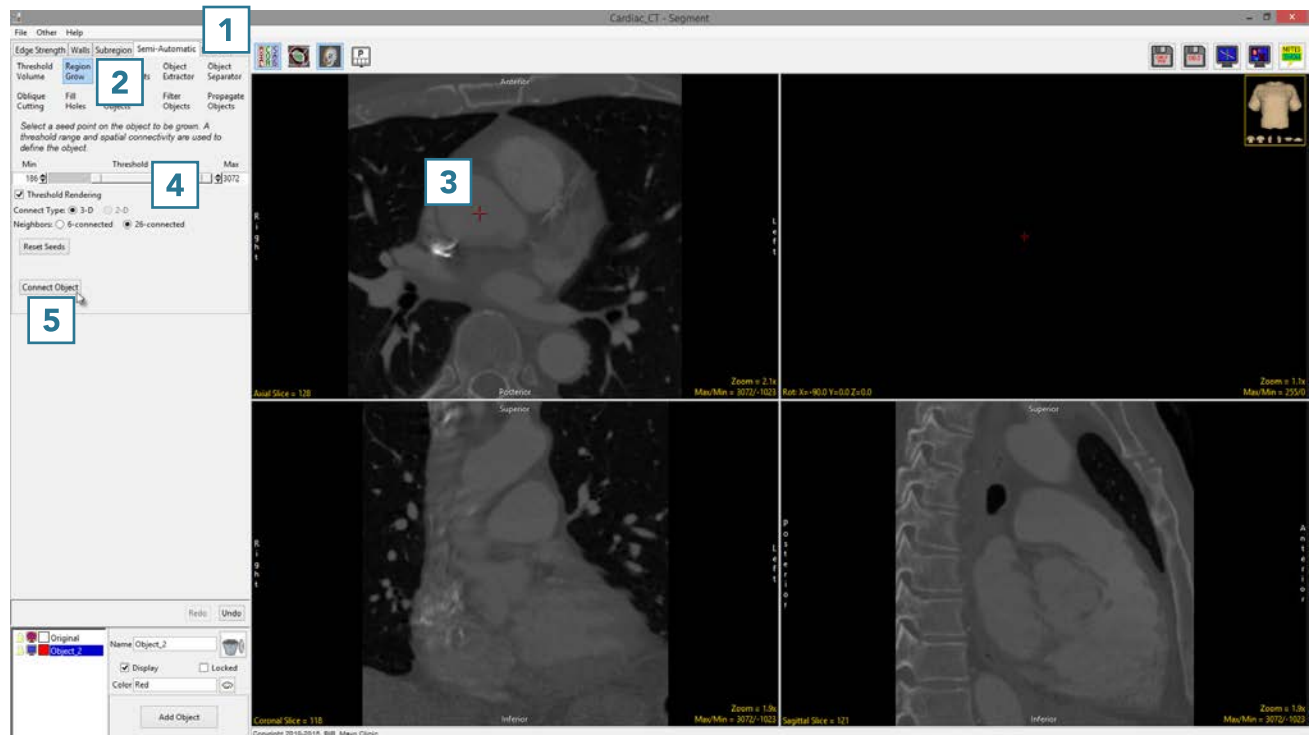
# Edge Strength

The Edge Strength option allows users to mask the input data with a set of enhanced gradients that act as limits aiding in the segmentation of structures. Edge strength works by applying a 3 X 3 X 3 Sobel filter to the image data, which can be interactively adjusted using the Edge Strength Threshold slider. All voxels with gradient values less than or equal to the selected threshold value are displayed in red and form boundaries around structures. The boundaries act as limits, restricting semi-automatic segmentation operations.

# 1. Using Edge Strength In Segmentation

First we will attempt to segment the heart from this CT data set without using edge strength.

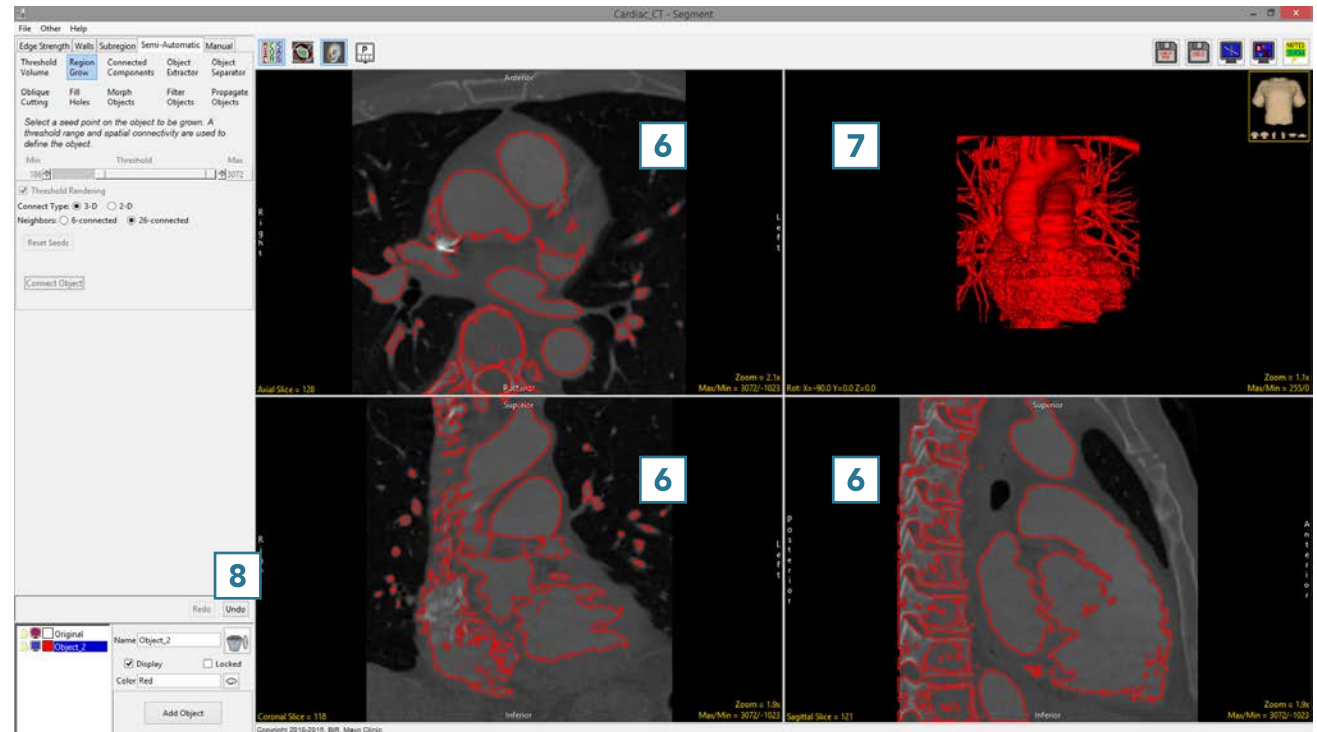
- Select a data set and open Segment.
- Select Semi-Automatic **1** and choose Region Grow. **2**
- Click on the image data to set a seed point. **3** The seed point should be in the object you would like to isolate.
- Set the threshold Min/Max values to define the object **4** and click Connect Object. **5**



- The results of the region grow are shown below.
- The segmented object is shown overlaid on the 2D slice data **6** and a 3D representation **7** is displayed.

Note that both the heart and the spine have been assigned to Object\_2.

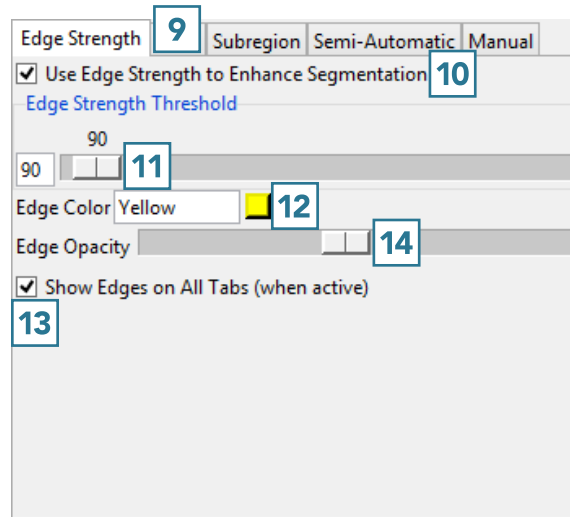
- Click Undo.



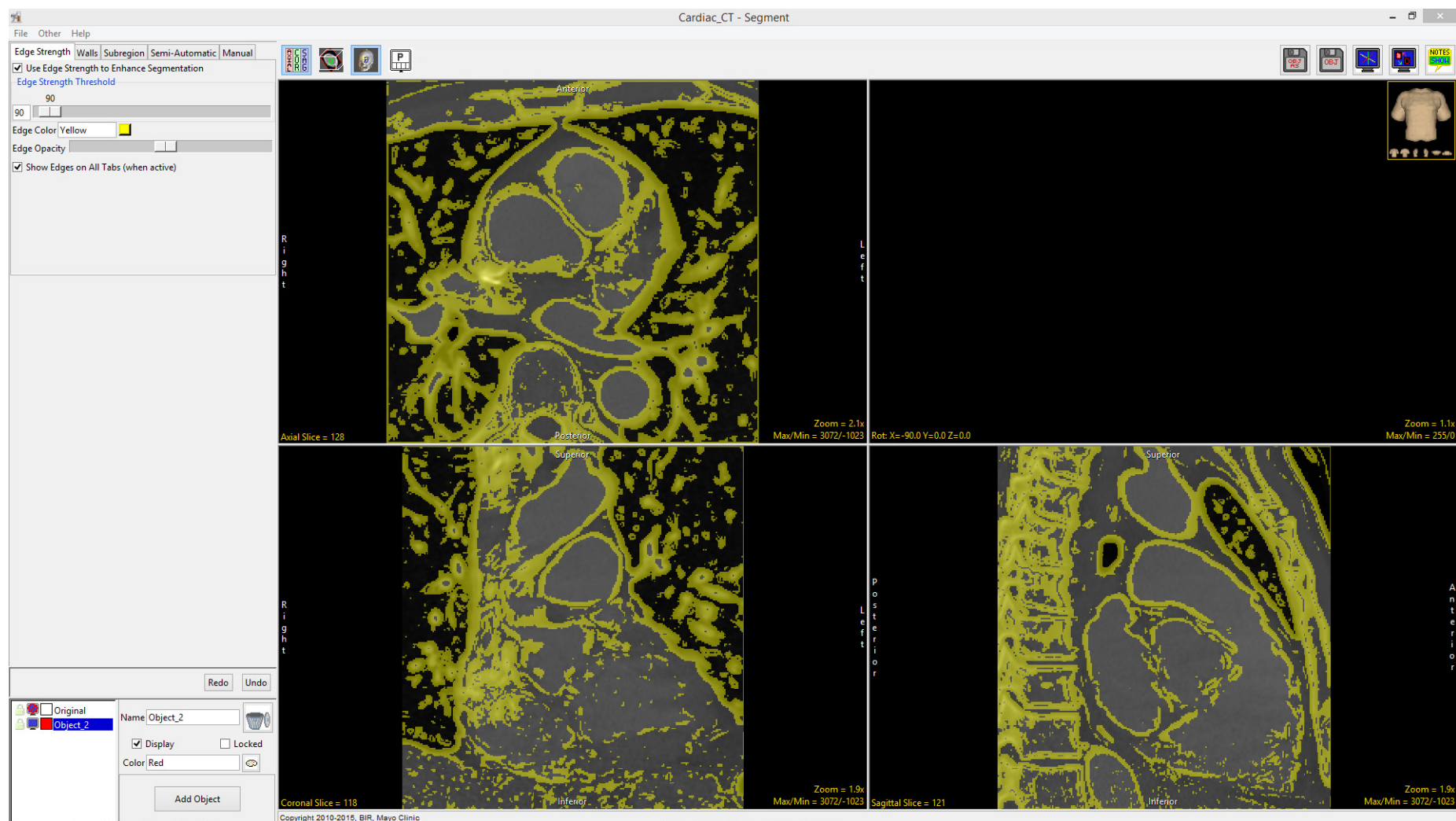


Now we will repeat this segmentation using edge strength to separate the heart from the rest of the data set.

- Select Edge Strength **9** and check Use Edge Strength to Enhance Segmentation. **10**
- Set the Edge Strength Threshold to 90. Note that this value will be different for each data set. In general, adjust the edge strength using the slider **11** until you find a suitable value. The edges will interactively update on the data set. Use the edge display to determine the suitable edge strength value.
- Optionally, change the color of the edge by entering the desired color in the text field or by using the color selector. **12**
- When performing the segmentation, leave the Show Edges checkbox **13** selected. If required, reduce the Edge Opacity using the slider. **14**

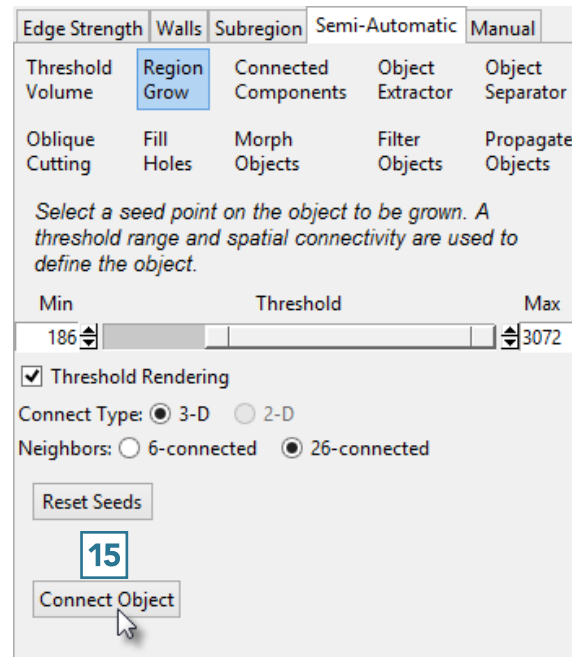


The edges detected on this data set using the Edge Strength algorithm with an edge strength threshold of 90 are shown overlaid on the data below.



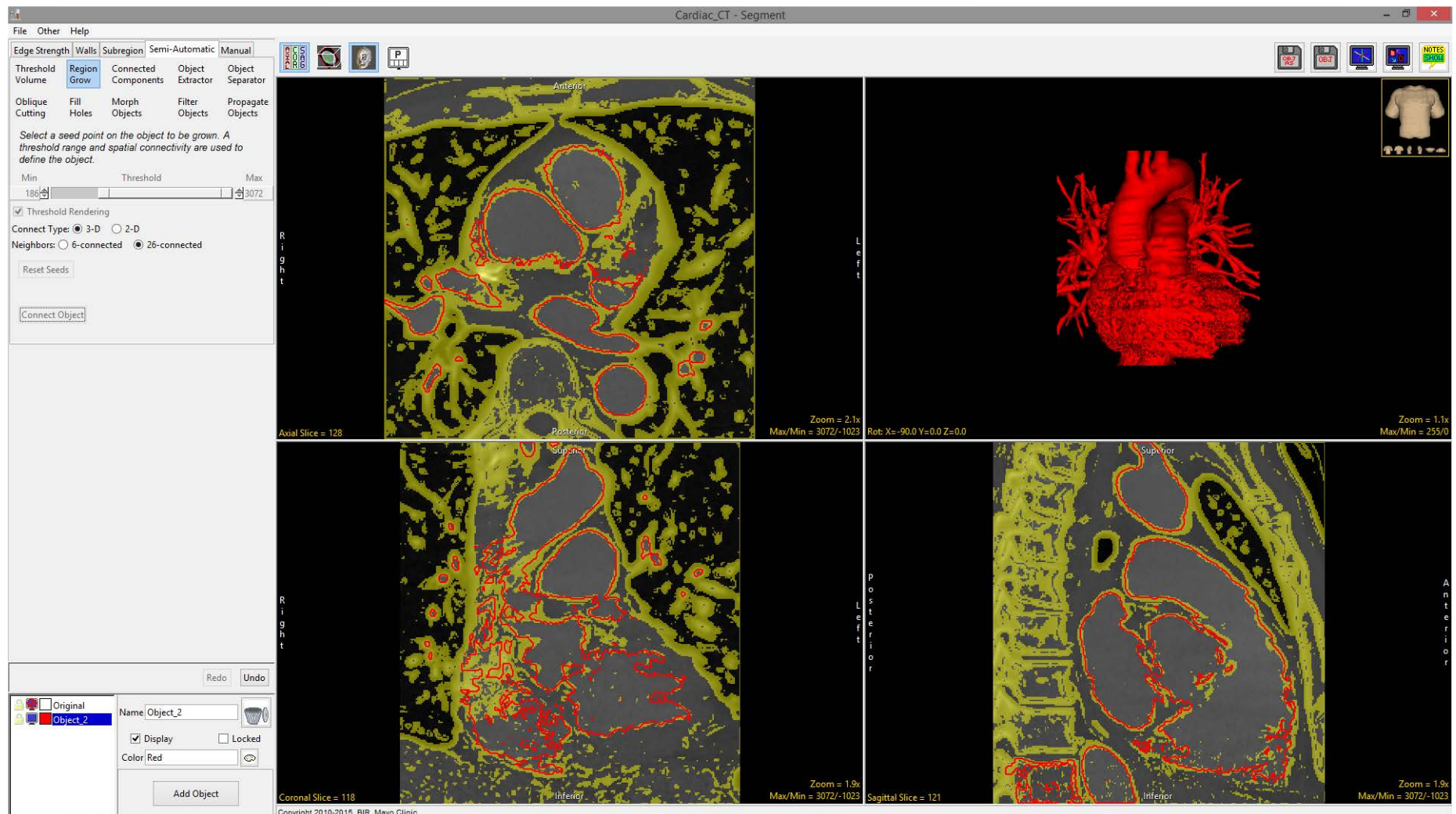


- Repeat the segmentation. Select Semi-Automatic, then choose Region Grow.
- Click on the image data to set a seed point. The seed point should be in the object you would like to isolate.
- The Threshold Min/Max values should still be set to the previous values. If not, reset them to define the object and then click Connect Object. **15**





Note that this time, only the heart was segmented. The Edge Strength technique prevented the region grow algorithm from including the spine in the object. Further segmentation can now be achieved with or without Edge Strength enabled. Select File > Save Object Map to save your work.





# Walls

Segmenting structures of interest that are connected to surrounding anatomy with similar grayscale values can be challenging. The Walls option provides tools to create adaptable 3D limits to help make this process easier for the user. The Walls tool is useful for many segmentation applications, particularly [isolating the cerebellum](#) from the rest of the brain parenchyma or limiting the boundaries of a region grow operation to [isolate blood pools](#) from cardiac data.



## 2. Using Walls with Semi-Automatic Segmentation

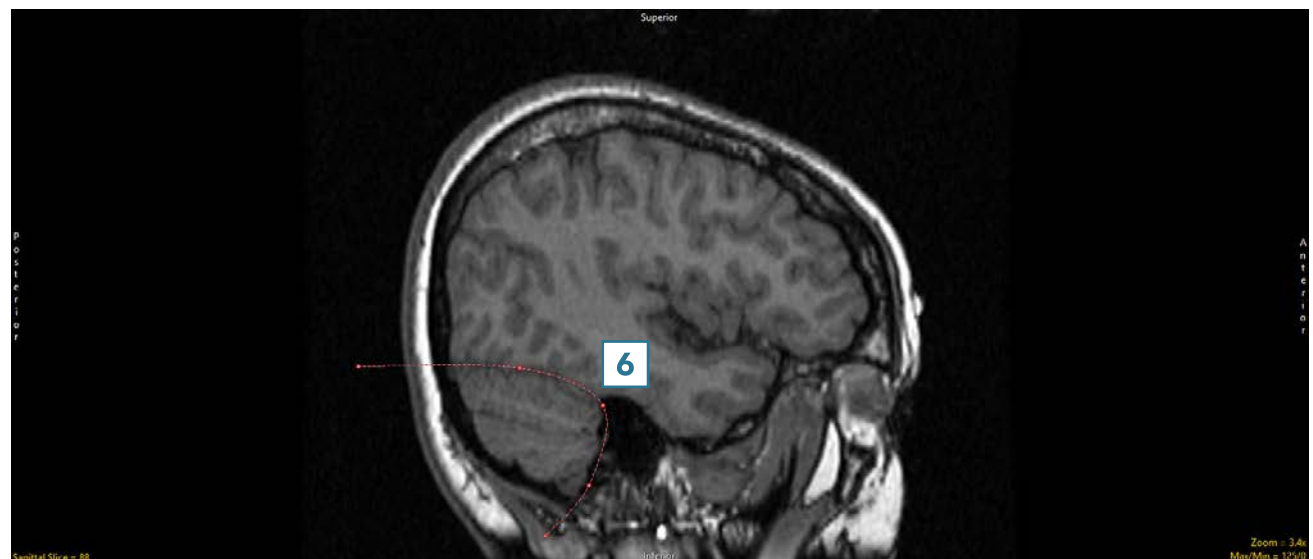
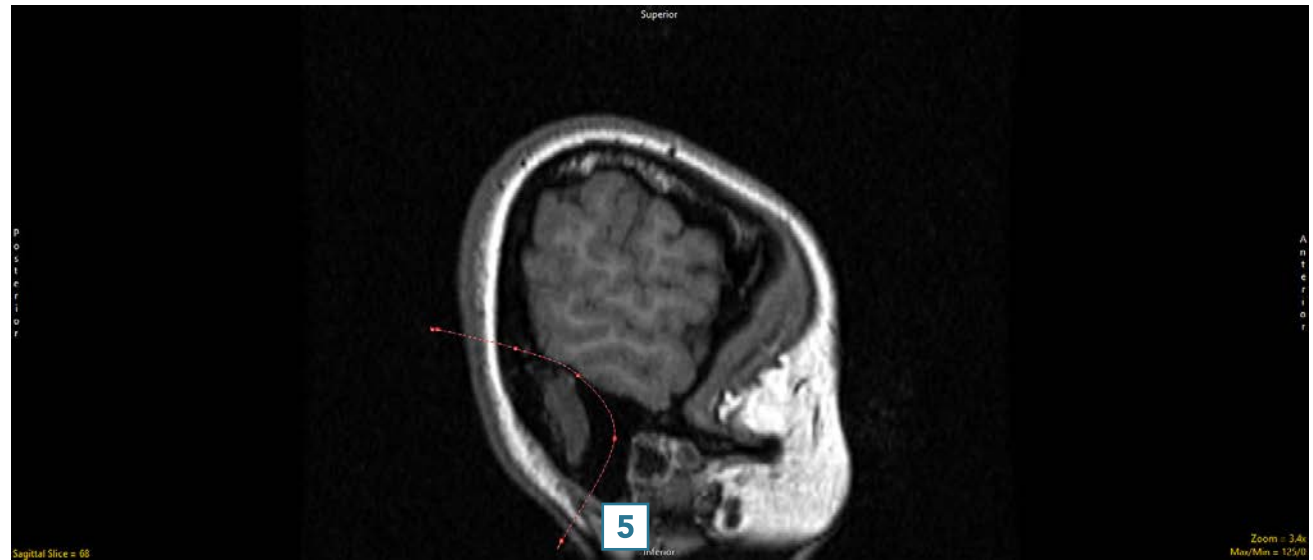
- Select a data set and open Segment.
- Select Walls **1** and check Define Walls to Limit Semi-Automated Operations. **2**
- Set the Wall Type to Spline. **3**
- Set the primary display to Sagittal. **4**



Download the EGV\_MRI data set to follow along  
<http://analyzedirect.com/data/>



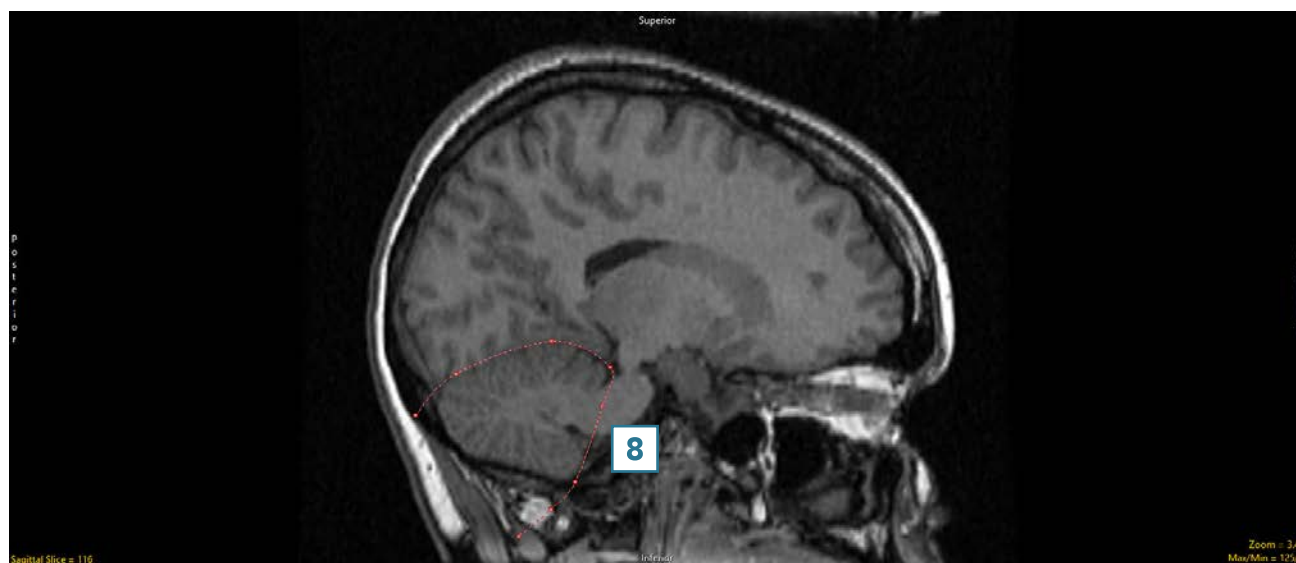
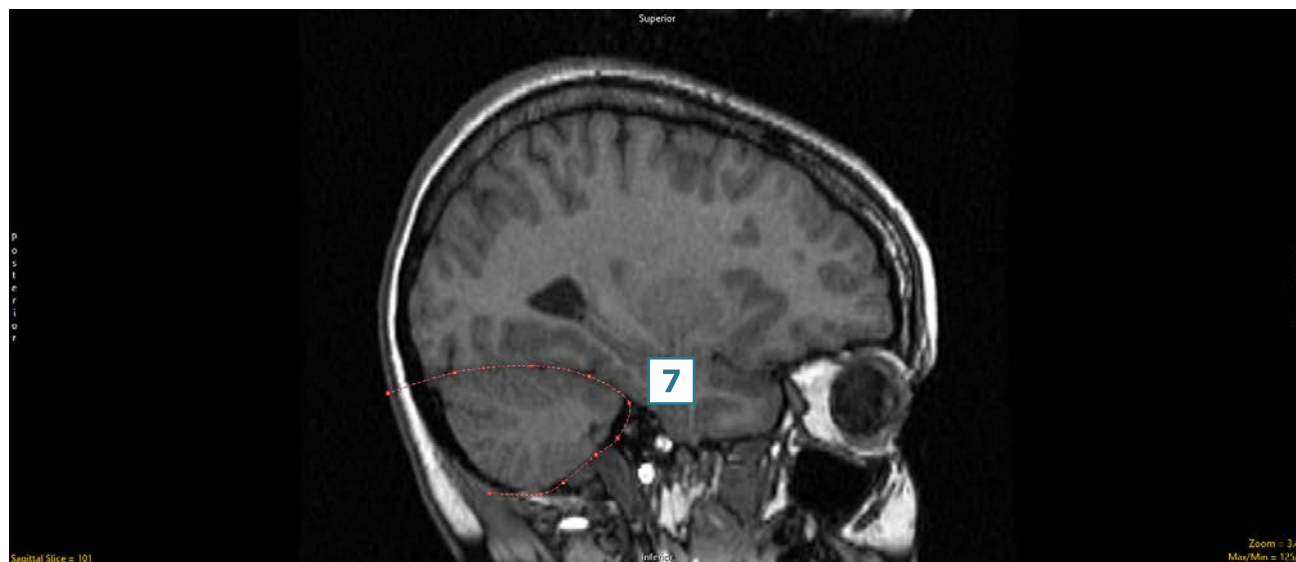
- Navigate through the sagittal slices to find the first slice that includes tissue belonging to the cerebellum. Draw a wall separating the cerebellum from the cerebrum on this slice.
- To draw a wall using the spline tool, left-click to set spline points which will connect into a smooth line. Double-click when defining the last spline point to set the spline. **5**
- The spline points can be adjusted by left-clicking and dragging. Right-clicking on a spline point allows you to delete it or make other changes to the spline such as closing the spline or deleting the entire spline.
- Move forward through the sagittal slices and adjust the wall as required. **6**
- The Wall can also be redrawn if necessary.



- Once the cerebellum is no longer well defined by the wall, redefine the wall on that slice. The wall will be interpolated between all slices on which it is defined. When finished, scroll through the slices to ensure that the cerebellum is well defined by the wall.

Note that walls can be set in multiple orientations. This is helpful when trying to isolate structures connected to several surrounding structures in all orientations. For example, it can be used when isolating the heart from the lungs, spine, sternum, etc. It can also be useful to define walls in the sagittal and coronal orientations to better segment the cerebellum.

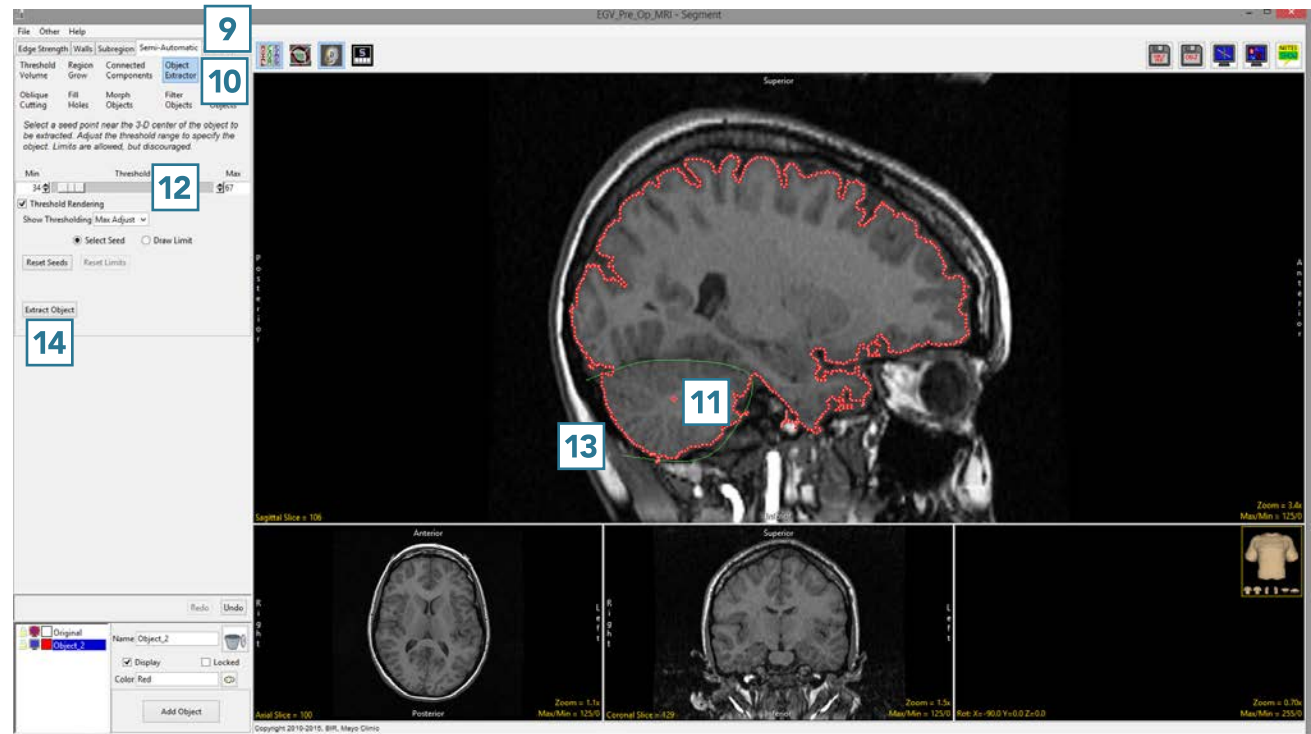
- Continue to define walls around the cerebellum in the sagittal orientation. 7 8



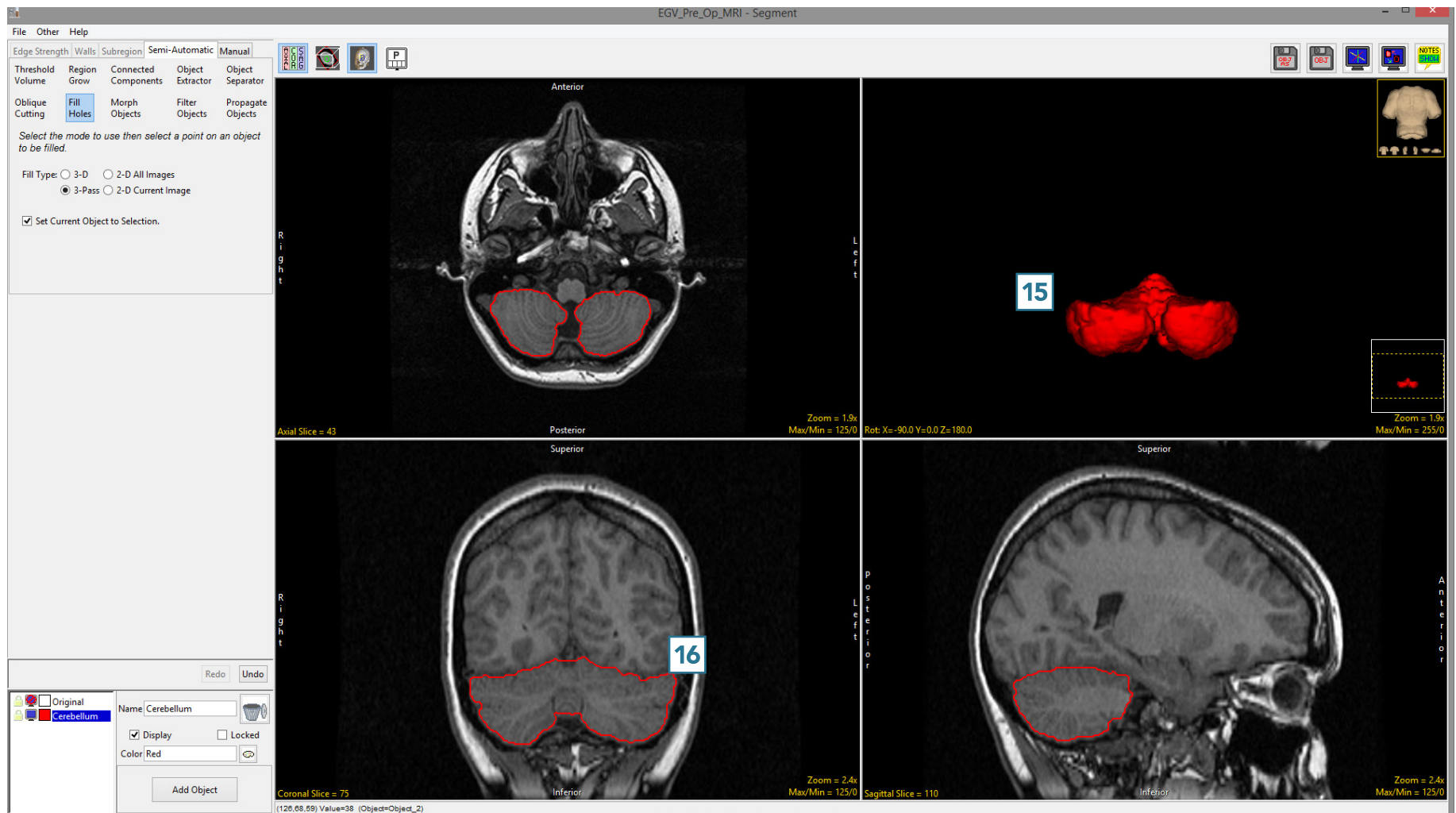
- 11

14

- 14



- The cerebellum will be isolated and displayed in 3D.
- Once segmentation is complete, the structure will be rendered **15** and overlaid on the slice data. **16**
- Save your work by selecting File > Save Object Map.





# Subregion

Subregion allows users to limit segmentation to a specific user-defined region. This tool is particularly useful when you would like to segment a structure of interest, such as the hippocampus, without having to crop the original image data.

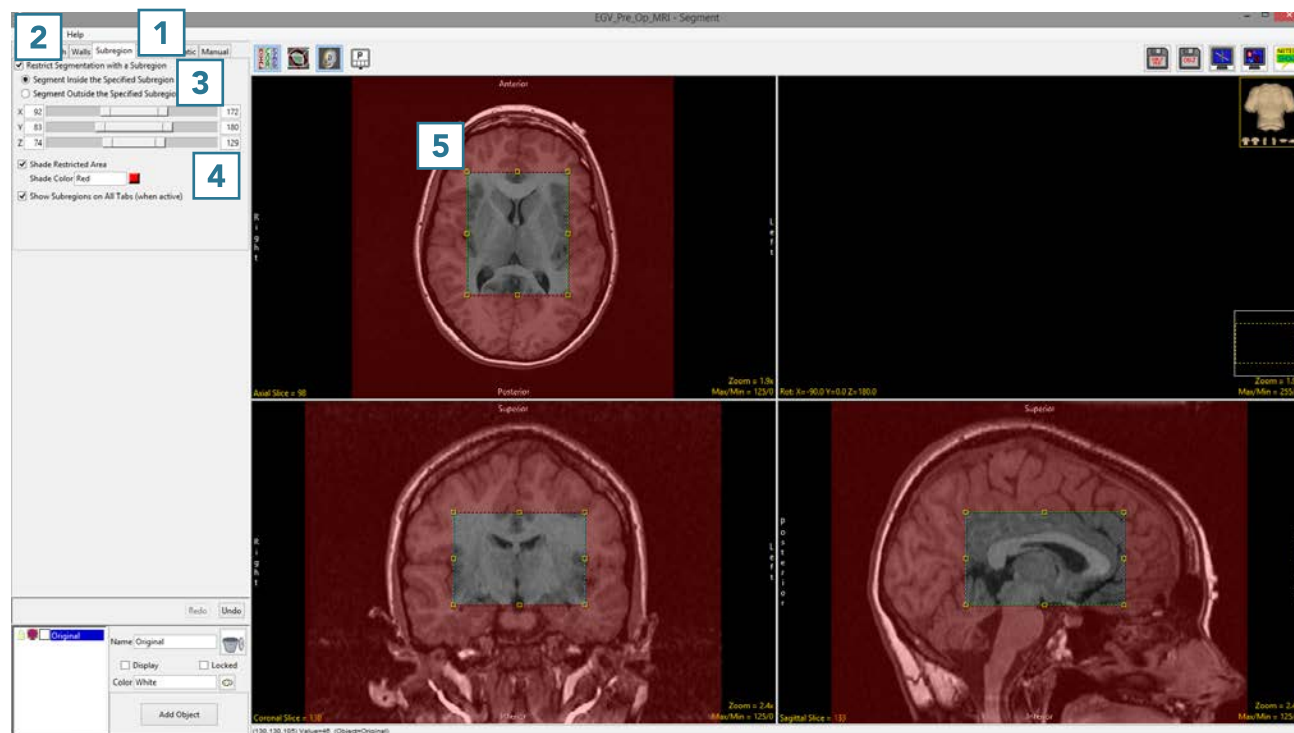


### 3. Setting a Subregion

- Select a data set and open Segment.
- Select Subregion **1** and check the Restrict Segmentation with a Subregion checkbox. **2**
- Choose to Segment Inside (default) or Outside the Subregion. **3**
- Use the X, Y, Z sliders **4** or the yellow control points **5** to specify the Subregion in all orientations.
- The area in red will be protected as you move to the Semi-Automatic or Manual tools to segment regions of interest.



Download the EGV\_MRI data set to follow along  
<http://analyzedirect.com/data/>







# Semi-Automatic Tools

The Semi-Automatic tab provides access to many useful tools for interactive, efficient segmentation of objects. These tools include simple segmentation options, such as threshold, to more advanced, semi-automated techniques like object extraction and object separation. The segmentation tools available also include those that use 3D spatial connectivity and include region growing and connected components.



## Threshold Volume

Threshold segmentation allows a range of voxels from the input volume to be assigned to an object. All voxels greater than or equal to the threshold minimum and less than or equal to the threshold maximum are assigned to the object.

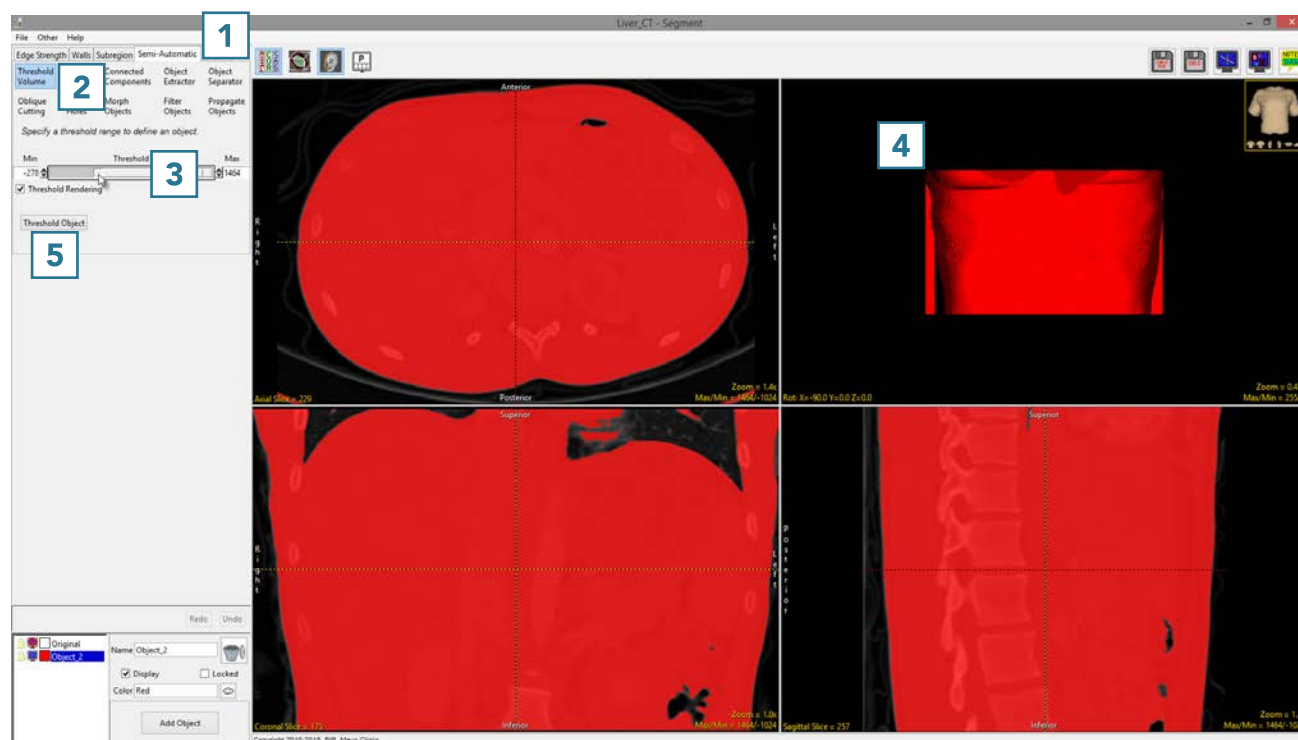


## 4. Threshold Volume and Segmentation

- Select a data set and open Segment.
- Select Semi-Automatic **1** and choose Threshold Volume. **2**
- Use the Threshold slider **3** to adjust the voxel intensity range, so that the soft tissue is displayed in the binary mask preview. This data set is scaled to Hounsfield Units (HU), so the grayscale intensities represent HU. This may be used to isolate tissue with a known HU range. **4**
- Click Threshold Object **5** to assign all selected voxels to the current object.

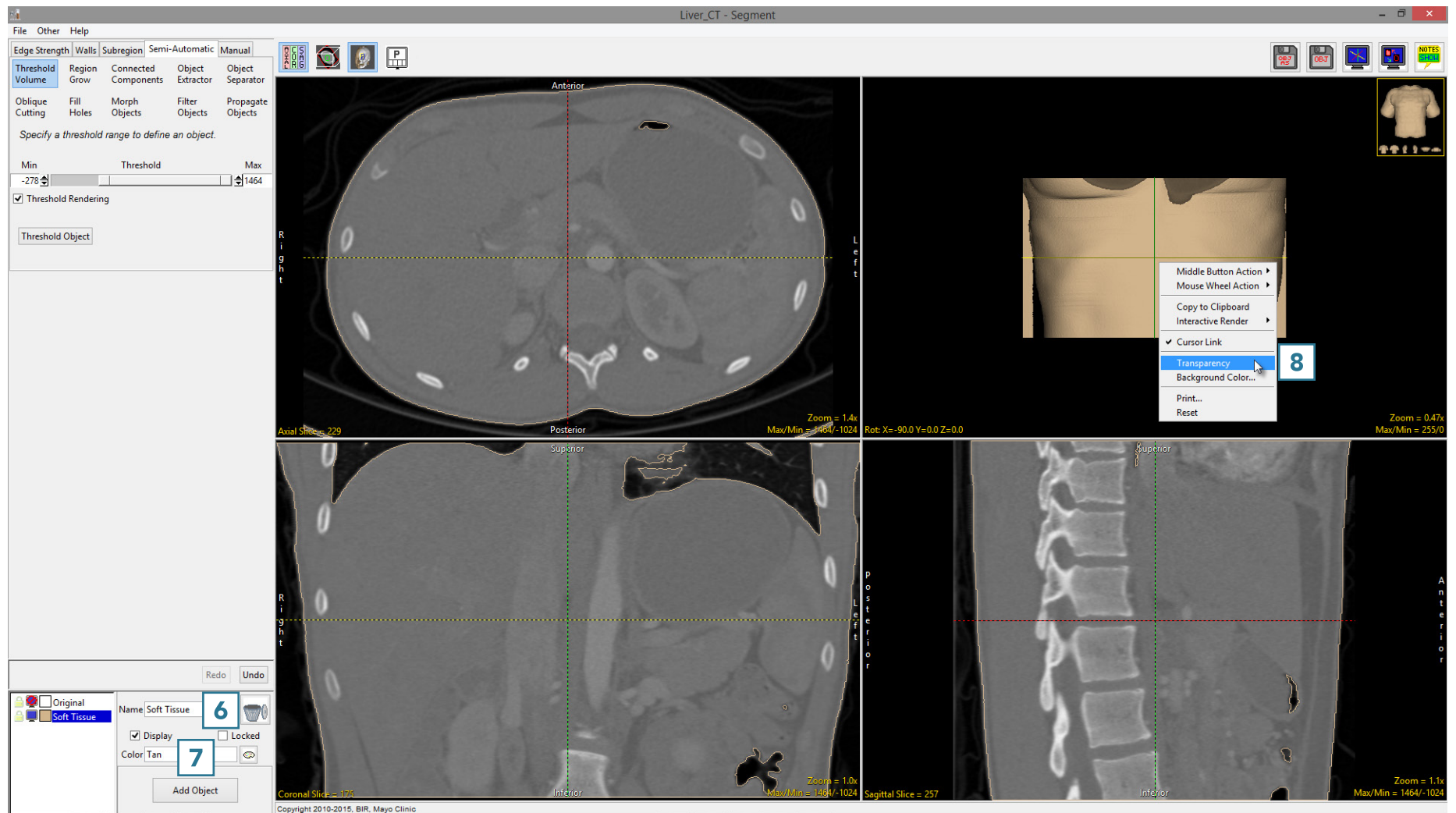


Download the CT\_Liver data set to follow along  
<http://analyzedirect.com/data/>



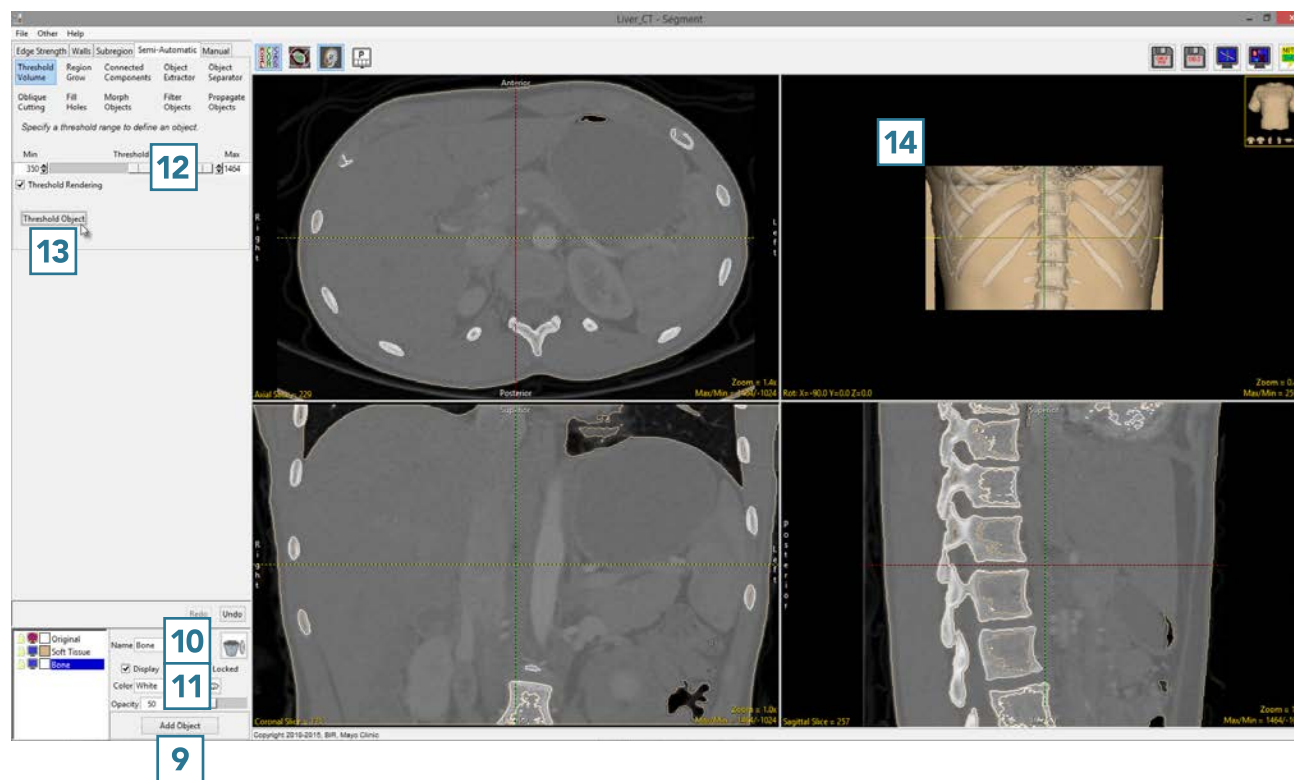


- Rename the object, **6** then change the color. **7**
- Right-click on the rendering and select Transparency. **8**





- Add a new object. **9**
- Update the name **10** and color. **11**
- Adjust the threshold range **12** so that the bone is displayed in the binary preview, then click Threshold Object. **13**
- Note that the rendering **14** will update to display both objects. The bone is now fixed to visible, as the rendering transparency is enabled. **8**
- Select File > Save Object Map to save your work.





## Region Grow

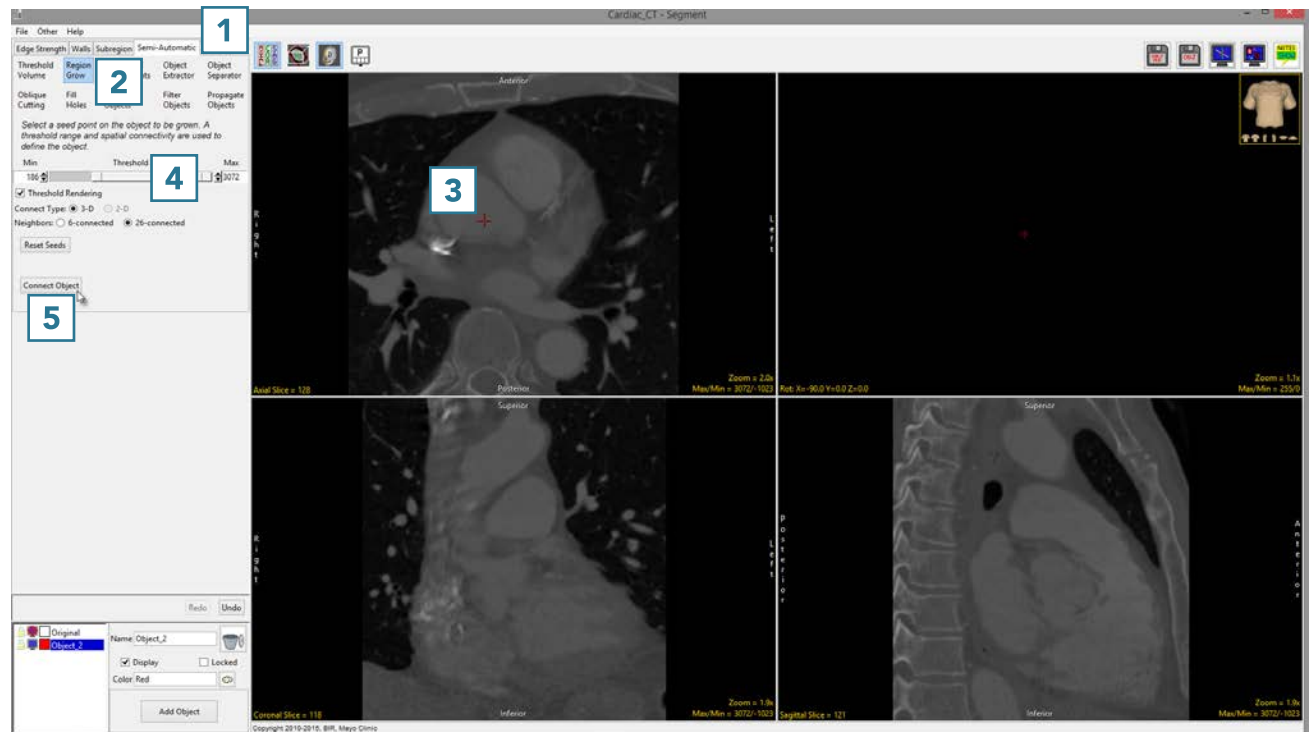
Whereas threshold-based segmentation applies globally to all voxels in the volume, region growing can be used to limit the segmentation to voxels that are connected to a user-defined seed point which fall within a specified threshold range.

## 5. Segmentation with Region Grow

- Select a data set and open Segment.
- Select Semi-Automatic **1** and choose Region Grow. **2**
- Click on the image data to set a seed point in the object you would like to isolate. **3**
- Set the Threshold Min/Max values to define the object. **4**
- Click Connect Object. **5**

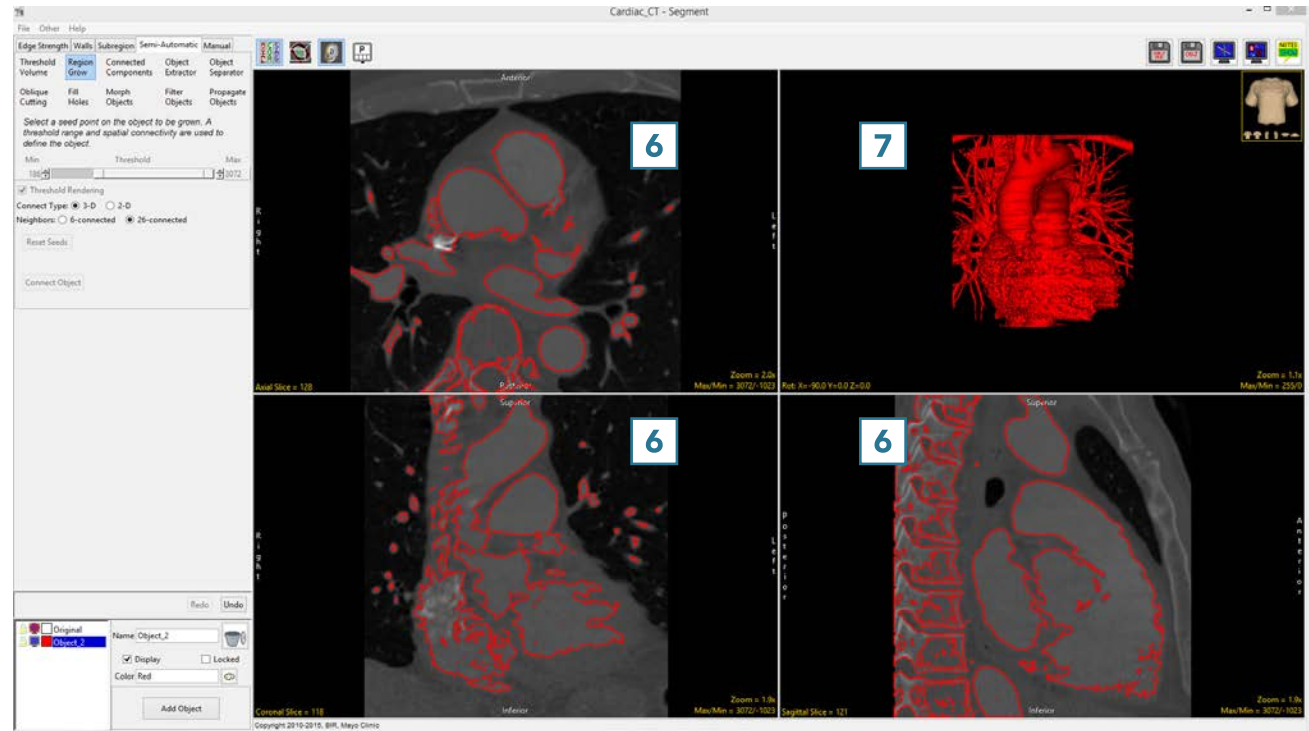


Download the CT\_Heart data set to follow along  
<http://analyzedirect.com/data/>





- The voxels fulfilling the seed point and threshold criteria for the region grow will be assigned to a new object.
- The segmented object is shown overlaid on the 2D slice data **6** and a 3D rendering **7** is displayed.





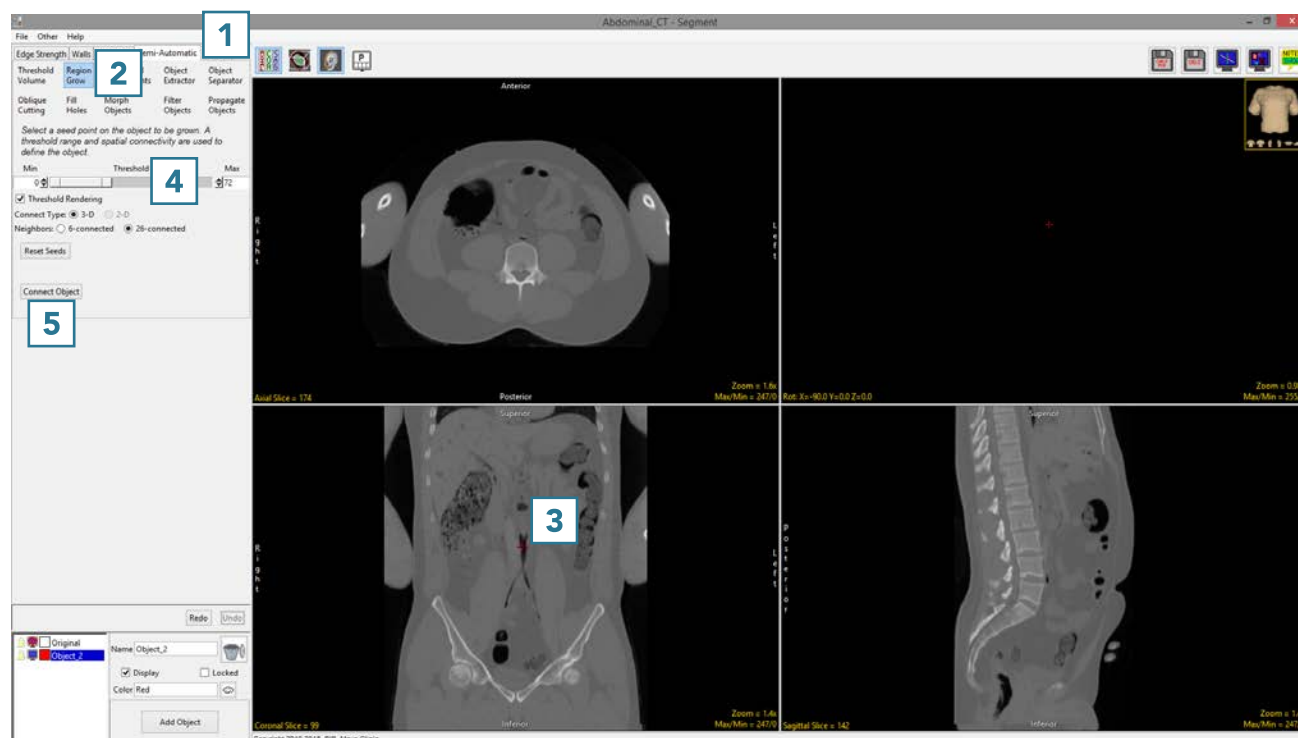
## 6. Adjusting Connected Neighbors

It may be necessary to adjust the number of neighbors used in order to limit the region grow. This will help prevent unwanted objects from being segmented with the target object.

- Select a data set and open Segment.
- Select Semi-Automatic **1** and choose Region Grow. **2**
- Click on the image data to set a seed point in the structure you would like to isolate. **3**
- Set the Threshold Min/Max values to define the object **4** and click Connect Object. **5**



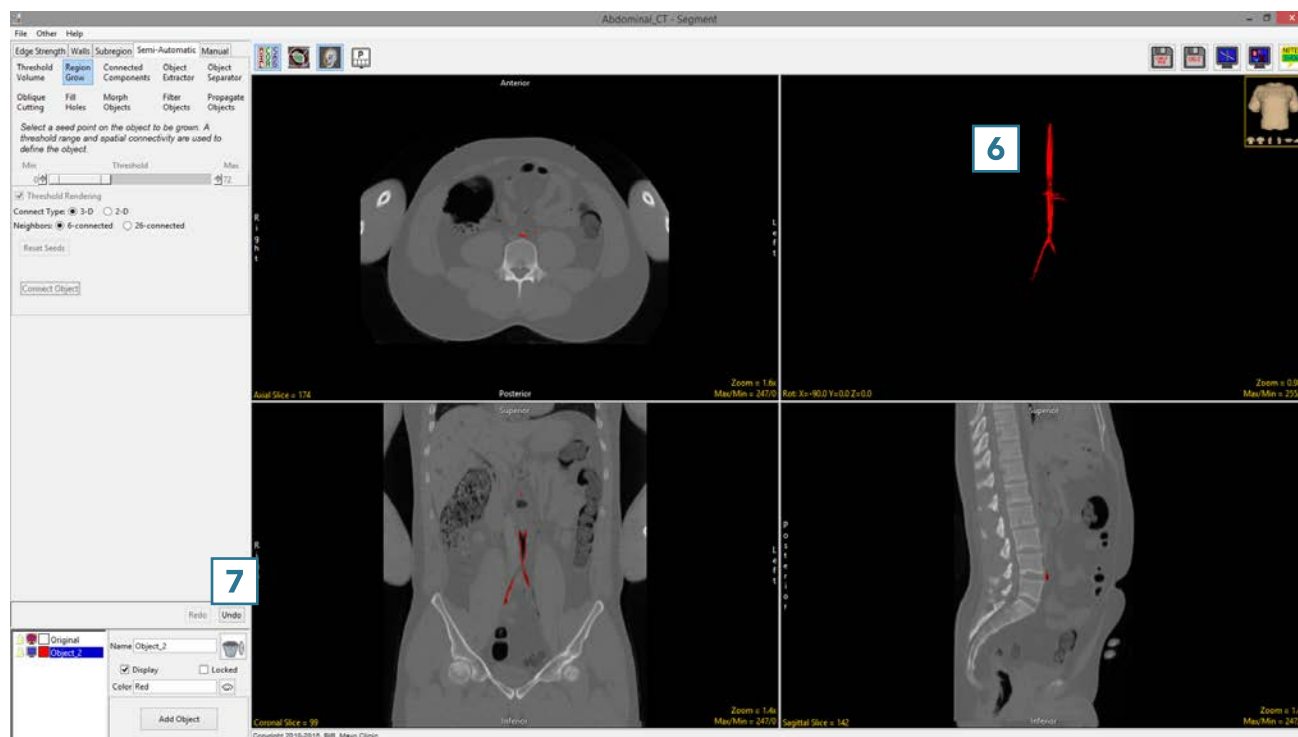
Download the VH\_Abdomen data set to follow along  
<http://analyzedirect.com/data/>





Note that the segmentation of the abdominal aorta in the example, using the default 26-connected neighbors, also assigns part of the left lung into the object. **6**

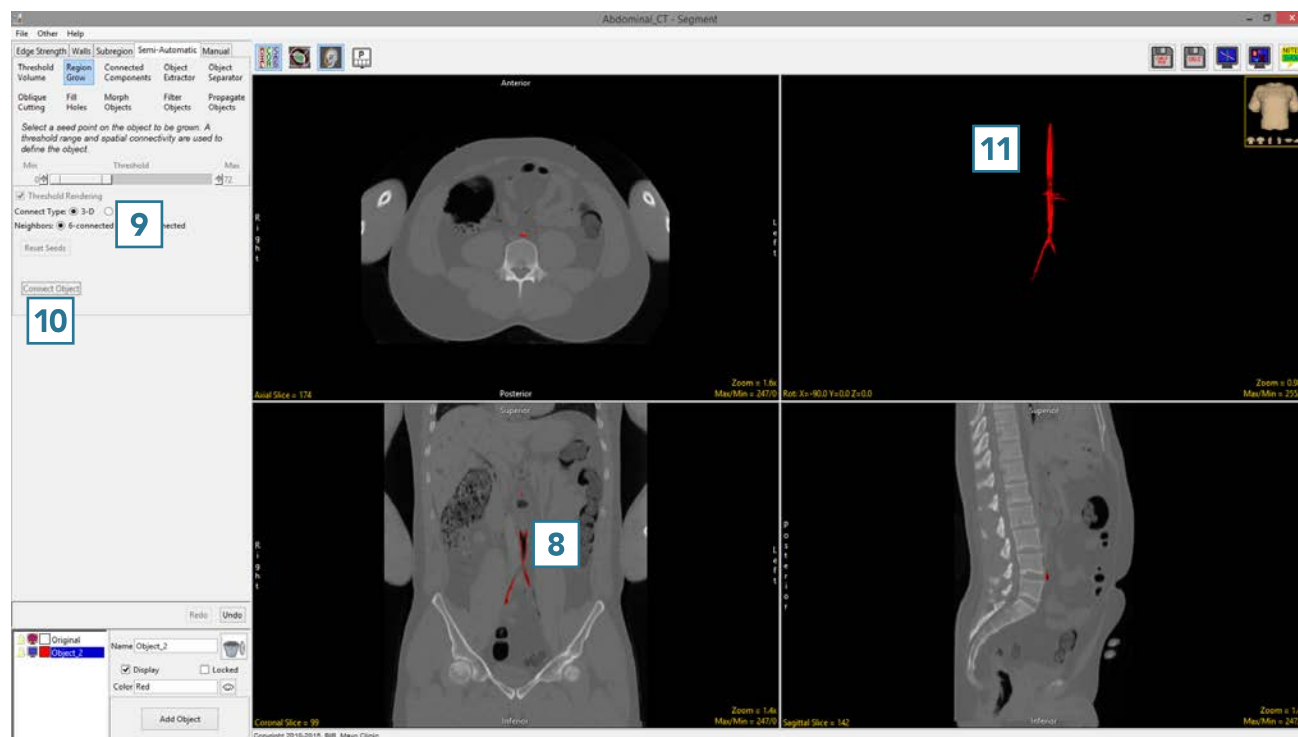
- Click Undo. **7**





- Set the seed point, **8** set Neighbors to 6-connected, **9** and click Connect Object. **10**

Note the segmentation result for the abdominal aorta **11** no longer contains part of the left lung.





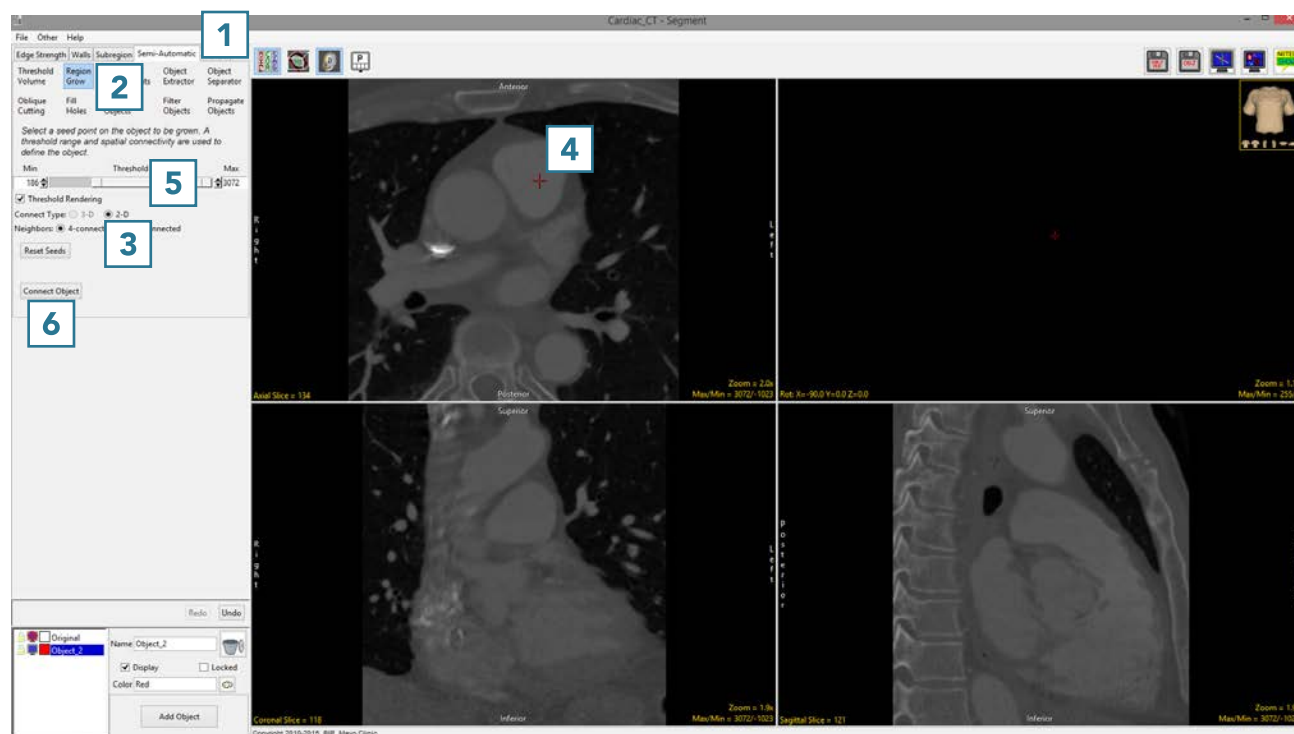
## 7. 2D Region Grow

Region grow also provides the ability to limit the region to a single slice via the 2D Connect Type option.

- Select a data set and open Segment.
- Select Semi-Automatic, **1** choose Region Grow **2** and set the Connect Type to 2D. **3**
- Click on the image data to set a seed point. **4** The seed point should be in the 2D structure you would like to isolate.
- Set the Threshold Min/Max values to define the object **5** and click Connect Object. **6**

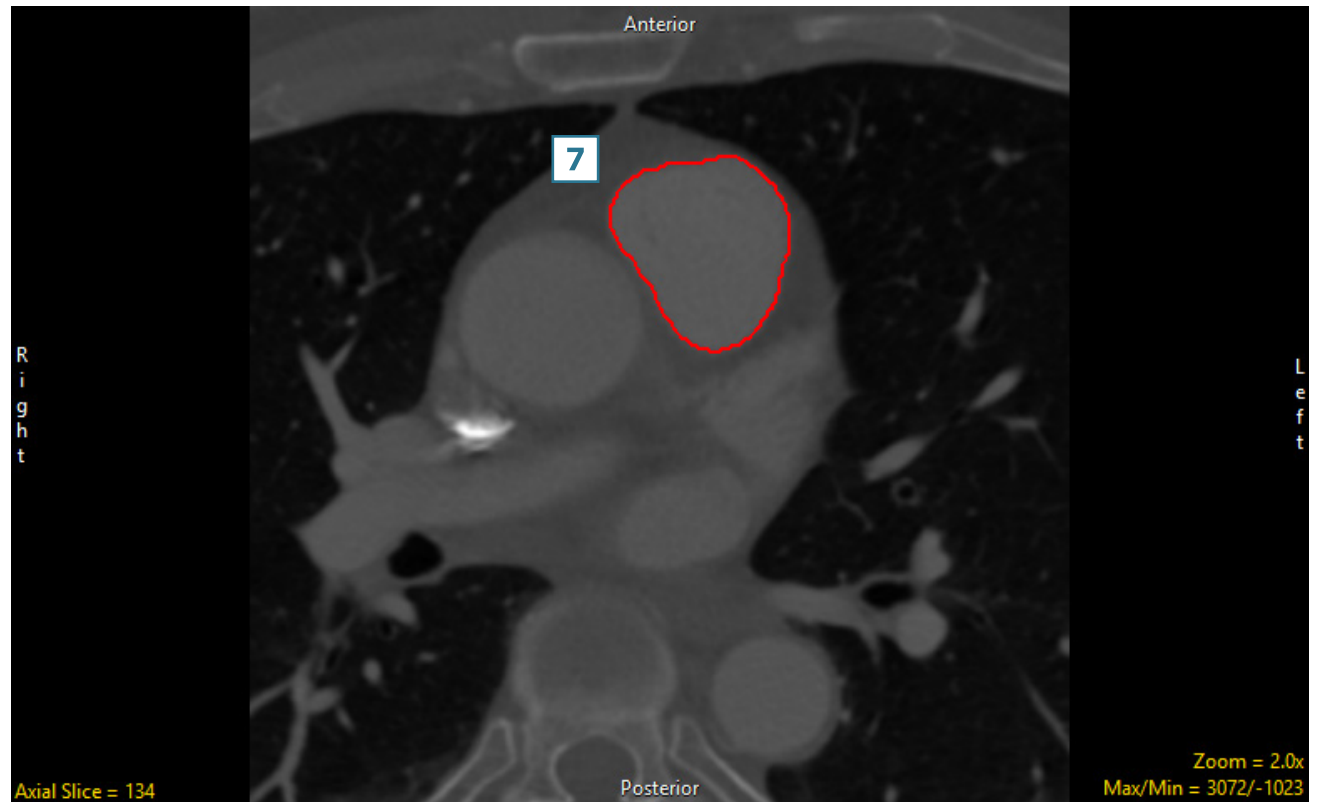


Download the CT\_Heart data set to follow along  
<http://analyzedirect.com/data/>



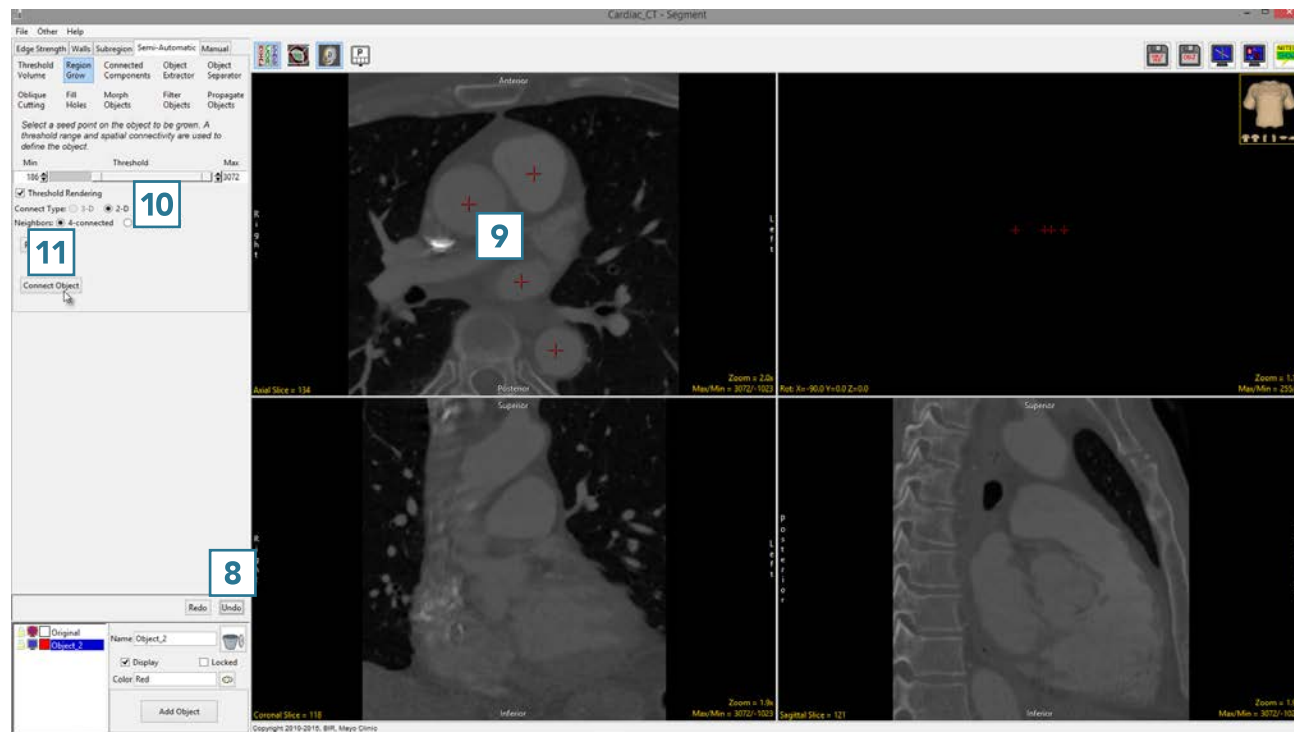


- The region will be isolated on the single slice. **7**





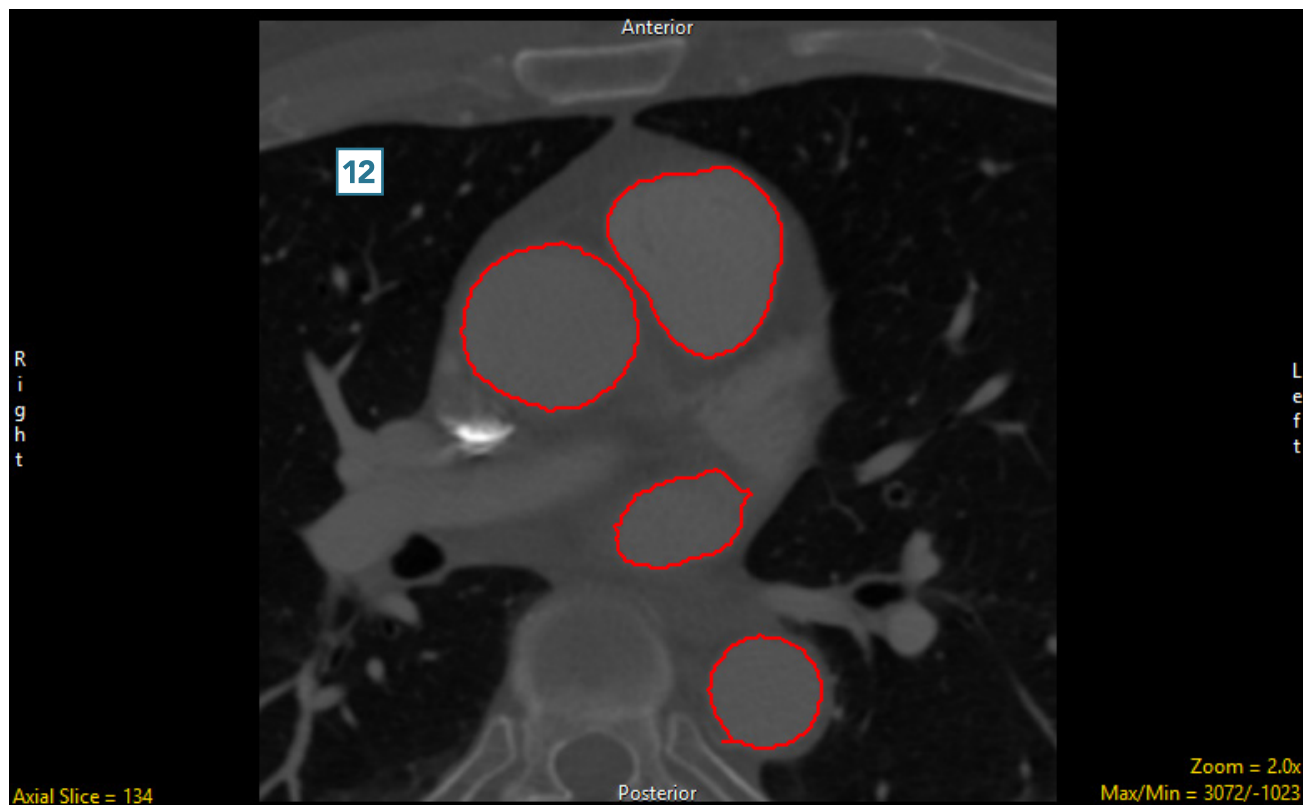
- To segment multiple 2D regions, click Undo. **8**
- Click on the image data to set multiple seed points on the regions you want to segment. **9**
- Set the Threshold Min/Max values to define the object **10** and click Connect Object. **11**







- All of the regions falling within the threshold criteria will be isolated in 2D. **12**





## Connected Components

The connected components tool allows users to identify groups of objects based on spatial connectivity and intensity range. This segmentation method finds groups of voxels within a user-specified intensity range and assigns spatially disconnected groups to independent objects. The number of objects identified is specified by the user, and objects are created in order of largest to smallest based on the number of connected voxels in each object.

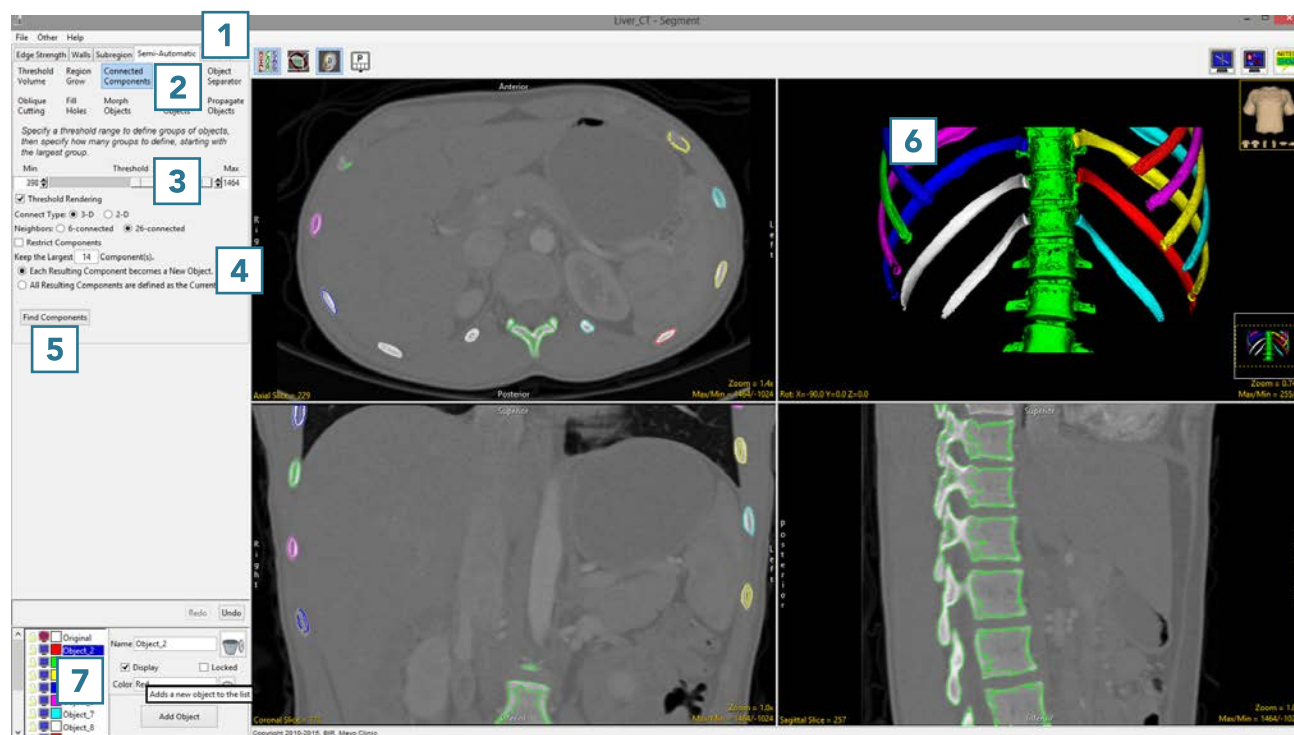


## 8. Segmenting Multiple Objects Using Connected Components

- Select a data set and open Segment.
- Select Semi-Automatic **1** and choose Connected Components. **2**
- Set the threshold range **3** to isolate a group of objects, such as spine and ribs.
- Set the number of components to keep to 14. **4**
- Click Find Components.
- The data will be thresholded and the largest groups of voxels specified **5** will be identified and rendered. **6**
- The objects will be listed in the object control window. **7**



Download the CT\_Liver data set to follow along <http://analyzedirect.com/data/>





## Object Extractor

The Object Extractor tool enables the user to define and extract objects from image data using a combination of thresholding, region growing and morphological operations.

First, a seed point is manually set on a structure of interest. Next, a threshold range is established by the user to define the structure. The region defined by a given threshold range is shown on the 2D slice containing the seed point using a 2D auto trace mechanism. This region updates interactively as the threshold range is adjusted, allowing the user to determine the threshold range that properly defines the region of interest. The Object Extractor segmentation routine is ready to be started once the seed point and threshold range define the structure on the initial slice.

The algorithm first applies a global threshold to the data set, using the minimum and maximum values specified by the user. Next a 3D binary erosion is performed on the binary result of the global threshold. The erosion attempts to break connections between the target structure and neighboring regions which have similar intensity values. The erosion is followed by a 3D 6-neighbor region grow, which uses the initial seed point. The processed target slice on which the initial seed point was set is compared to the initial auto trace from the user-defined seed point and threshold range. The erosion and region growing steps are repeated until the set of voxels on the processed target slice are a subset of the initial auto trace. Next, the processed data is conditionally dilated until 99% of the voxels in the auto traced region on the processed target slice are recovered. Once the extraction process is complete, the resulting object is rendered and displayed over the 2D slice data.

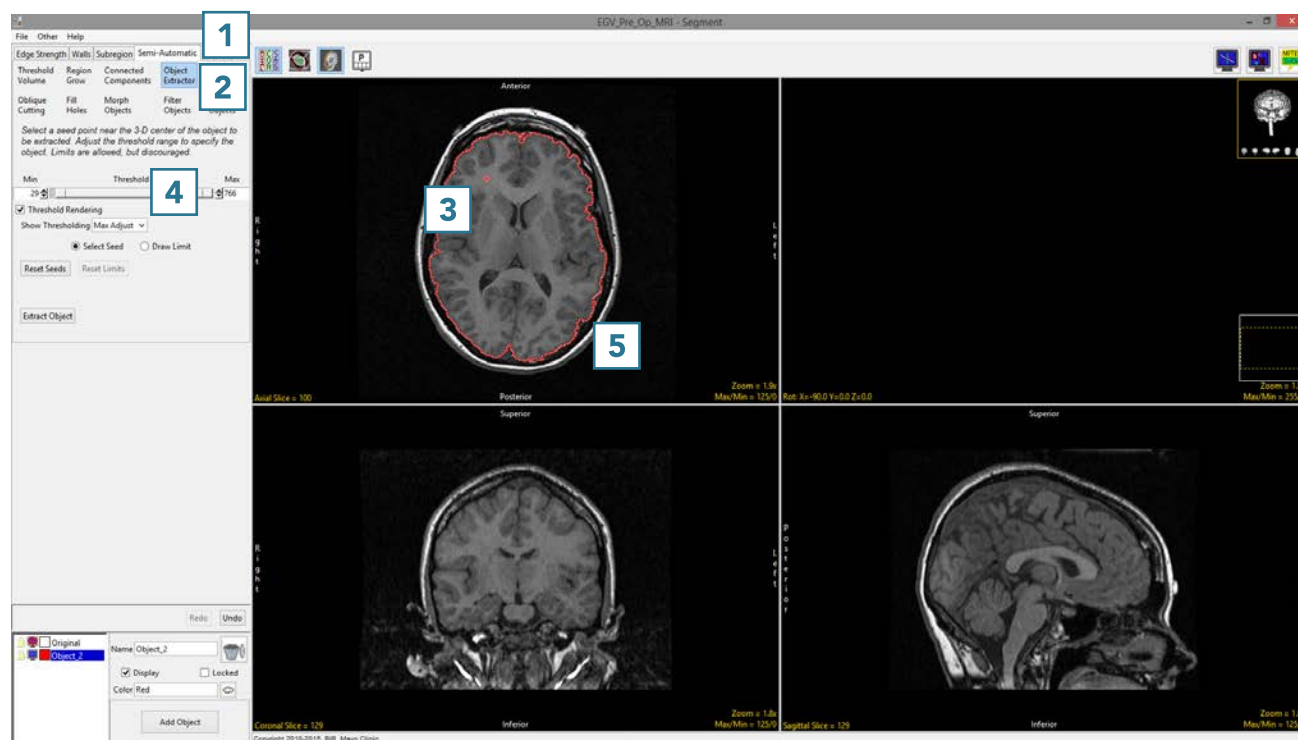


## 9. Segmentation of a Single Object Using Object Extractor

- Select a data set and open Segment.
- Select Semi-Automatic **1** and choose Object Extractor. **2**
- Click on the image data to set a seed point in the object you would like to isolate. **3**
- Adjust the minimum threshold value **4** until the auto trace defines the object. **5**



Download the EGV\_MRI data set to follow along <http://analyzedirect.com/data/>



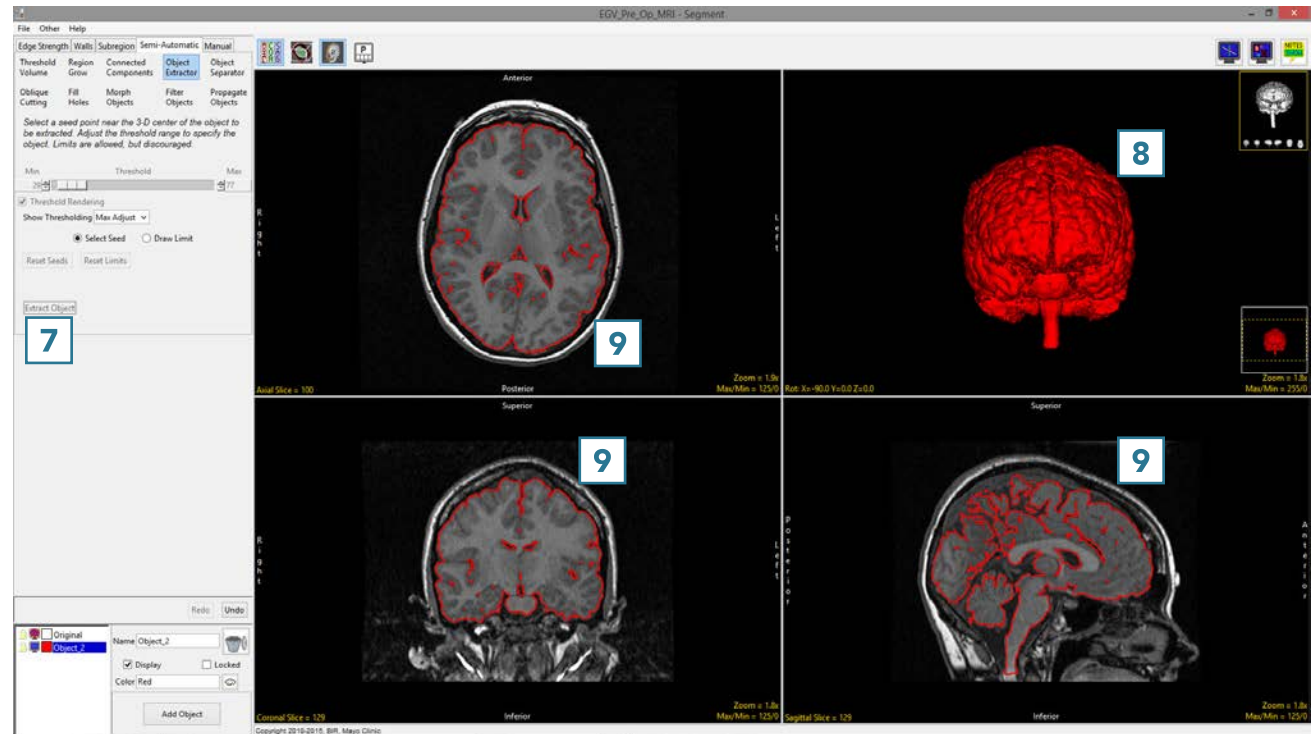


- Adjust the maximum threshold level and note that the red binary mask will interactively update.
- Lower the maximum threshold value until holes start to appear in the red binary mask in the structures surrounding the brain, but not in the brain. **6**





- Click Extract Object. **7**
- Once segmentation is complete, the object map will be rendered **8** and overlaid on the slice data. **9**
- Save your work by selecting File > Save Object Map.





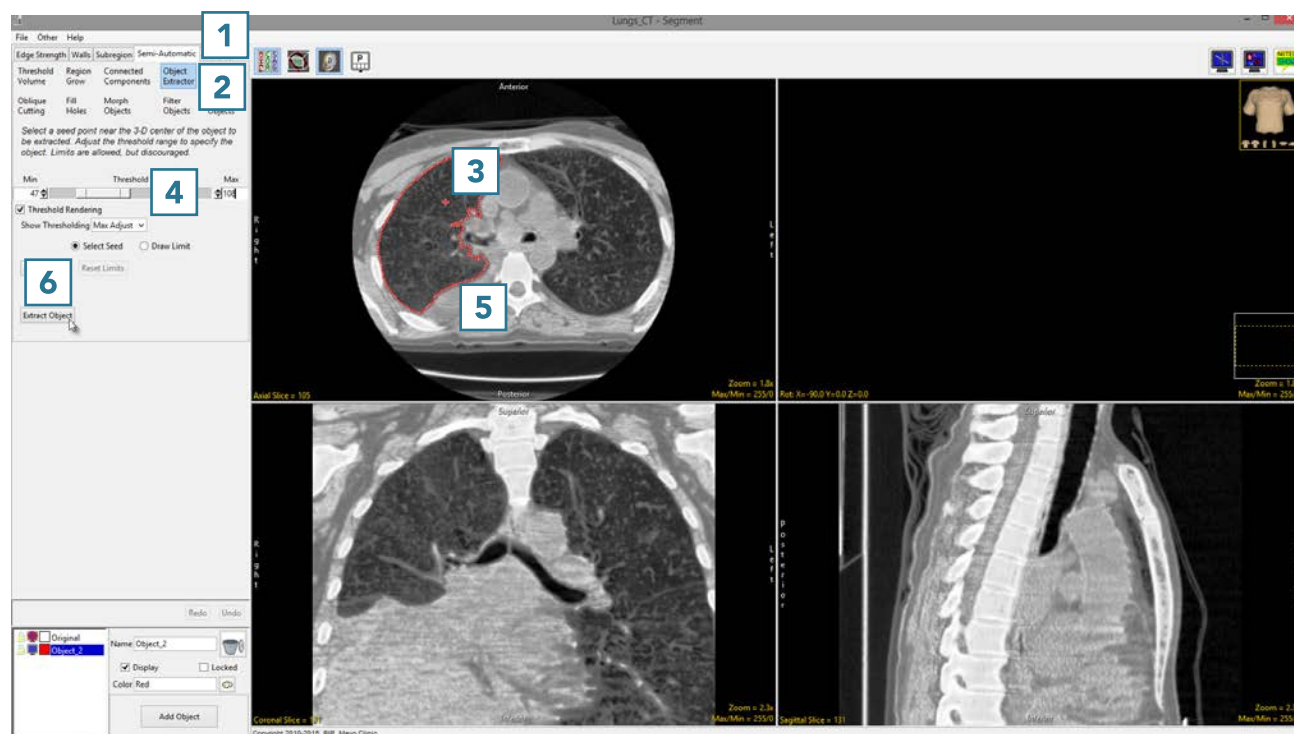


## 10. Segmentation of Multiple Objects Using Object Extractor

- Select a data set and open Segment.
- Select Semi-Automatic **1** and choose Object Extractor. **2**
- Click on the image data to set a seed point in the object you would like to isolate. **3**
- Adjust the minimum and maximum threshold values **4** until the auto trace defines the object. **5**
- Select Extract Object. **6**

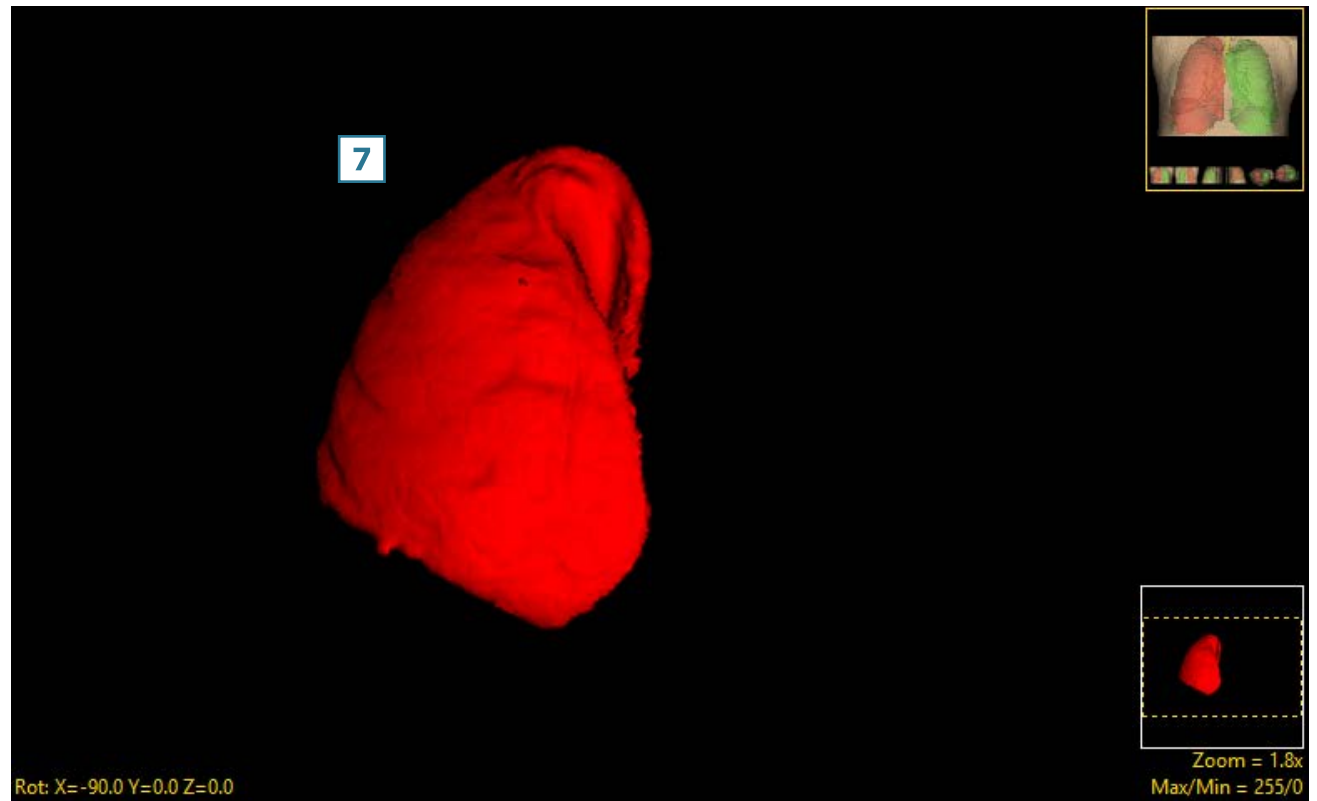


Download the CT\_Lungs data set to follow along  
<http://analyzedirect.com/data/>



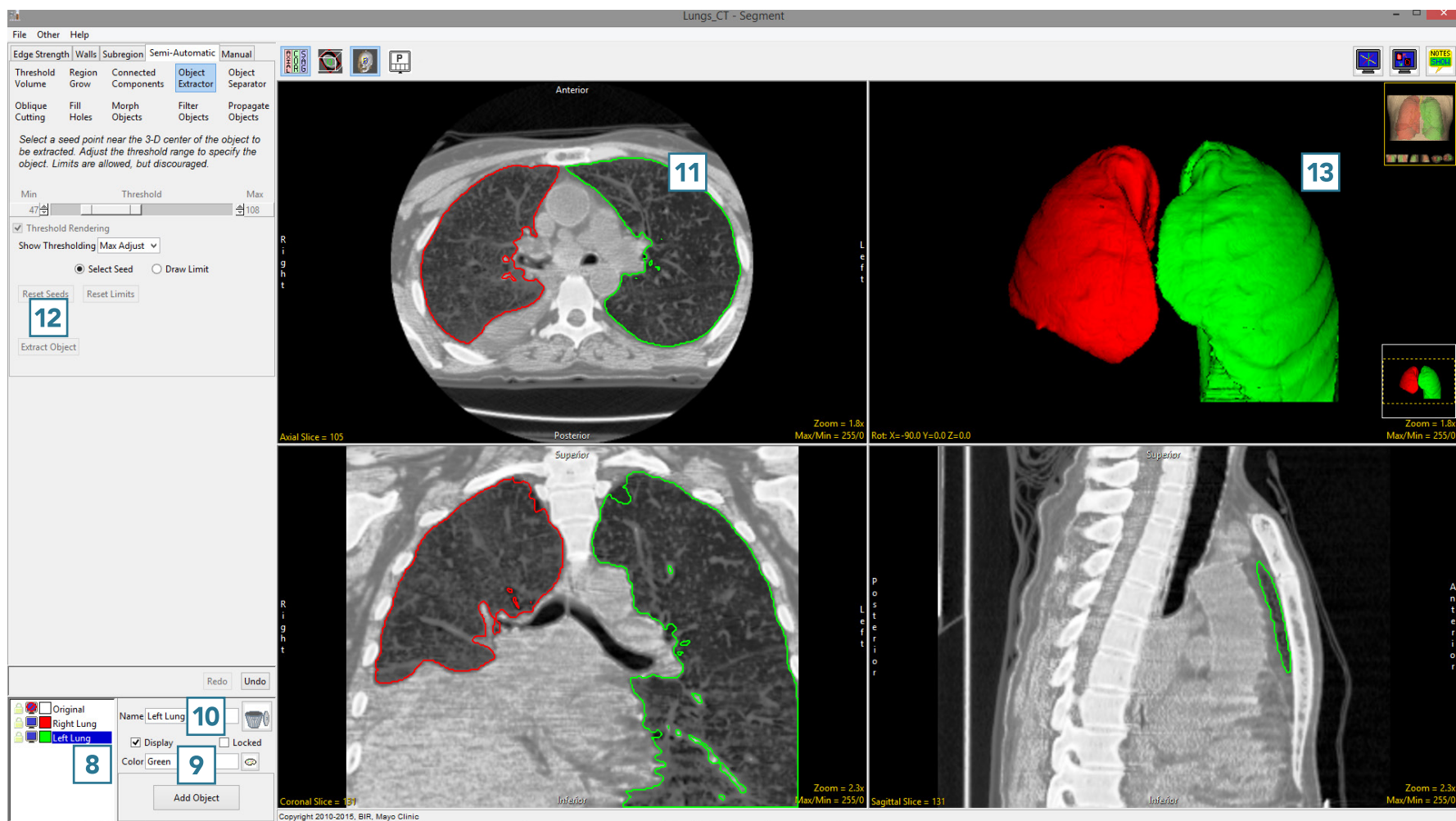


- Once the segmentation process is complete, the object will be rendered. **7**





- Rename the object. **8** Add a new object **9** and rename. **10**
- Set a seed point in the next object **11** and select Extract Object. **12**
- Once the segmentation process is complete, the object will be rendered. **13**
- Save your work by selecting File > Save Object Map.





## Object Separator

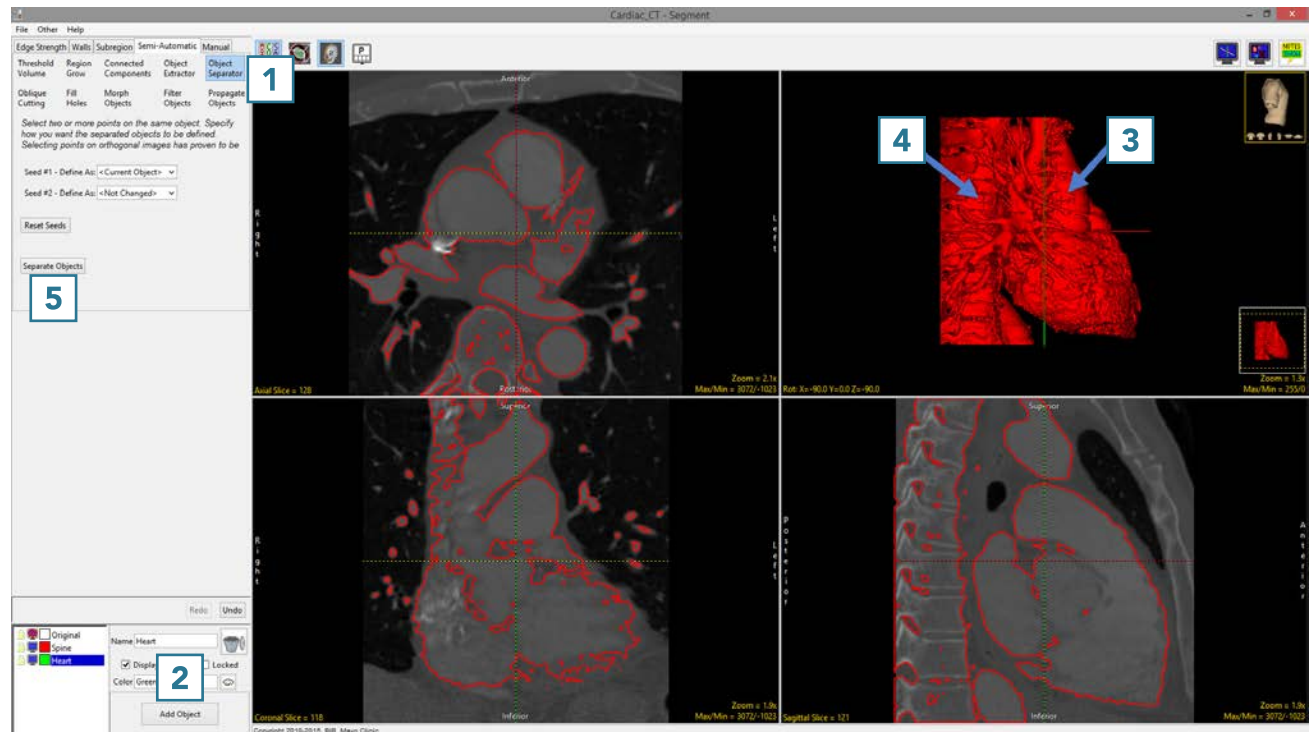
The Object Separator tool uses morphologic erosion to break connections between objects based on user-defined seed points to specify objects to separate.

## 11. Separating Objects

- Select a data set and open Segment.
  - Select Semi-Automatic and choose Region Grow.
  - Click on the image data to set a seed point. The seed point should be in the object you would like to isolate.
  - Set the Threshold Min/Max values to define the object and then click Connect Object.
  - The structure will be isolated.
  - Rotate the rendering to view the objects to disconnect.
  - Select Object Separator **1** and click Add Object. **2**
  - Set a seed point on the first structure **3** and add a seed point to the second structure. **4**
- Object separator usually works best when the seed points are set in the orthogonal images.
- Click Separate Objects. **5**

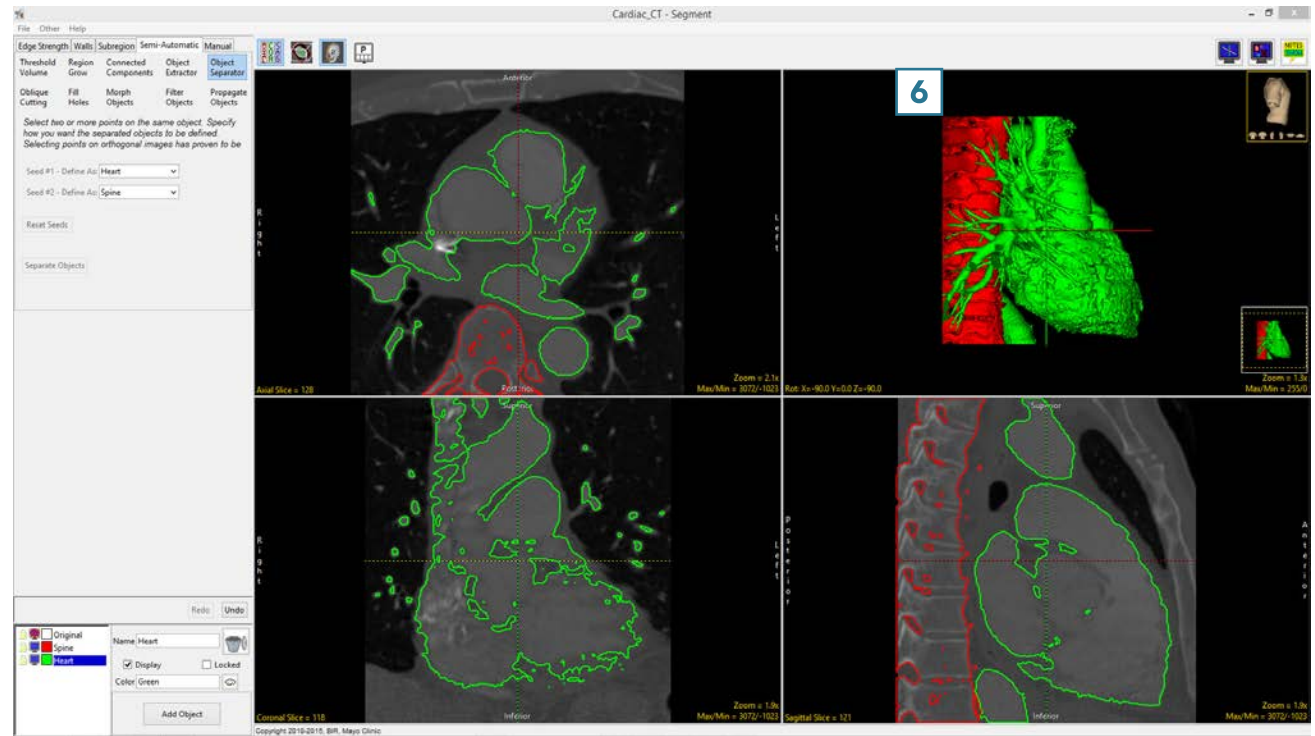


Download the CT\_Heart data set to follow along  
<http://analyzedirect.com/data/>





- The structures will be disconnected and assigned to different objects. **6**
- Save your work by selecting File > Save Object Map.





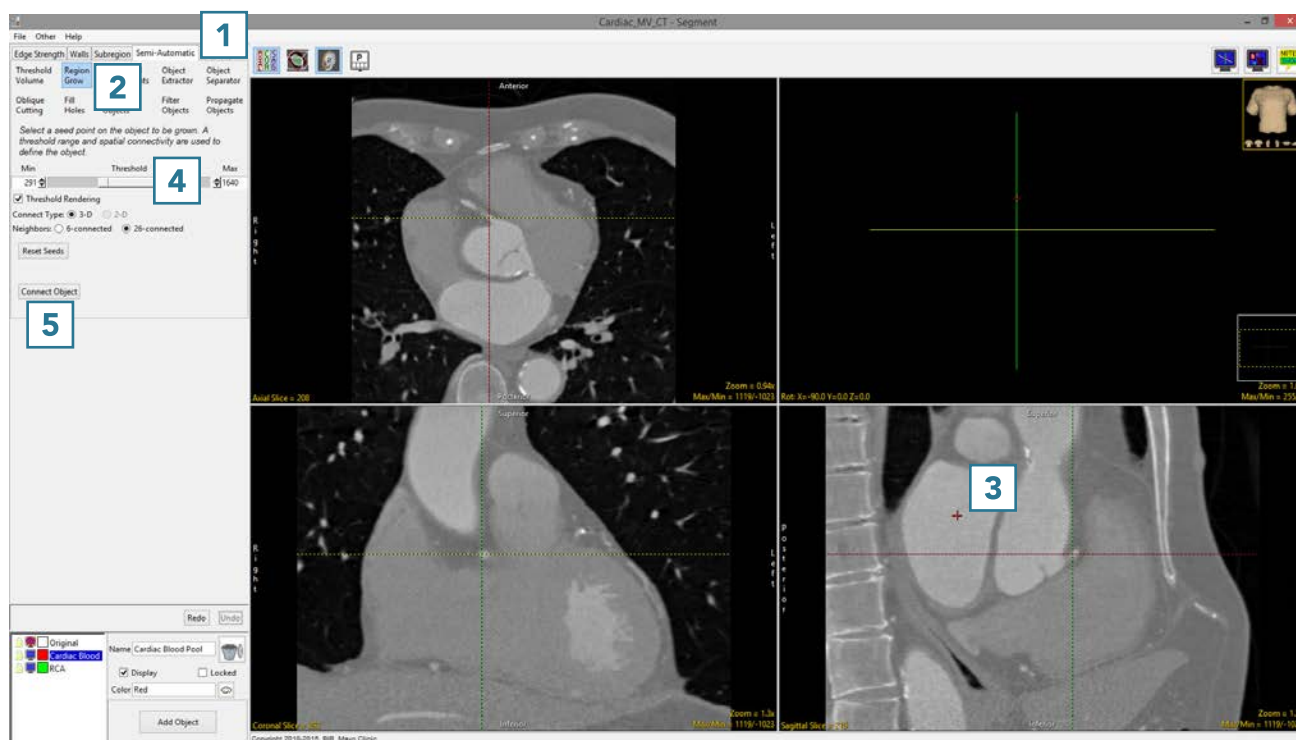


## 12. Editing Objects via Oblique Cutting

- Select a data set and open Segment.
- Select Semi-Automatic **1** and choose Region Grow. **2**
- Set a seed point in the middle of the left atrium. **3**
- Define a threshold range to describe the blood pool **4** and click Connect Object. **5**



Download the Cardiac\_CT data set to follow along <http://analyzedirect.com/data/>





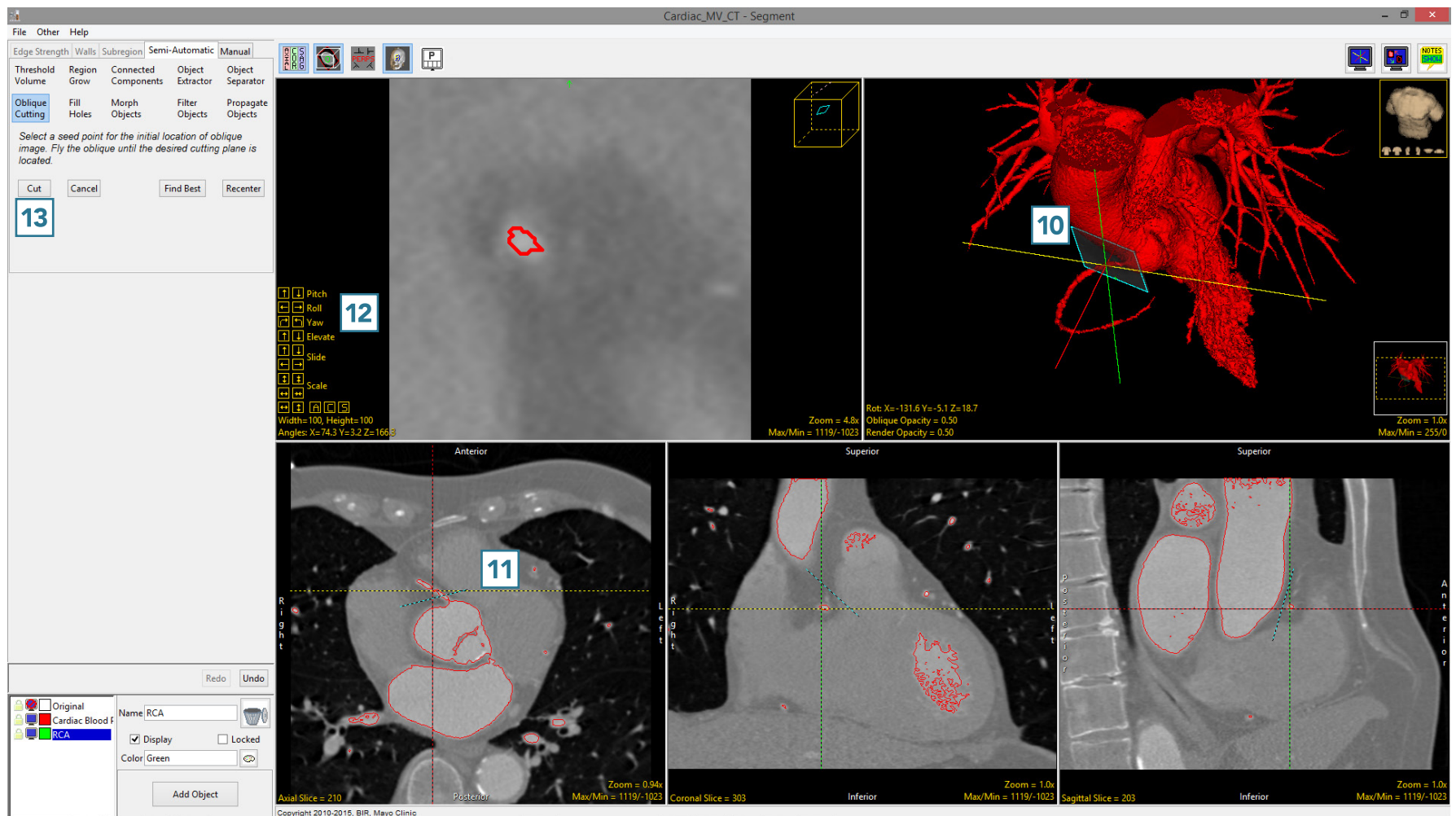


- Add a new object and name it RCA (right coronary artery). **6**
- Select Oblique Cutting. **7**
- Rotate the rendering of the heart so the RCA is visible. **8**
- Move your cursor to the base of the RCA and click to set a seed point on the RCA. **9**



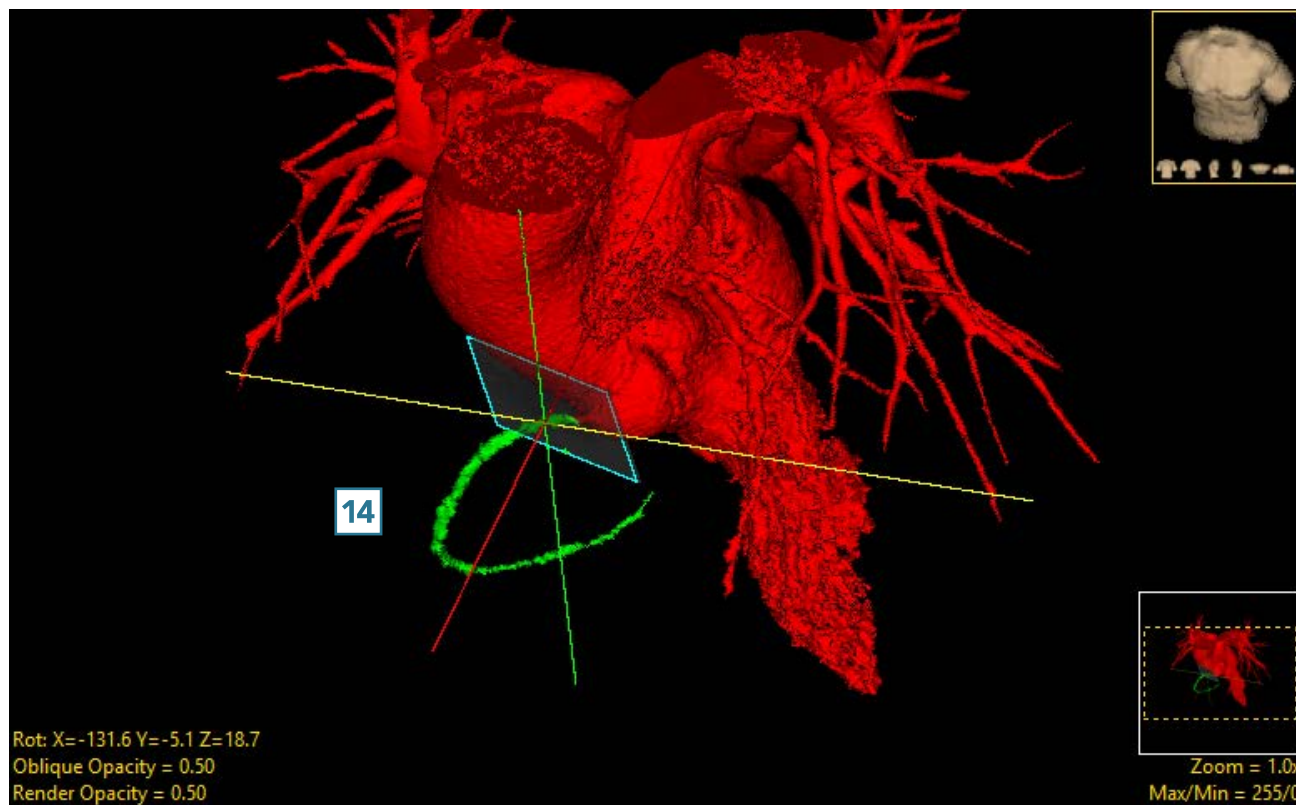


- The Segment interface will update while the Oblique Cutting algorithm finds the best plane to cut the RCA from the main heart object.
- If the computed cut plane is not ideal you can adjust the plane interactively on the rendering **10** or on any of the slice displays. **11**
- The navigation tools can also be used on the oblique image. **12**
- Select Cut **13** to cut the data.





- The RCA will be separated from the main object and assigned to the RCA object. **14**
- To return to the regular display, click on the Toggle Obliques button to switch off the display of the oblique image.
- Select File > Save Object Map to save your work.





## Fill Holes

The fill holes function performs a flood-fill operation on the selected object. The operation reassigns voxels belonging to other objects to the selected object. The fill operation stops when it reaches the boundary of the object.

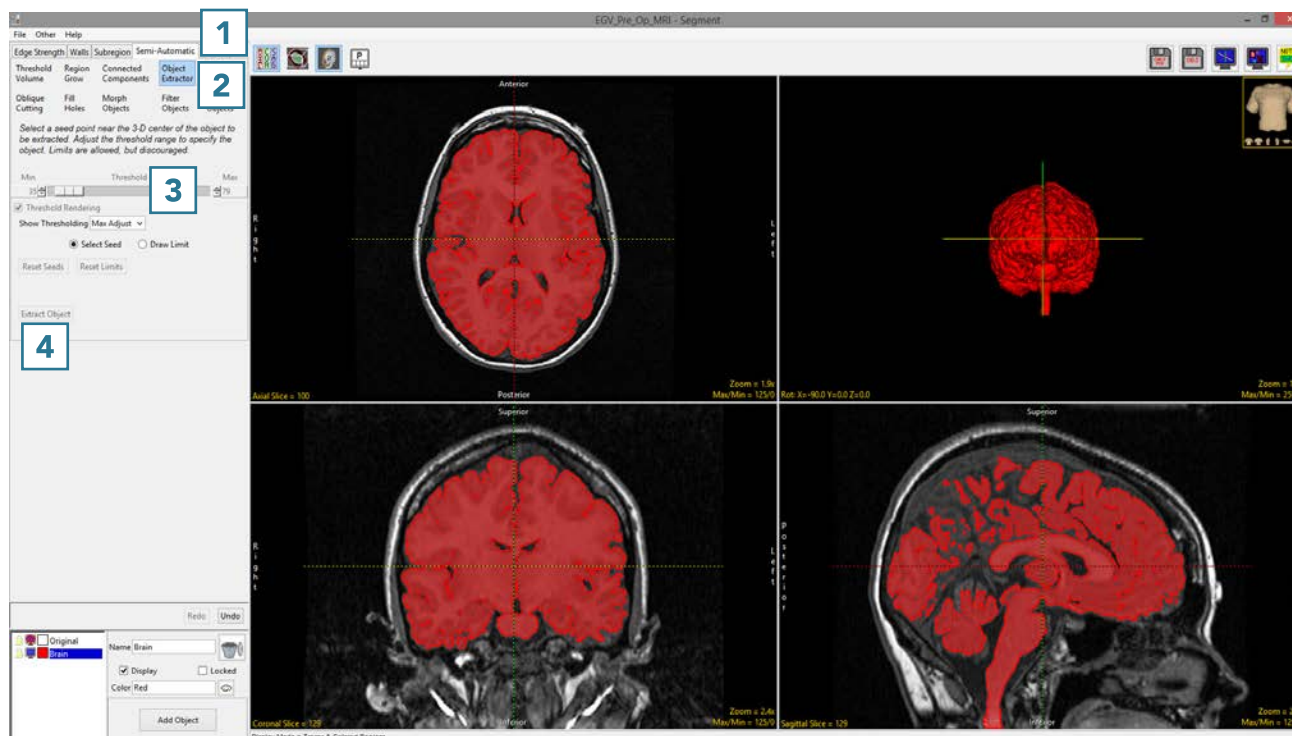
## 13. Filling Holes in Objects

After the initial segmentation, an object may contain holes, which are voxels belonging to the Original object. To obtain an accurate volume measurement and to ensure the object is whole, it may be necessary to apply a fill holes operation on the object.

- Select a data set and open Segment.
- Select Semi-Automatic **1** and choose Object Extractor. **2**
- Click on the image data to set a seed point.
- Adjust the minimum and maximum threshold values **3** to define the structure and select Extract Object. **4**



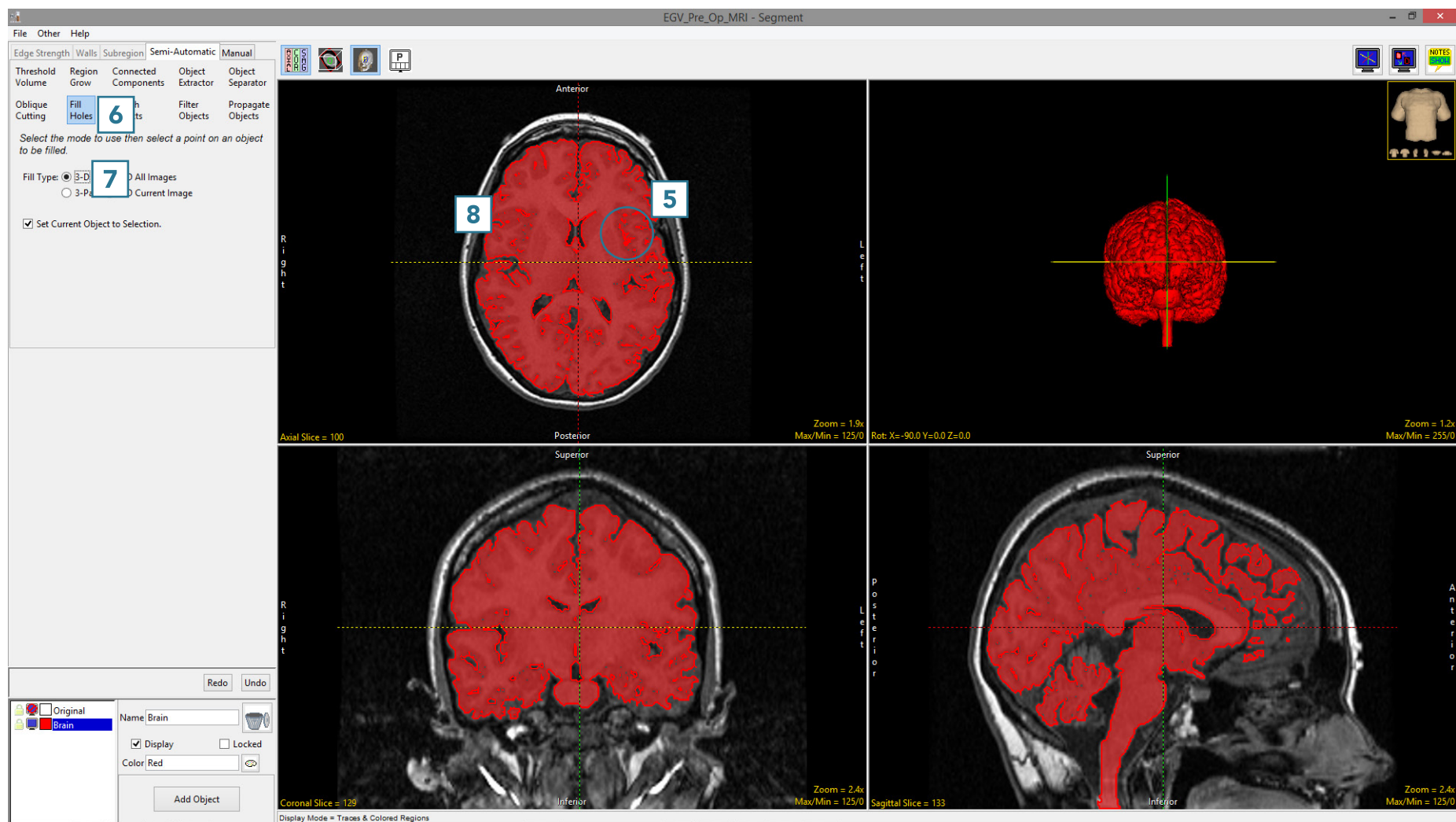
Download the EGV\_MRI data set to follow along  
<http://analyzedirect.com/data/>





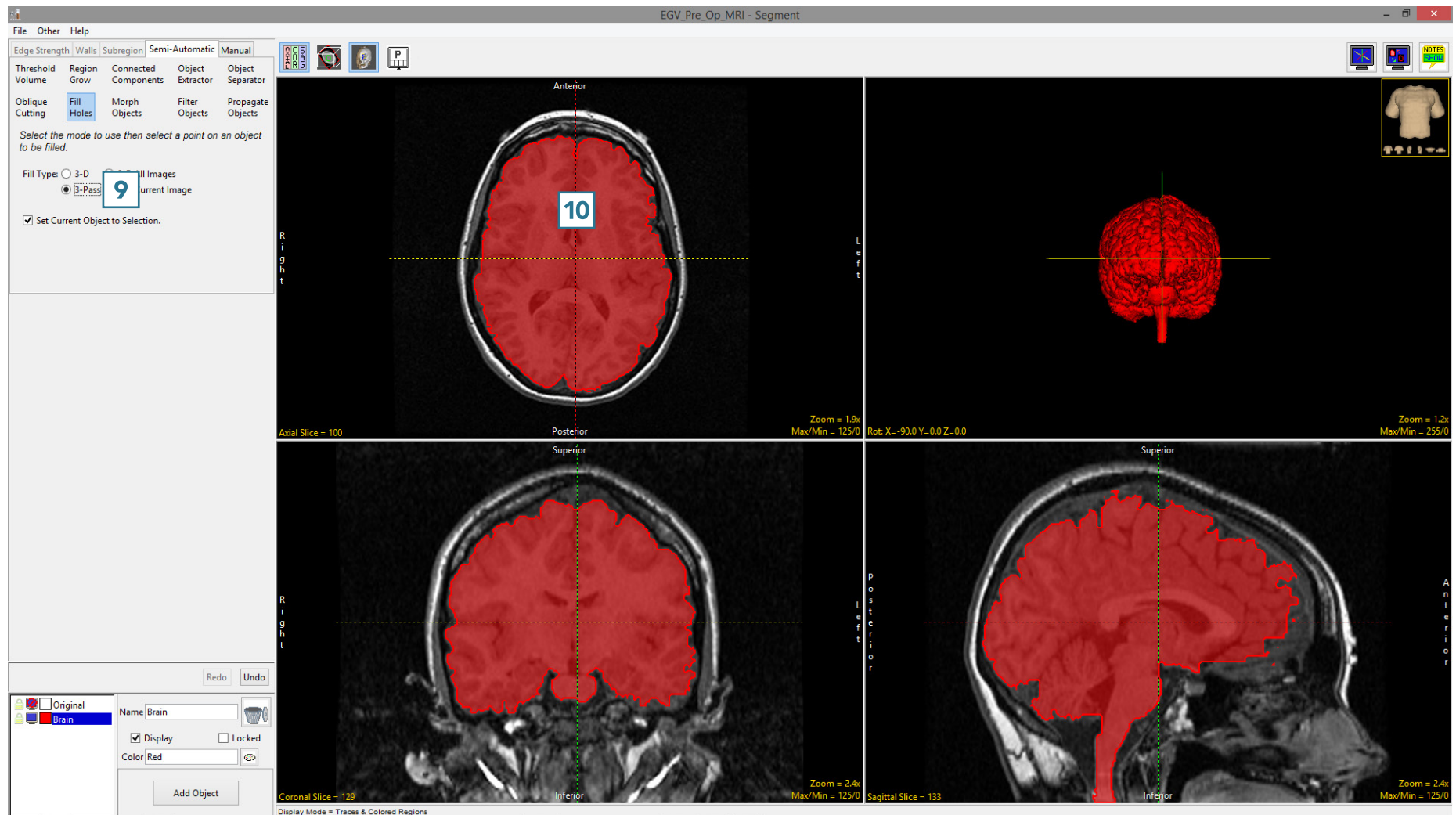


- To remove small holes in the object **5** which are a result of the segmentation parameters, select Fill Holes. **6**
- With the Fill Type set to 3D, **7** click on the object to fill smaller holes in the object. **8**





- To fill larger holes, such as the ventricular CSF, use the 3-Pass Fill Type **9** and click on the brain. **10** All larger holes will be filled and assigned to the object.
- Select File > Save Object Map to save your work.





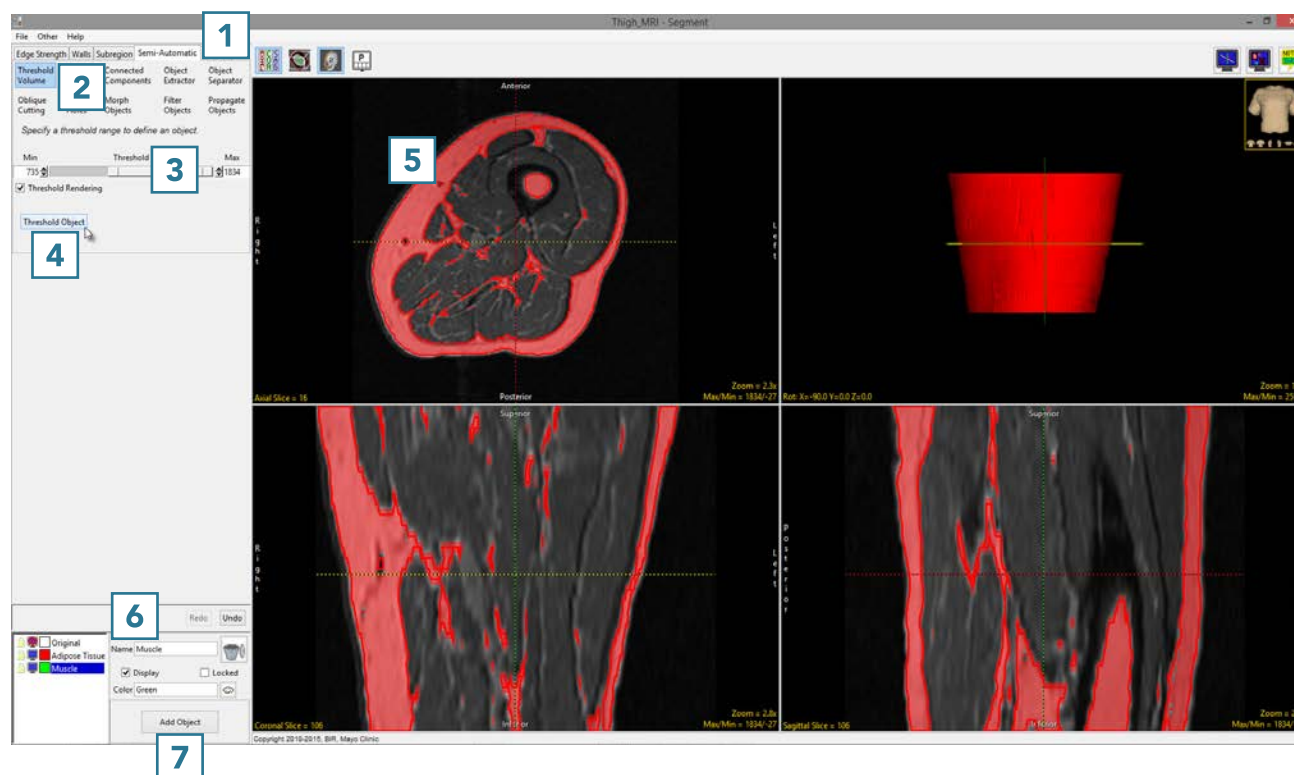
## 14. Using Fill Holes for Segmentation

The fill holes option can also be used as a strategy to segment multiple objects. In this example we isolate the adipose tissue via threshold-based segmentation from a water-suppressed MRI data set. We will then use fill holes to create the muscle object and the intramuscular adipose tissue object.

- Select the data set and open Segment.
- Select Semi-Automatic **1** and choose Threshold Volume. **2**
- Set a threshold range **3** to globally segment the adipose tissue and click Threshold Object. **4**
- The adipose tissue will be segmented. **5**
- Rename the object, **6** add a new object **7** and name the object Muscle.

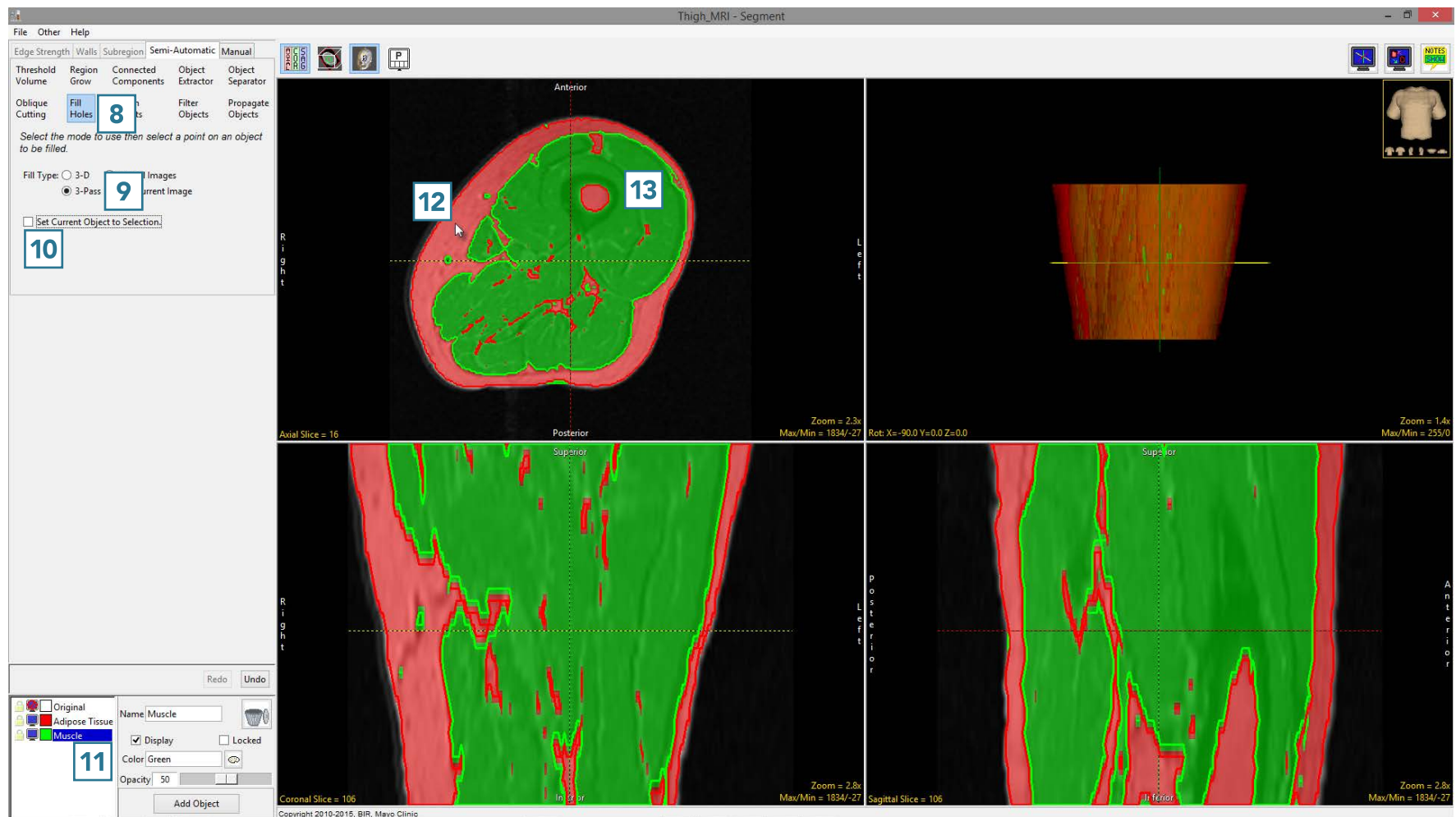


Download the Thigh\_MRI data set to follow along <http://analyzedirect.com/data/>



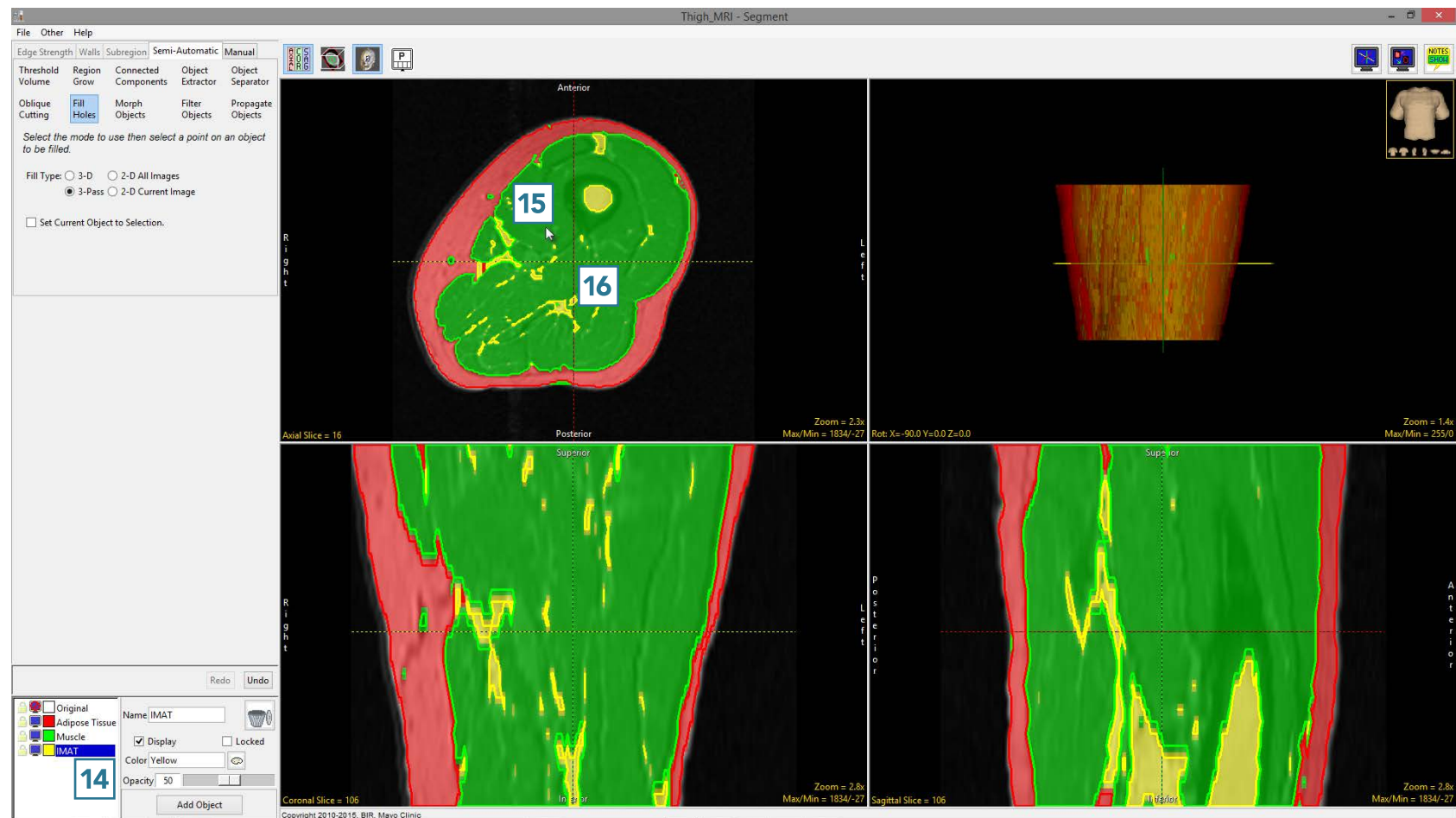


- Select Fill Holes **8** and set the Fill Type to 3-Pass. **9**
- Uncheck the Set Current Object to Selection **10** checkbox.
- Ensure that the Muscle object is selected **11** and click on the Adipose Tissue object. **12** The voxels inside the Adipose Tissue object currently assigned to the Original object will be reassigned to the Muscle object. **13**





- To assign the voxels labeled as Adipose Tissue within the Muscle object to Intramuscular Adipose Tissue (IMAT).
- Add a new object **14** and name it IMAT.
- Click on the Muscle object to fill it. **15** The voxels inside the Muscle object currently assigned to the Adipose Tissue object will be filled and assigned to the IMAT object. **16**
- Select File > Save Object Map to save your work.





## Morph Objects

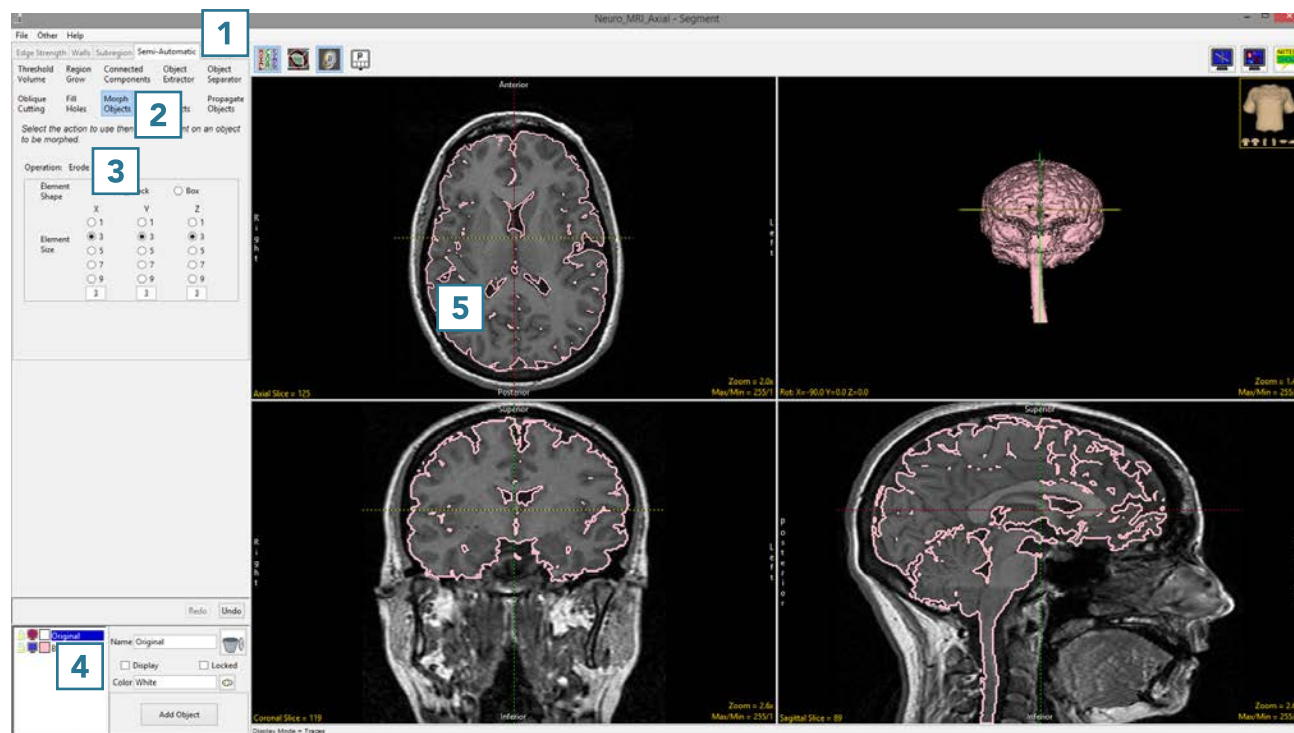
The Morph Objects option allows users to apply rudimentary morphological operations to objects. The operations available are dilate, erode, open and close. Additional morphological operations are accessible from the [Morphology](#) tool in Process.

## 15. Using Morphological Operations to Improve Segmentation

- Select a data set and open Segment.
- Select Semi-Automatic **1** and choose Object Extractor.
- Click on the image data to set a seed point.
- Adjust the minimum and maximum threshold values to define the structure and select Extract Object.
- Once the object is segmented, rename and update the color.
- Choose Morph Object **2** and set Operation to Erode. **3**
- Leave the element size set to 3 X 3 X 3.
- Set the target object to Original. **4** This will specify that any eroded voxels will be reassigned to the Original object.
- Now click on the brain **5** to initiate the erosion.



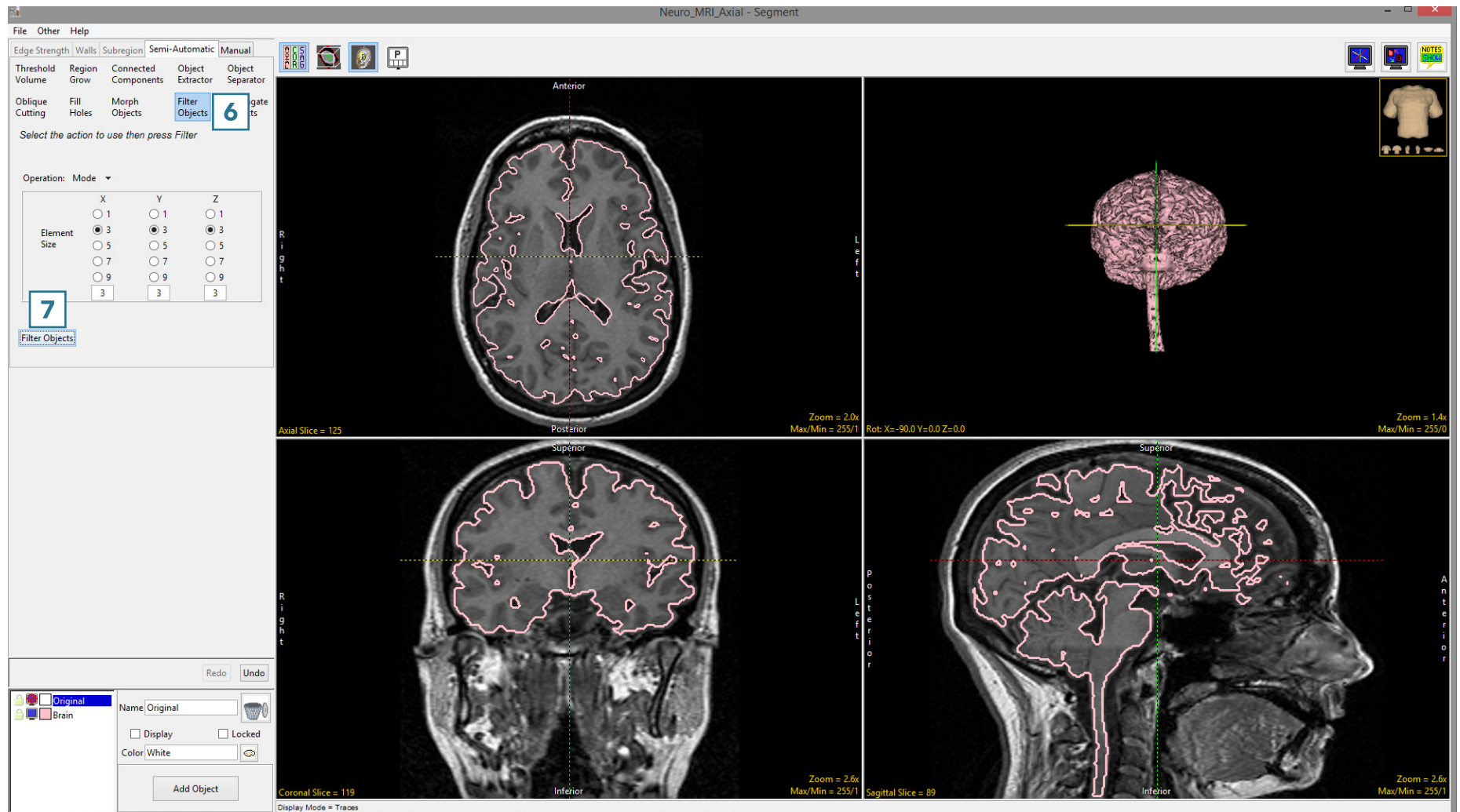
Download the MRI\_3D\_Head data set to follow along  
<http://analyzedirect.com/data/>





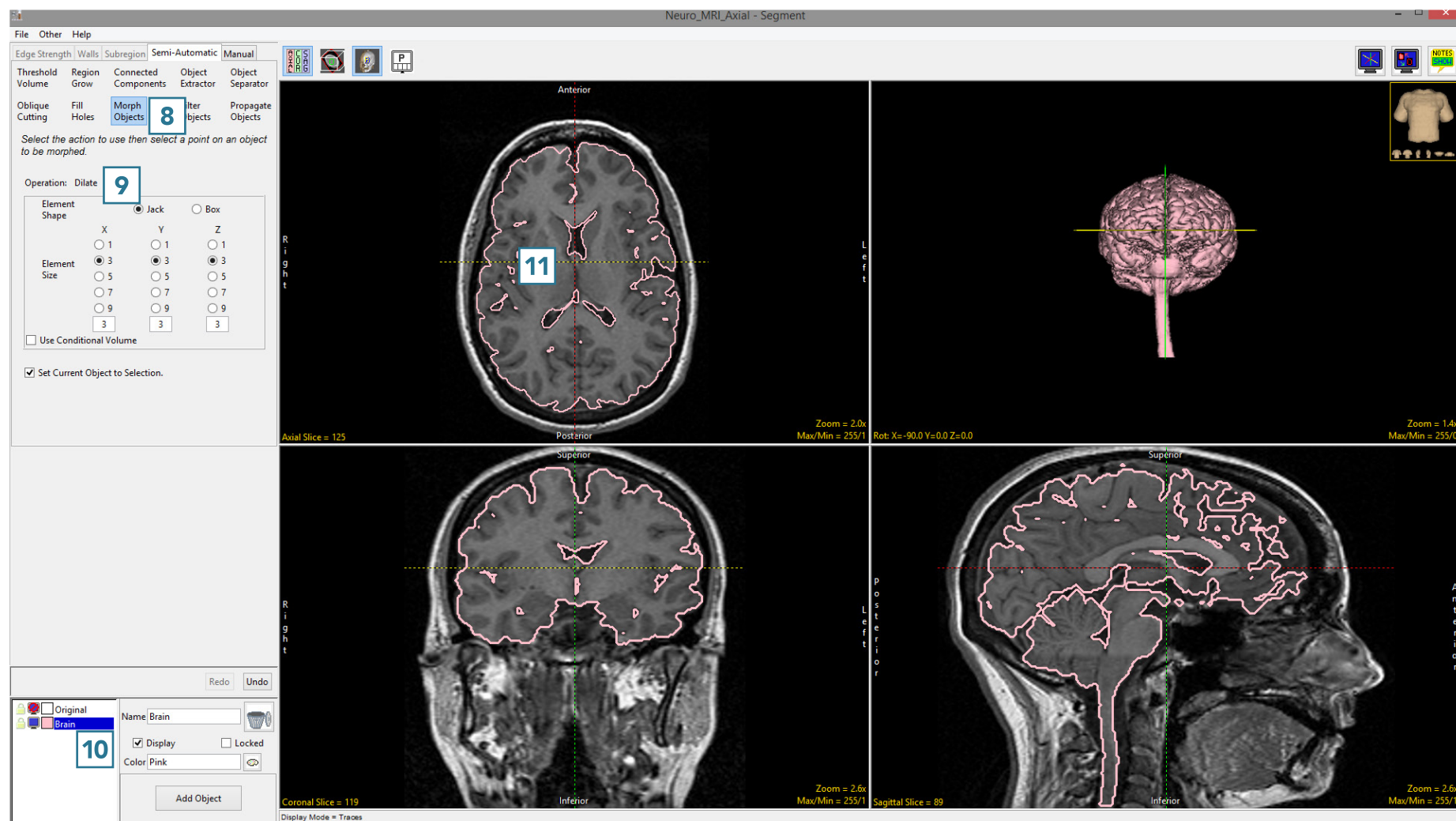


- Select Filter Objects **6** and apply a 3 X 3 X 3 Mode filter to the brain by clicking Filter Objects. **7**





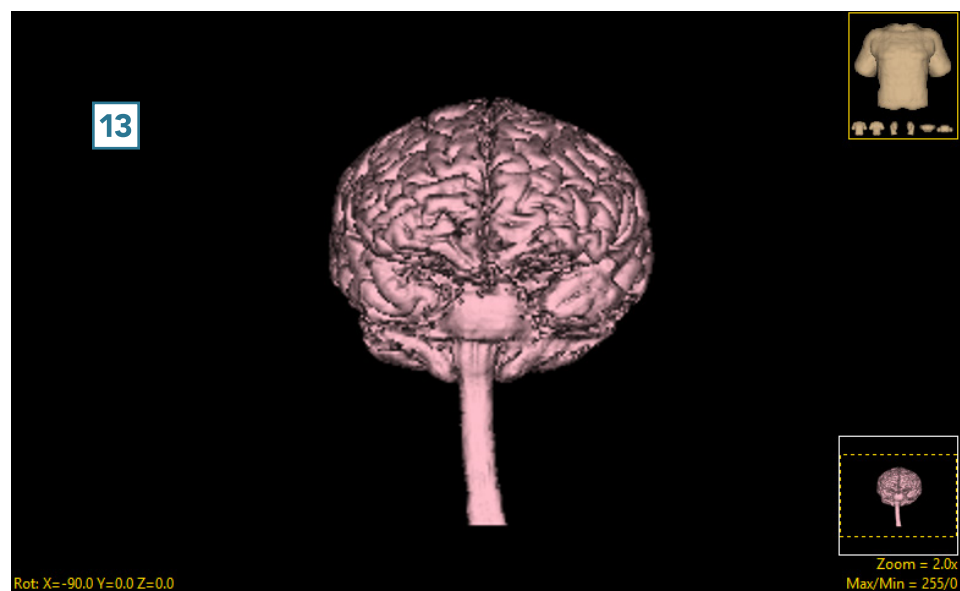
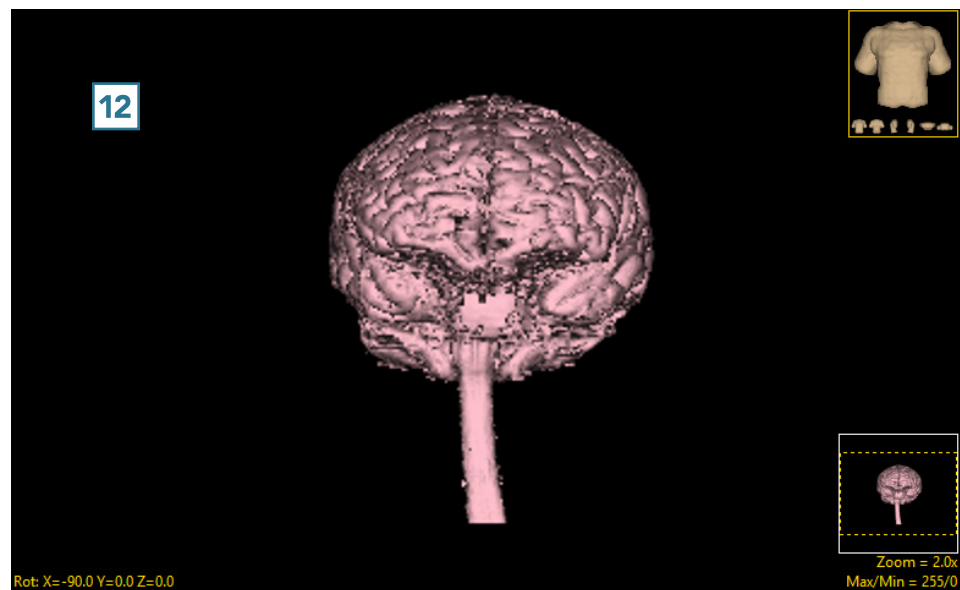
- Select Morph Objects **8** and set the Operation to Dilate. **9**
- Select the Brain object **10** and click on the brain. **11**







Note the difference between the pre **12** and post **13** processed brain objects.





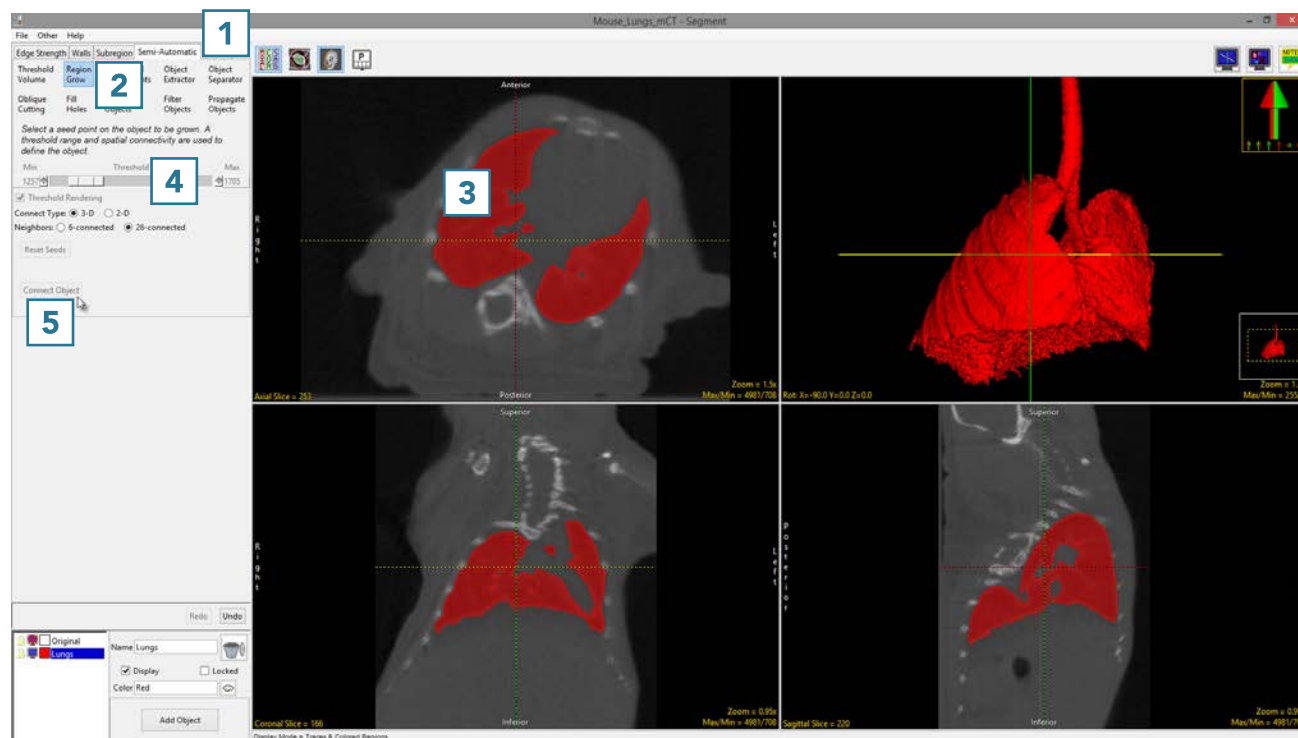
## Filter Objects

Filtering objects can reduce noise, fill small holes, and smooth edges. The filter is only applied to segmented objects and does not change the original data.

- Select the data set and open Segment.
- Select Semi-Automatic **1** and choose Region Grow. **2**
- Set a seed point on the object you want to isolate **3** and set a threshold range **4** that describes the object.
- Click Connect Object. **5**

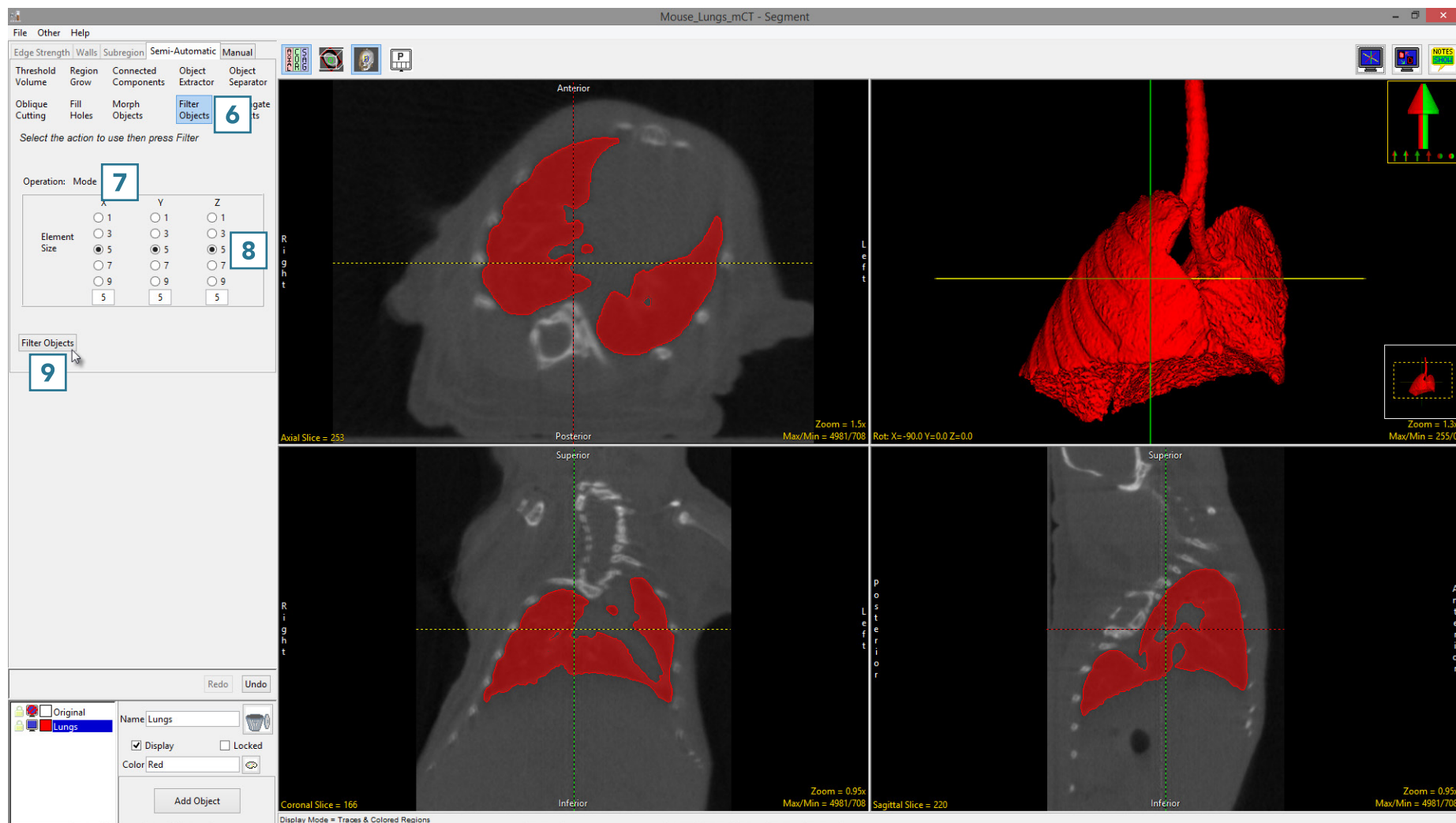


Download the Mouse\_Lungs data set to follow along  
<http://analyzedirect.com/data/>

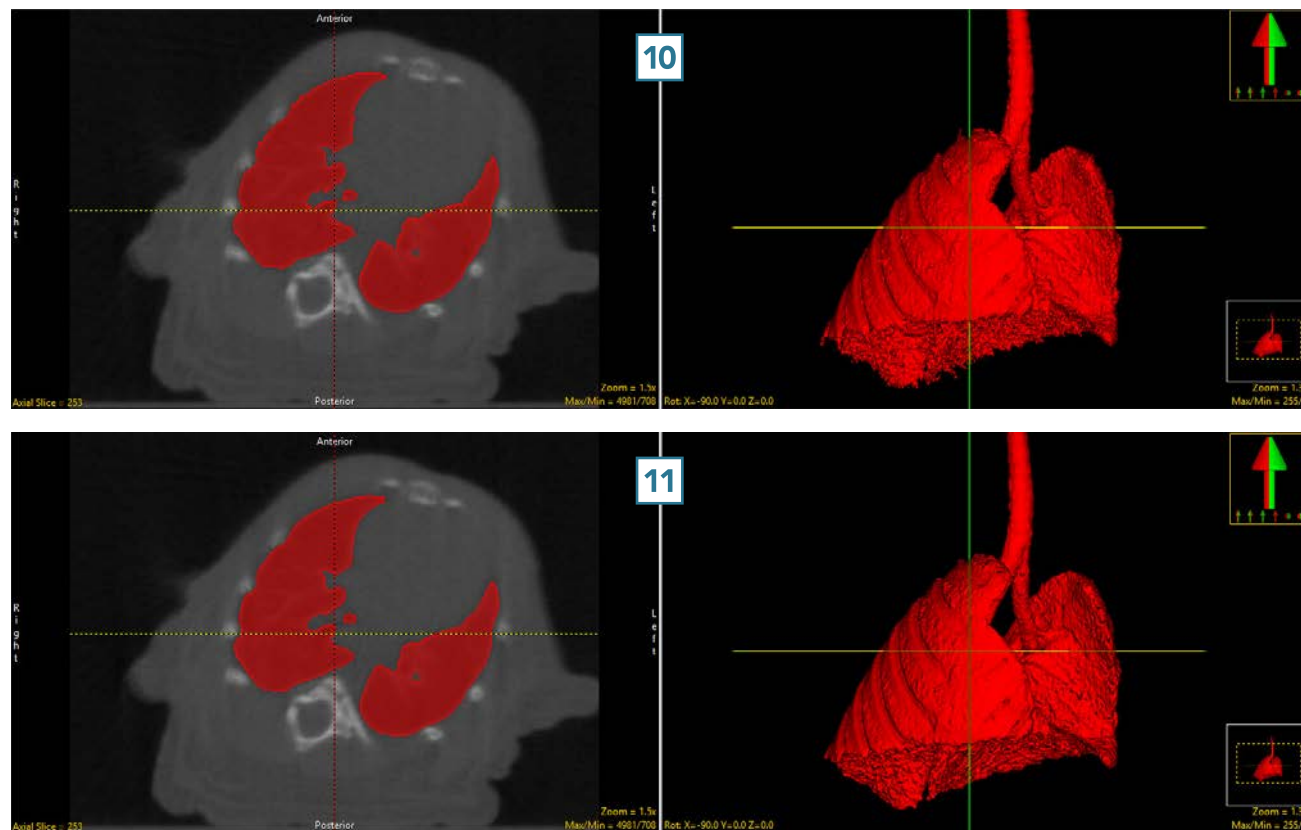




- Select Filter Objects. **6**
- Set the Operation to Mode. **7**
- Set the Element Size to 5 X 5 X 5 **8** and select Filter Objects. **9**



Note the difference in the 2D and 3D regions between the unfiltered **10** and filtered **11** segmentation results. Filtering has filled small holes, removed noise around the surface of the lung parenchyma and smoothed the contours of the segmentation.





## Propagate Objects

The Propagate Objects tool uses shape-based interpolation to extend the definition of a region to slices of the volume on which it was not defined. For example, if the user defined a region on every fifth slice, this tool could be used to fill in the region on the skipped slices. The user must specify the direction in which objects are propagated by choosing the orthogonal orientation in which they were defined. A smoothing option is available which filters the objects to produce a smoother segmentation result.

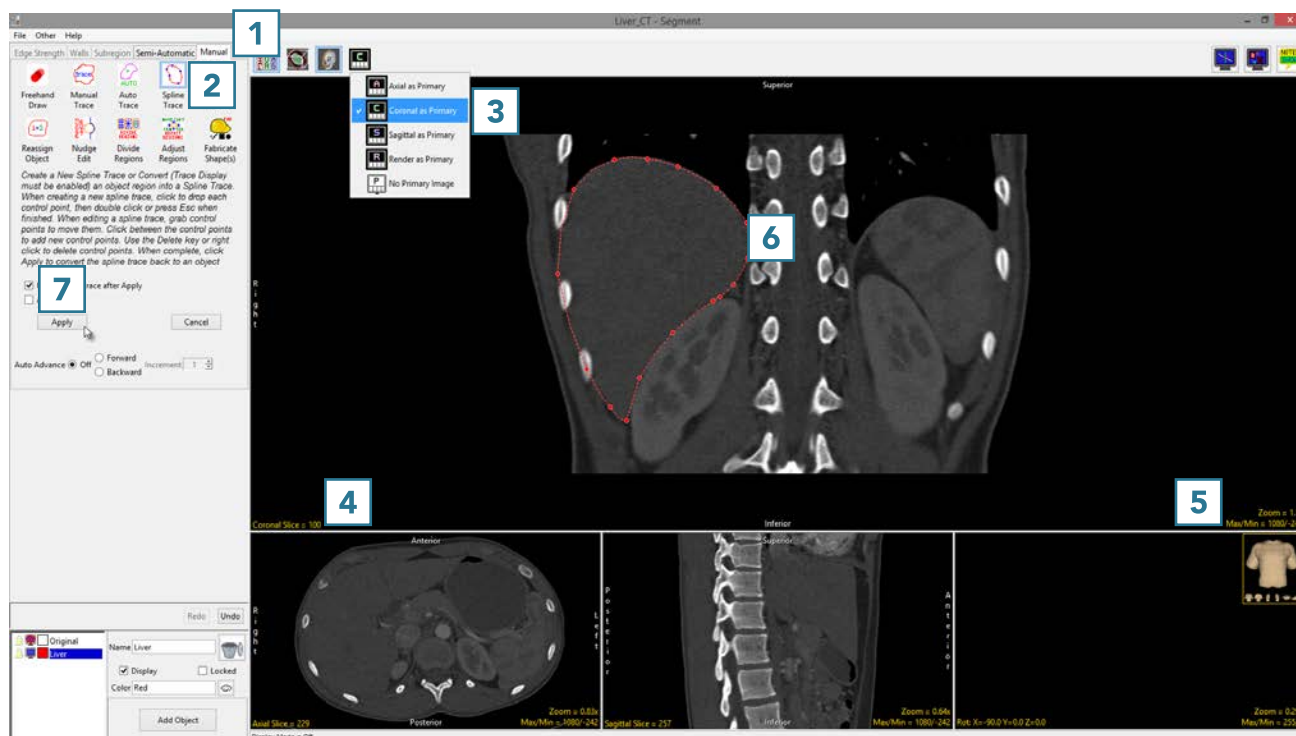


## 16. Propagate Objects

- Select a data set and open Segment.
- Select Manual **1** and choose Spline. **2**
- Set the primary display to Coronal **3** and double-click on Slice **4** to move to coronal slice 100.
- Adjust the display intensity, **5** if desired.
- Trace a spline around the liver **6** and select Apply. **7**



Download the CT\_Liver data set to follow along <http://analyzedirect.com/data/>





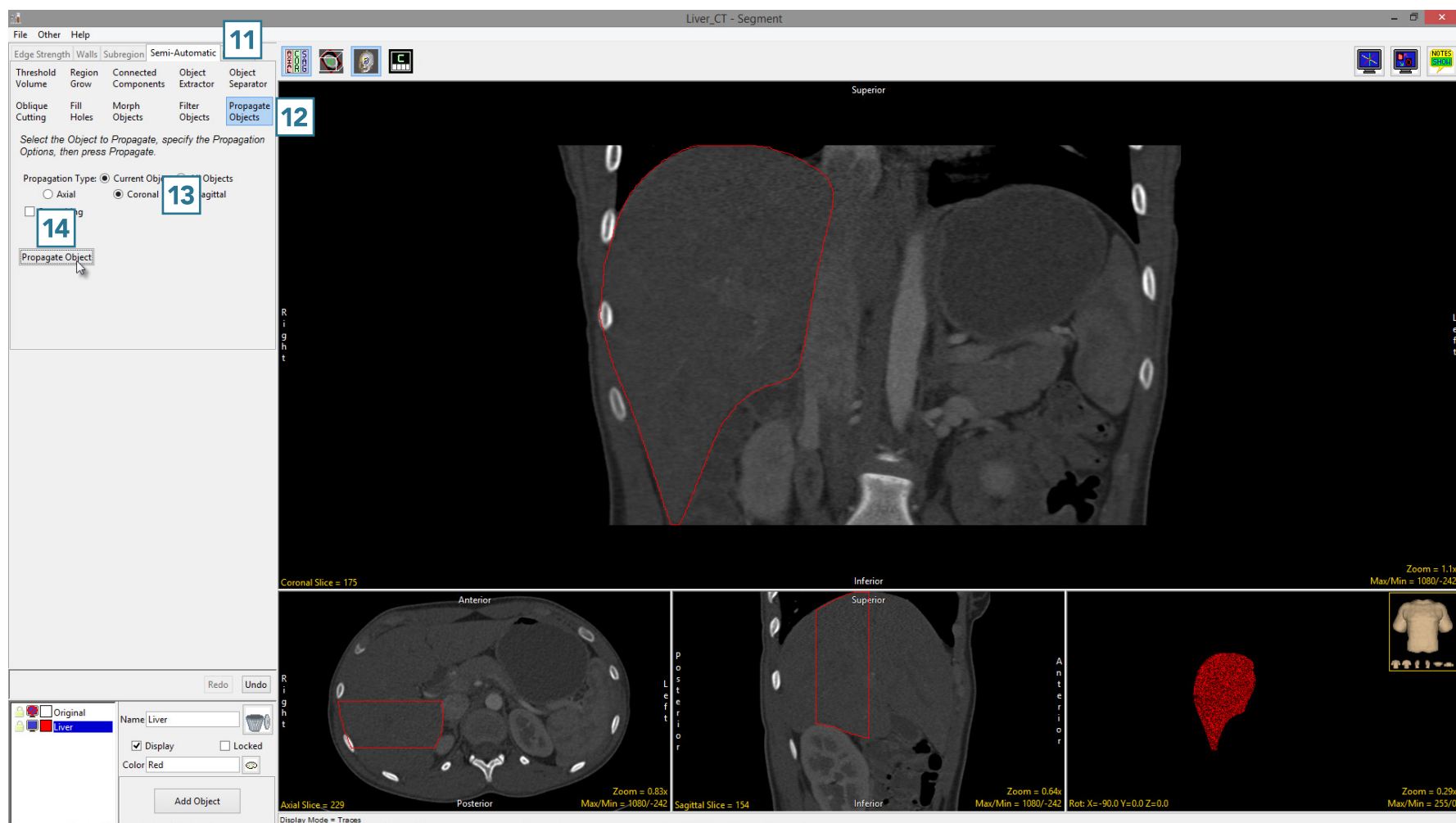
- Move to coronal slice 125 and trace the liver. **8**
- Repeat on coronal slices 150 **9** and 175. **10**







- Select Semi-Automatic **11** and Propagate Objects. **12**
- Set the propagation orientation to Coronal **13** and click Propagate Object. **14**
- After the object propagation process is complete, the liver object will be defined from slice 100 to slice 175. The object can be reviewed in each orientation and the 3D rendering.





# Manual Tools

The Manual tab provides users with access to interactive segmentation tools for manual 2D slice-based segmentation. These tools allow users to define regions with precision while reducing the time required to perform manual segmentation.



## Freehand Draw

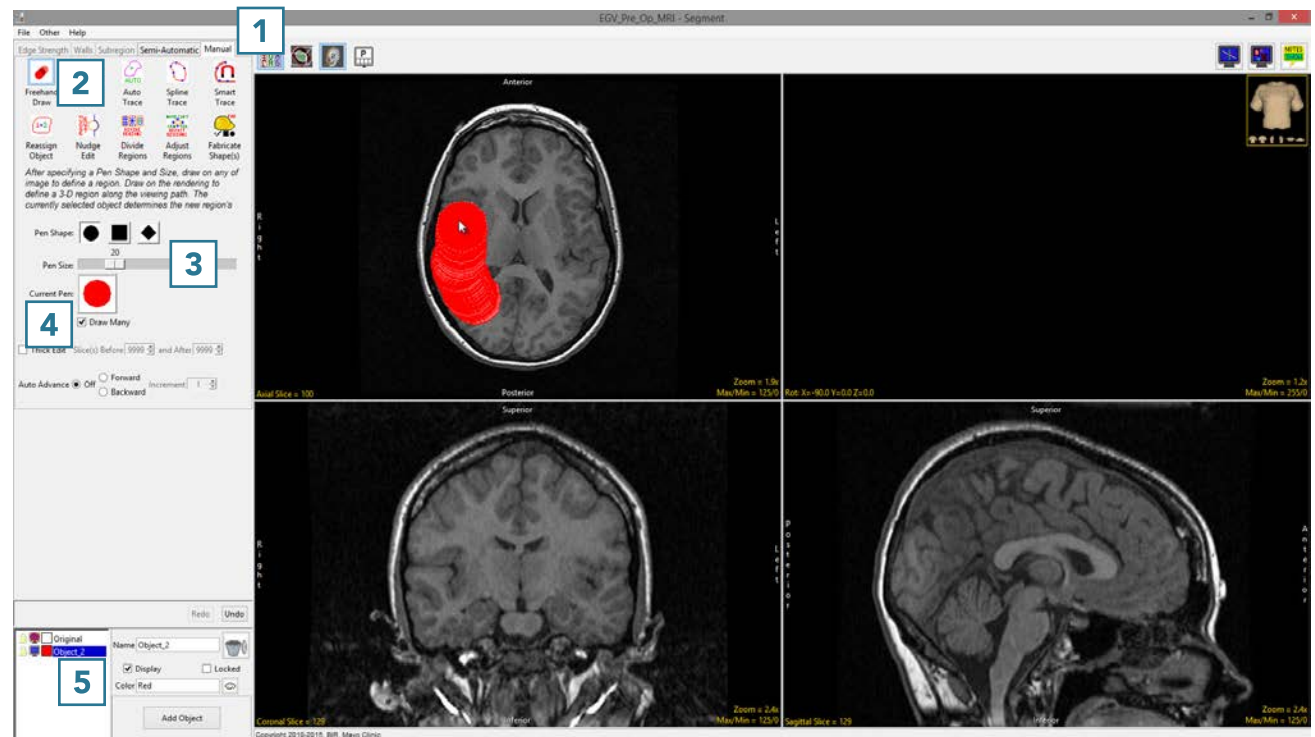
The Freehand Draw tool lets the user draw regions of interest directly onto the image data. Three different Pen Shape options (circle, square, diamond) and a customizable Pen Size (from 1 to 100 pixels) are available.

## 17. Using Freehand Draw to Define a 2D Region

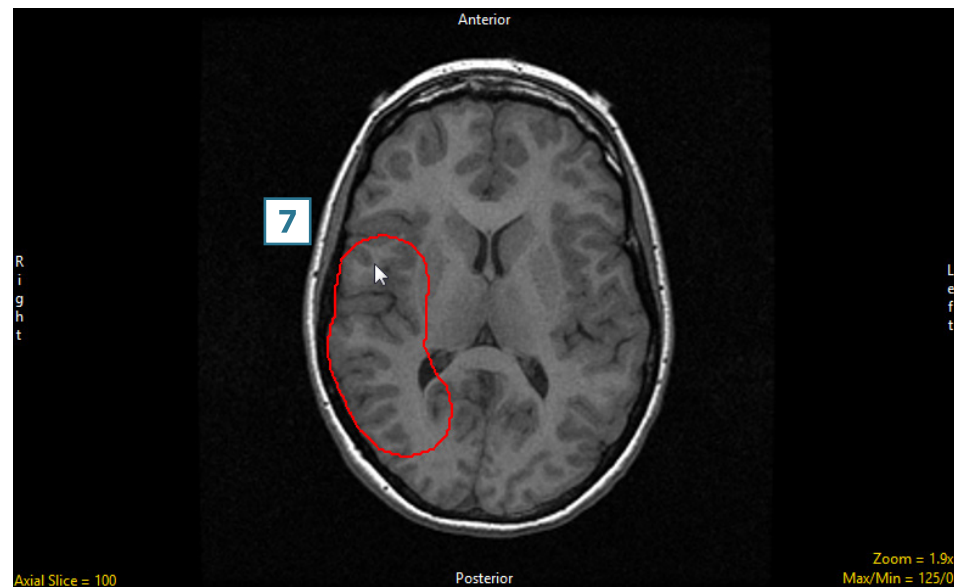
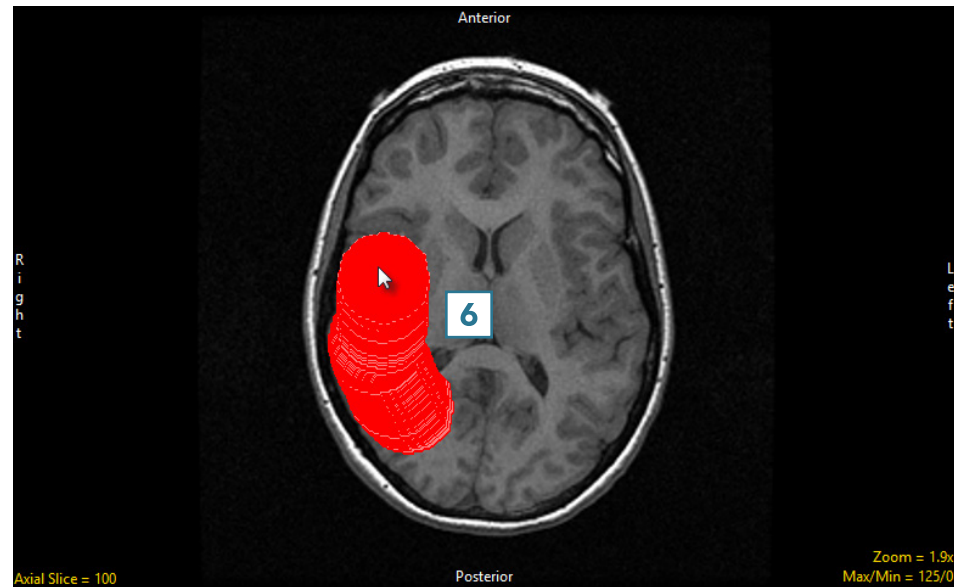
- Select a data set and open Segment.
- Select Manual **1** and choose Freehand Draw. **2**
- Use the Pen Size slider to change the Pen Size to 20. **3**
- The Current Pen **4** will update to the color of the currently selected object. **5**



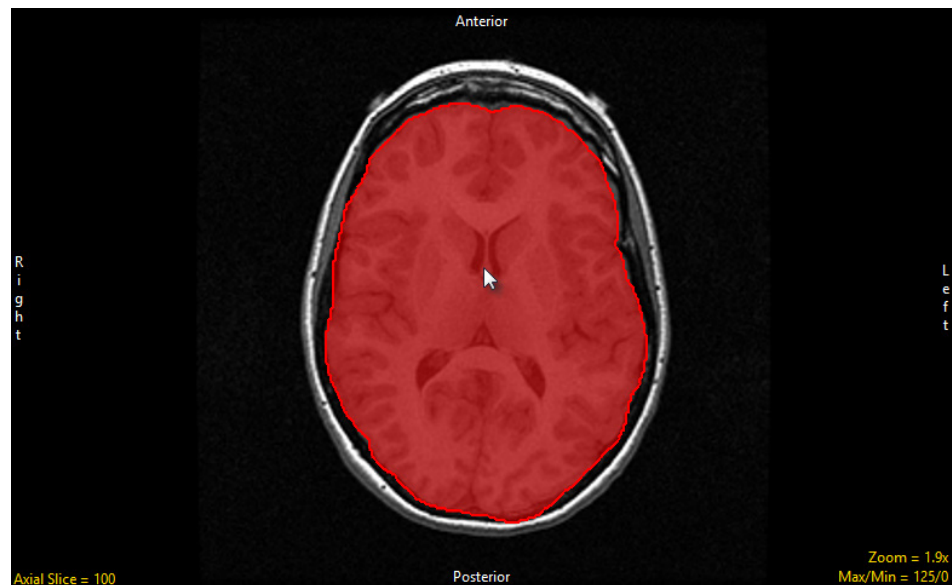
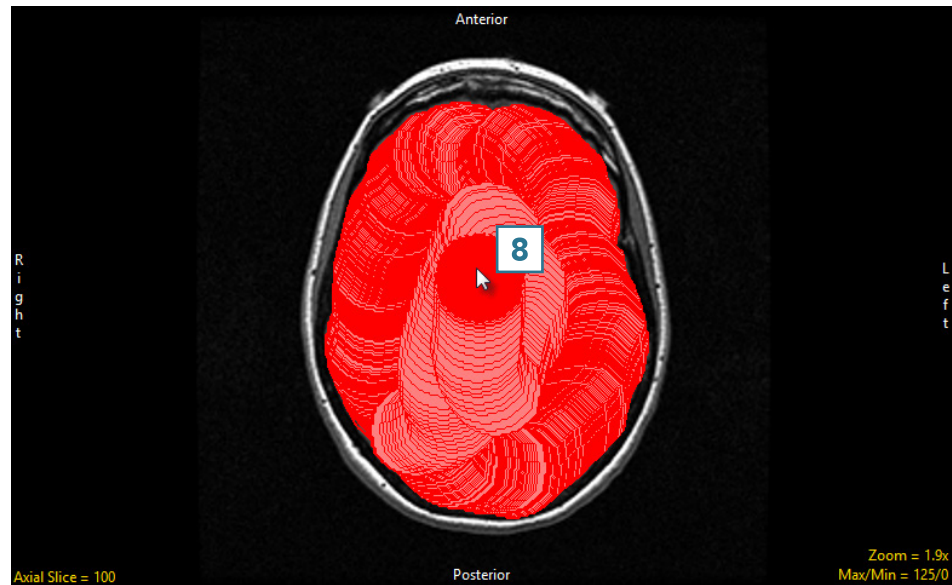
Download the EGV\_MRI data set to follow along  
<http://analyzedirect.com/data/>



- Left-click on the image and drag the cursor to trace a region. **6**
- Releasing the left mouse button will end the trace. **7**



Continue to define the brain using the pen tool. **8**





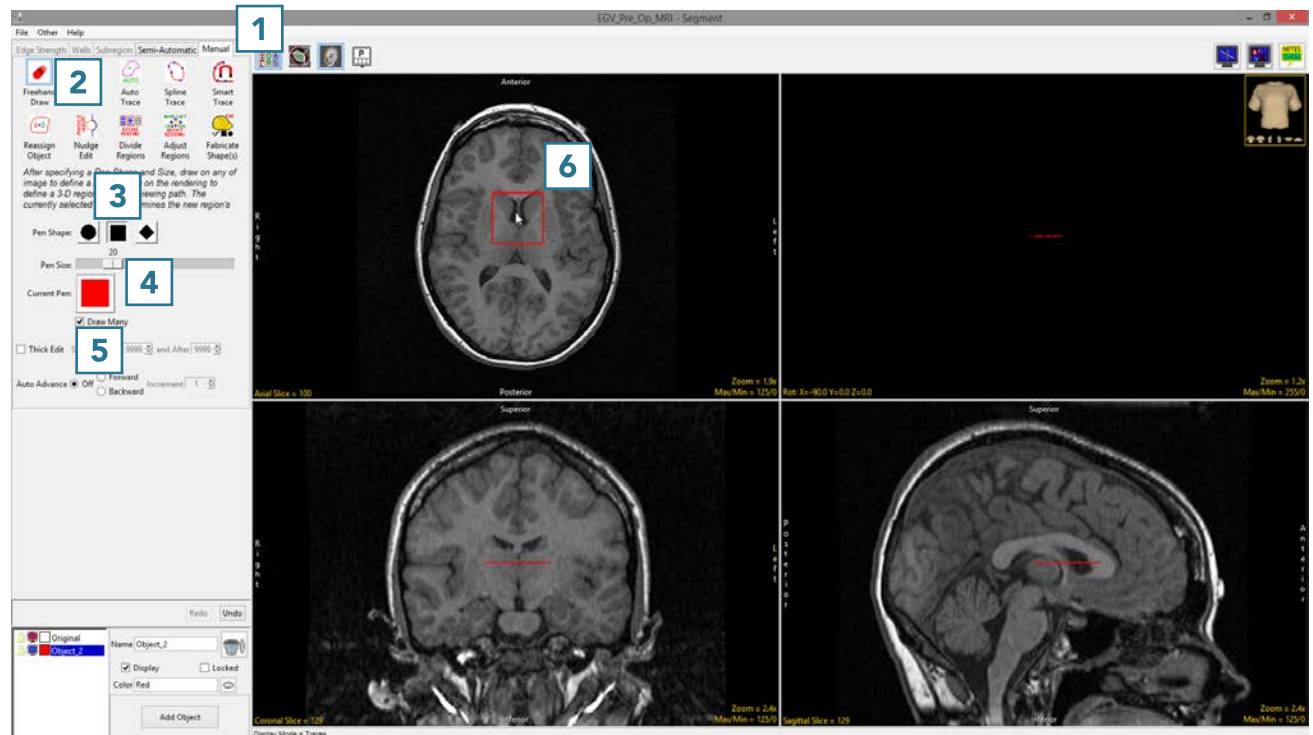
## 18. Using Freehand Draw to Define a Single Shape on a 2D Slice

The Freehand Draw tool allows users to define a single circle, square, or diamond.



Download the EGV\_MRI data set to follow along  
<http://analyzedirect.com/data/>

- Select a data set and open Segment.
- Select Manual **1** and choose Freehand Draw. **2**
- Set the Pen Shape to Square **3** and change the Pen Size to 25. **4**
- Uncheck the Draw Many option. **5**
- Click on the image to define a square. **6**
- Additional squares can be defined by clicking on the slice again.



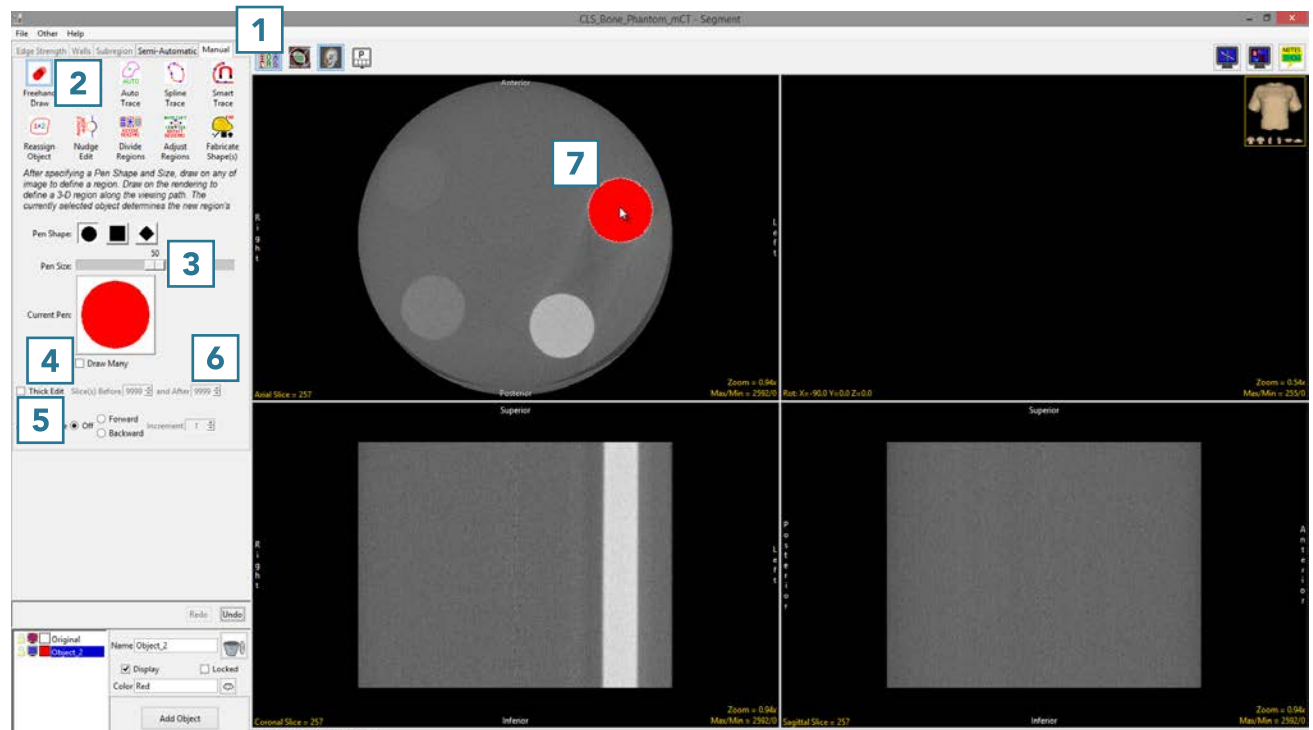
## 19. Using Freehand Draw to Define a Single Shape in 3D

The Freehand Draw tool allows users to define a single shape (circle, square, or diamond) over many slices. This can be helpful when defining regions that are constant through the 3D volume.

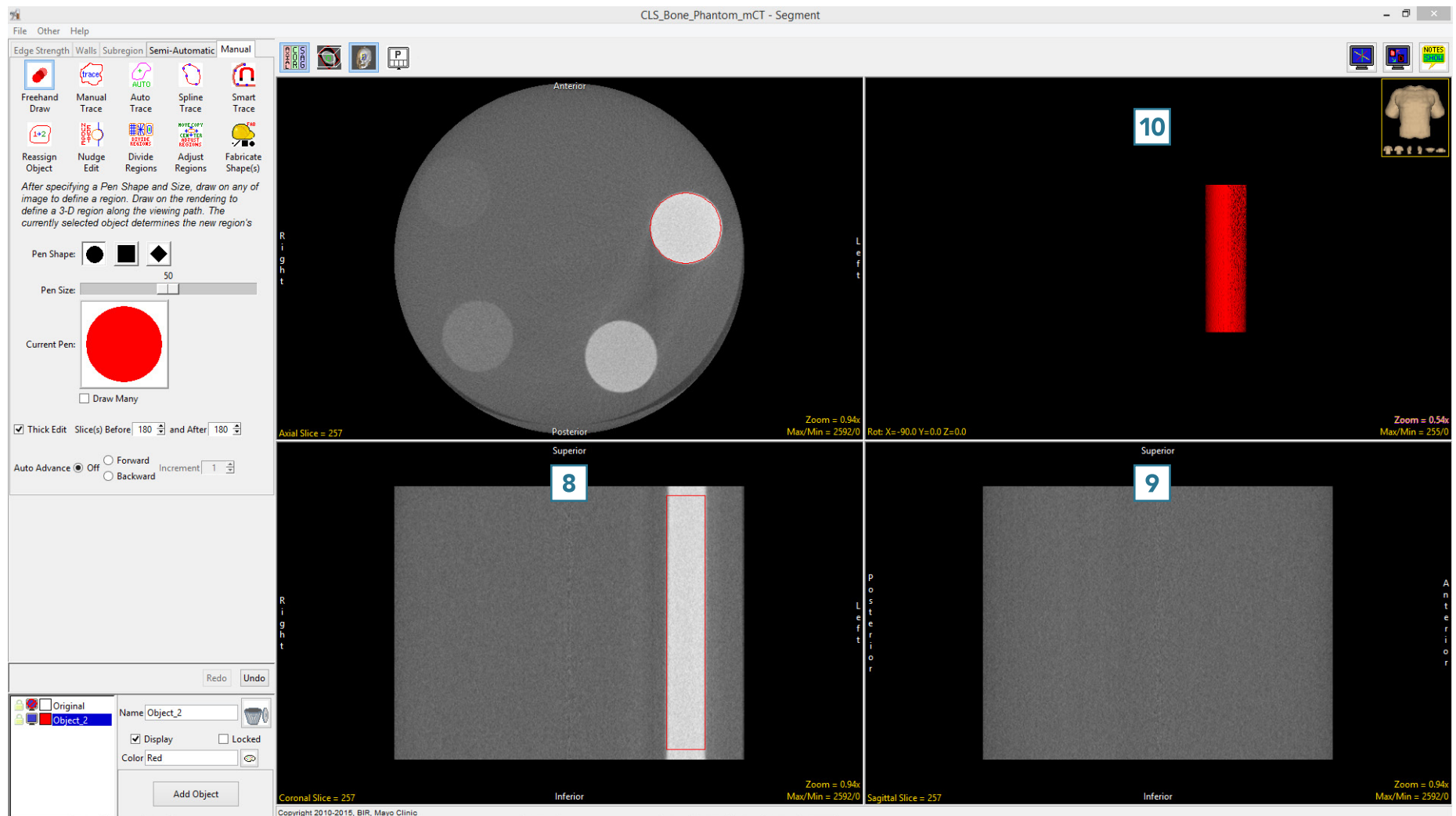
- Select a data set and open Segment.
- Select Manual **1** and choose Freehand Draw. **2**
- Change the Pen Size to 50 **3** and uncheck the Draw Many option. **4**
- Check the Thick Edit option. **5**
- To define the phantom insert on multiple slices, use the Slice(s) Before and After options **6** to specify the extent of propagation of the 2D region through the data set. In this example, set both parameters to 180.
- Click on an insert **7** to define a region, and note that you can move the 2D region around. The region will not be defined until the left mouse button is released.



Download the CLS\_Bone\_Phantom data set to follow along  
<http://analyzedirect.com/data/>



Once the left mouse button is released the regions will be applied to the specified slices. Note the update in the coronal **8** and Sagittal **9** orientations and the 3D rendering. **10**





## Painting Regions of Interest

The Freehand Draw tool is particularly useful for manually defining or filling regions between locked objects, specifically when the region of interest is not easily segmentable but the surrounding tissue is.

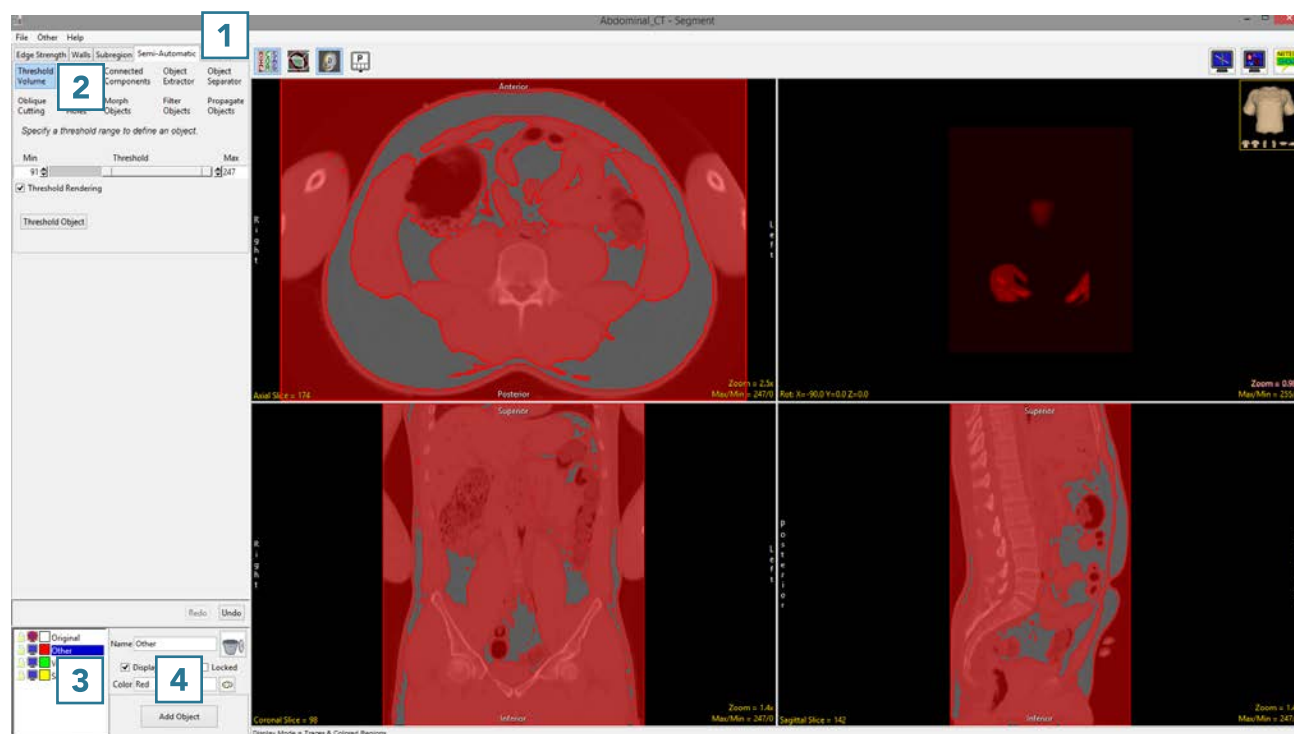
## 20. Using Freehand Draw to Paint Regions of Interest

- Select a data set and open Segment.
- Select Semi-Automatic **1** and choose Threshold Volume. **2**
- Change the name of the current object to Other, then add two new objects: VAT (visceral adipose tissue) and SAT (subcutaneous adipose tissue). **3**
- Select the Other object and use global thresholding to assign voxels having intensity values of 0 to 81 and 91 to 247 to the Other object. This will assign all of the non-adipose tissue voxels to the Other object.
- Lock the Other object. **4**

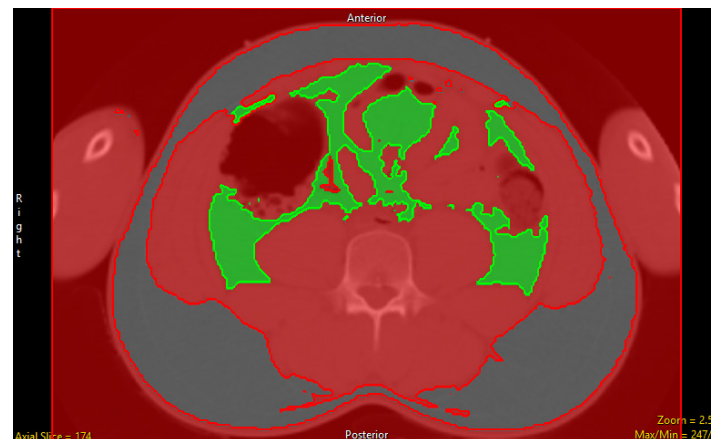
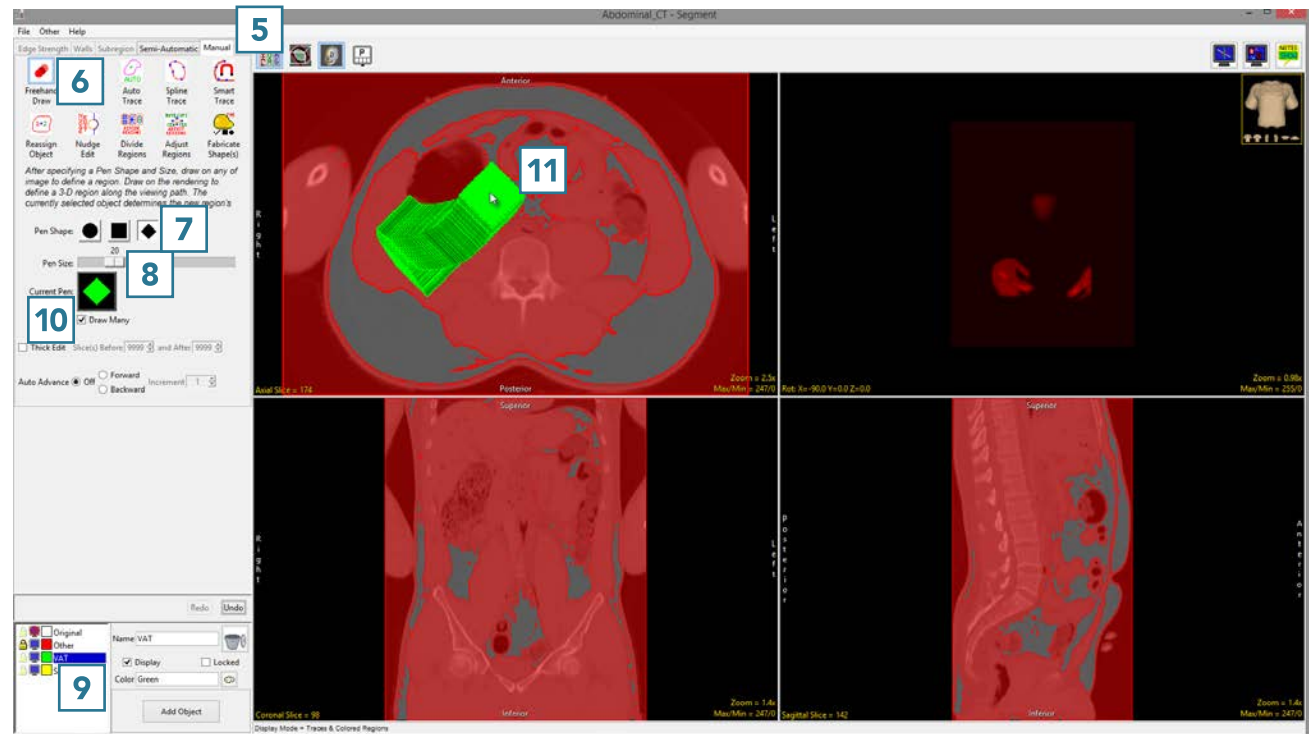
For more information on threshold-based segmentation, refer to [Threshold Volume](#).



Download the VH\_Abdomen data set to follow along <http://analyzedirect.com/data/>

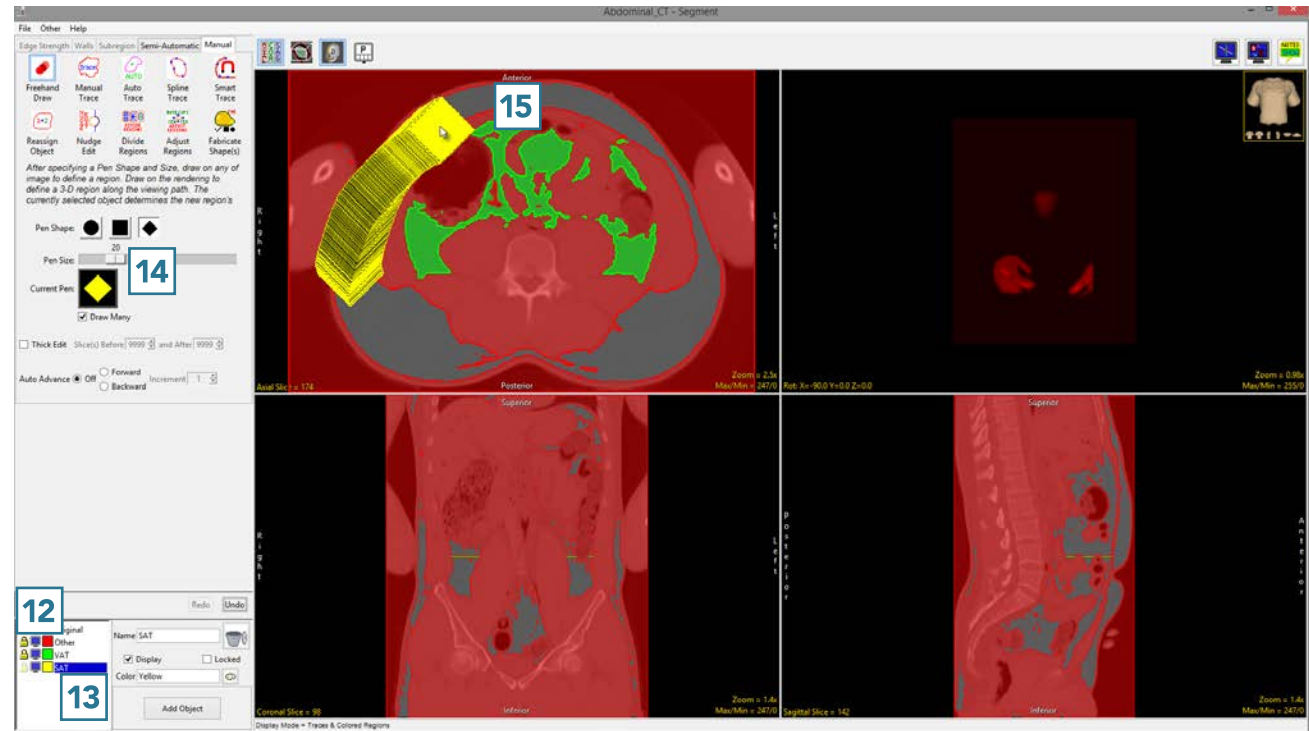


- Select Manual **5** and choose Freehand Draw. **6**
- Set the Pen Shape to Diamond **7** and change the Pen Size to 20. **8**
- Select the VAT object **9** and note that the Current Pen **10** will update to the color of the VAT object.
- Use the pen tool to draw over the VAT regions. **11**

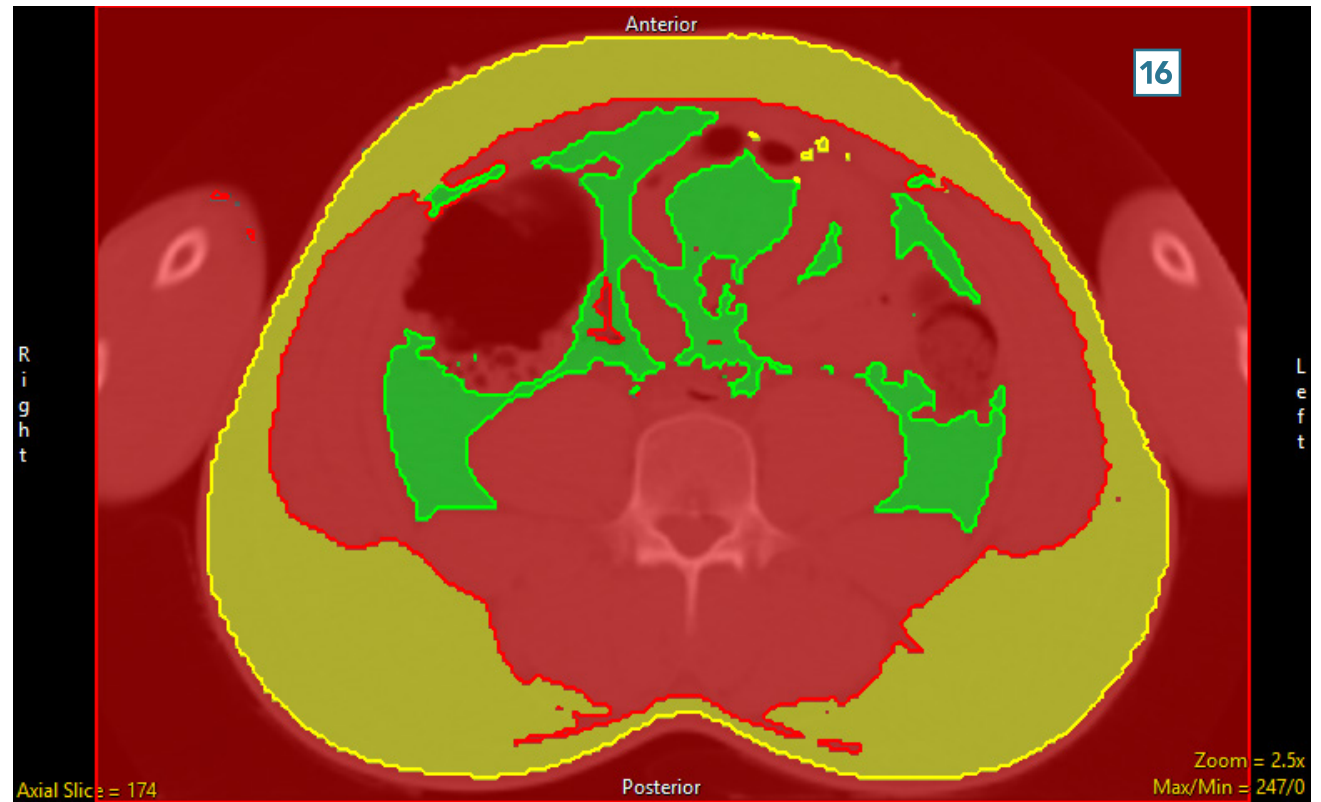




- Once the VAT region is defined, lock the VAT object **12** and select the SAT object. **13**
- Increase the Pen Size to 30 **14** and draw over the SAT regions. **15**



When finished, **16** use File > Save Object Map to save your work.

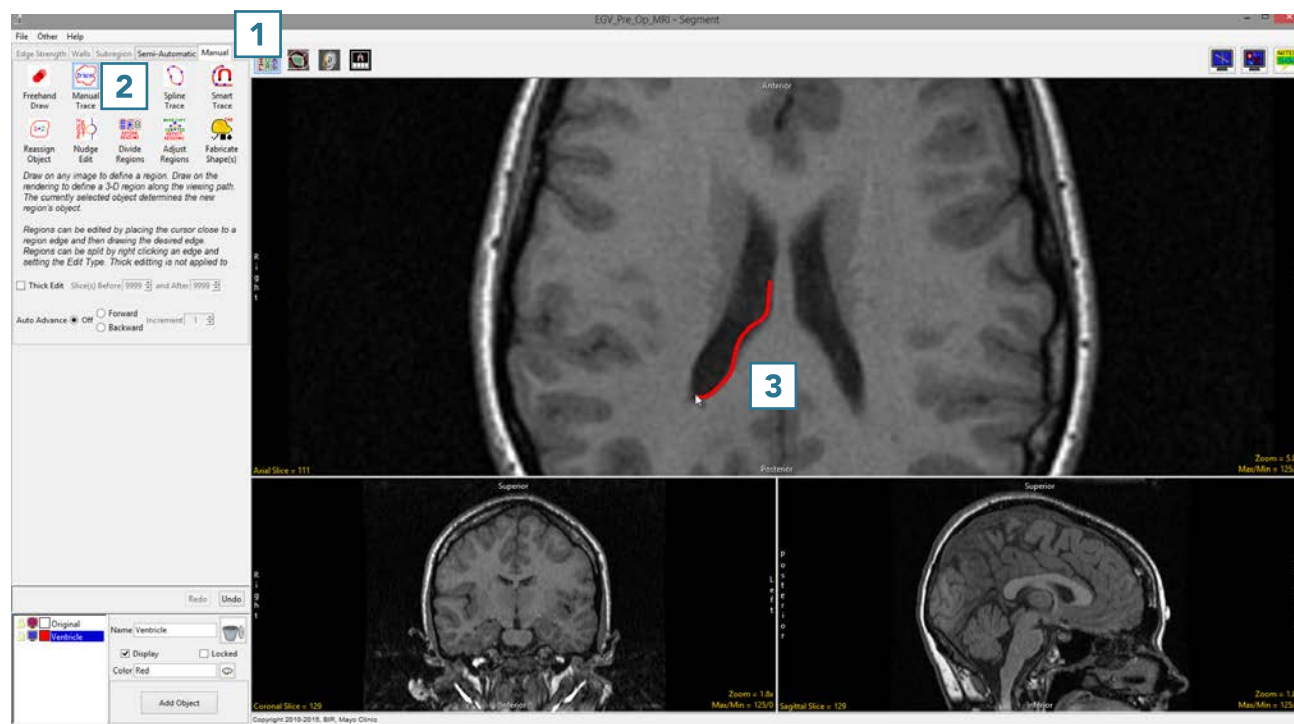


## Manual Trace

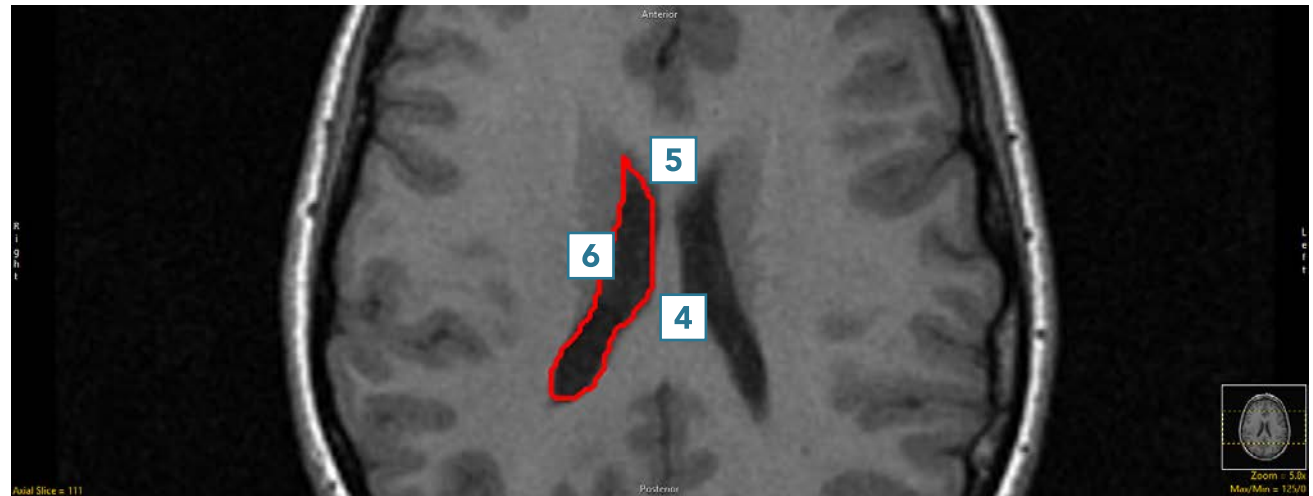
Like the Freehand Draw tool, the Manual Trace tool allows the user to draw regions of interest directly onto the image data. Manual tracing allows contours to be drawn around the edges of a region of interest.

## 21. Manual Contour Tracing and Editing

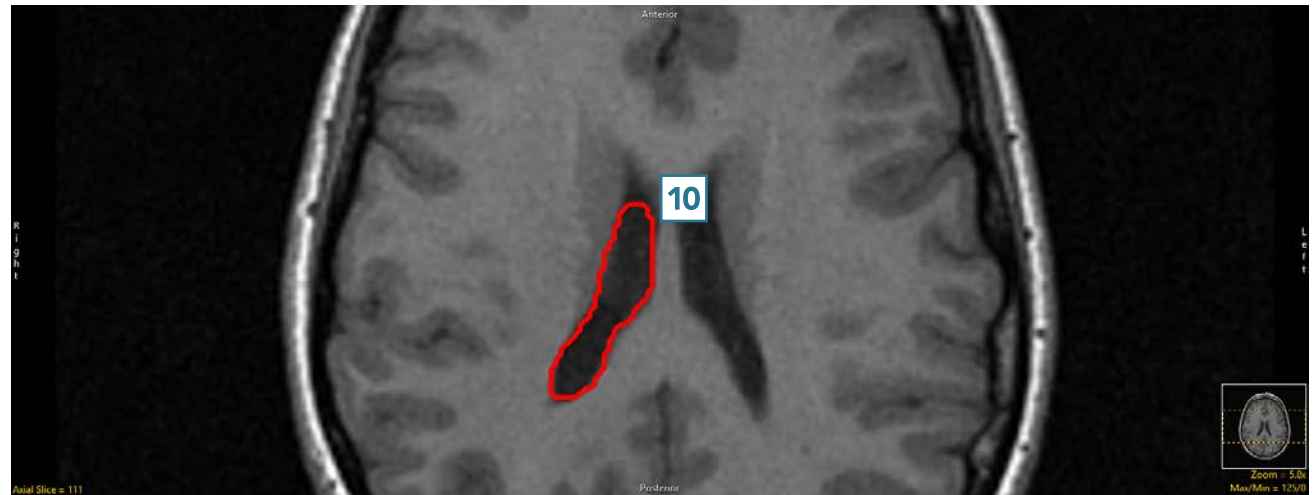
- Select a data set and open Segment.
- Select Manual **1** and choose Manual Trace. **2**
- Left-click on a slice to begin tracing and move the cursor around the region you want to define. **3**



- Release the left mouse button to complete the trace. **4**
- To edit the trace and add pixels that may be missing, **5** click on the trace **6** and draw in the missing region. **7**
- To edit the trace and remove additional pixels, **8** hover near the edge of the contour until the cursor changes to a + sign, then drag the cursor into the trace. **9**



- Adjust the trace to remove the undesired pixels. **10**



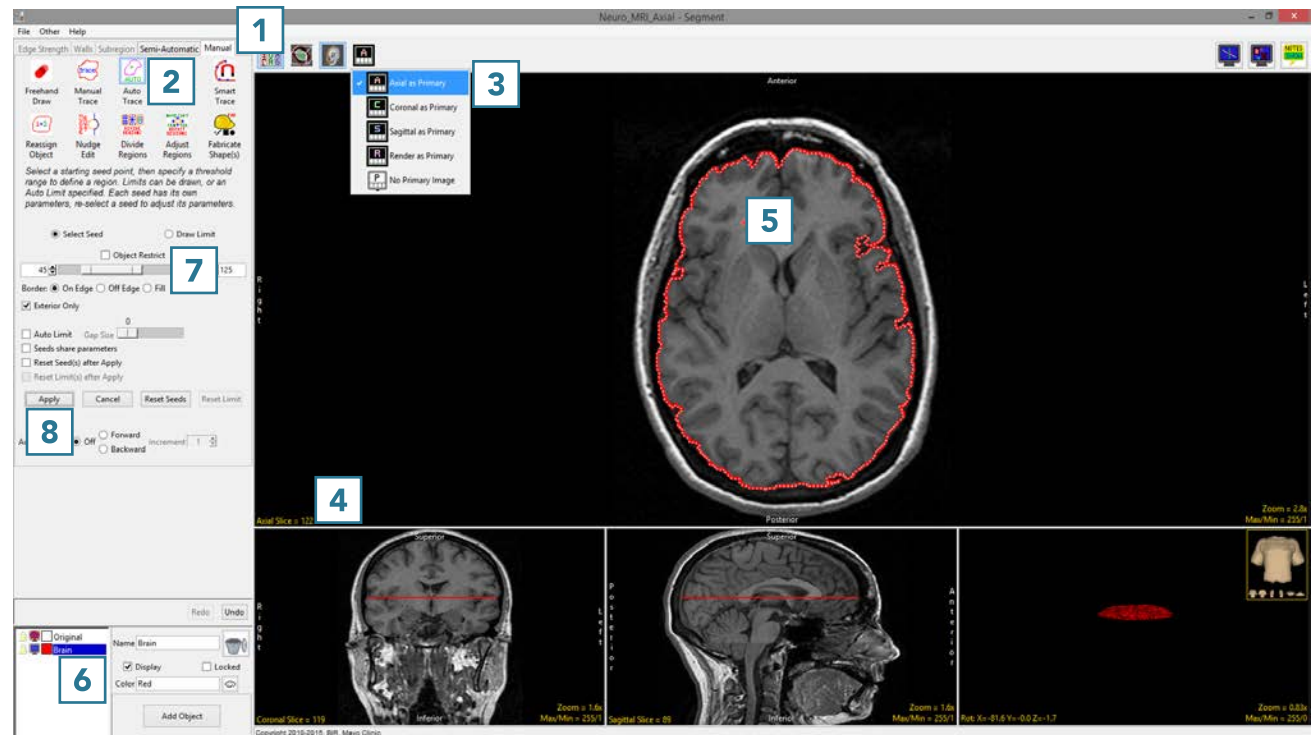
## Auto Trace

The Auto Trace tool enables the user to define and extract regions of interest from the image data using 2D seeded region growing. Region definition begins with a seed pixel, manually set by the user, on a structure of interest. Next, a threshold range is established by the user to define the boundary of the structure. The 2D region is defined by all the pixels in the threshold range that are connected to the seed pixel.

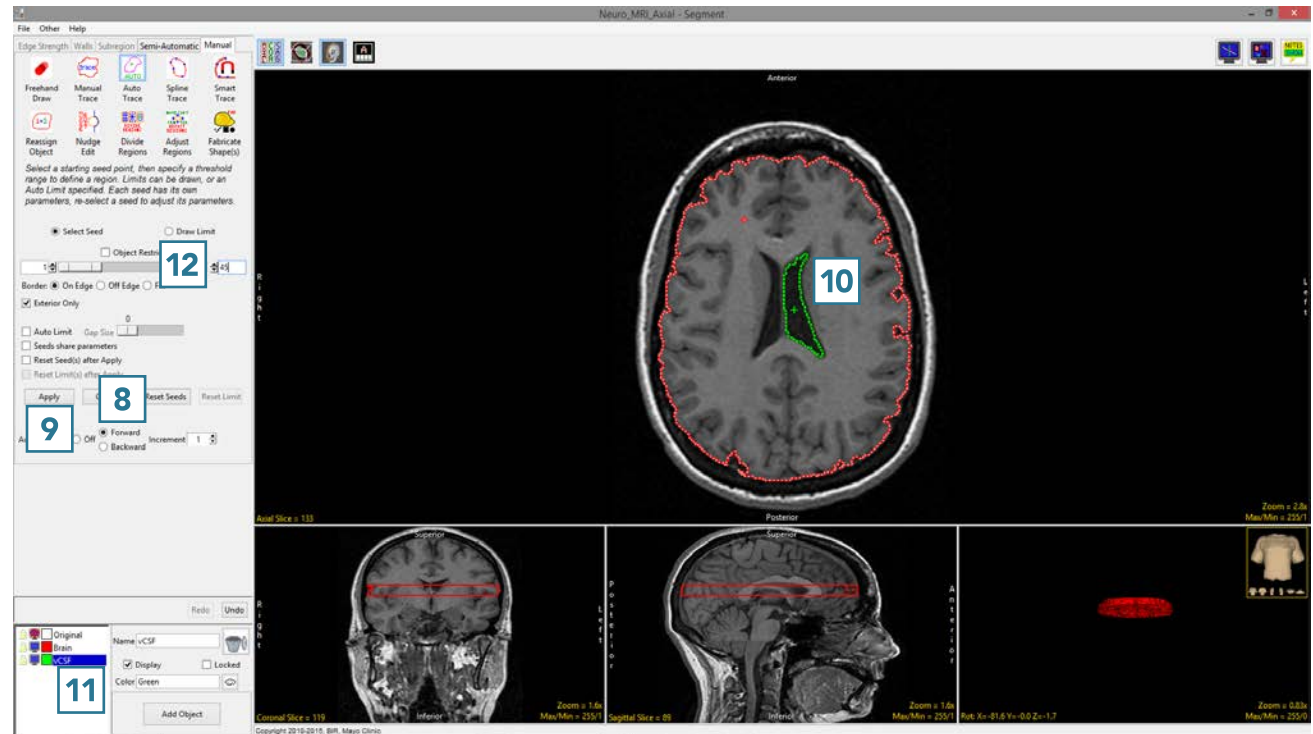


## 22. Using Auto Trace to Define a 2D Region of Interest

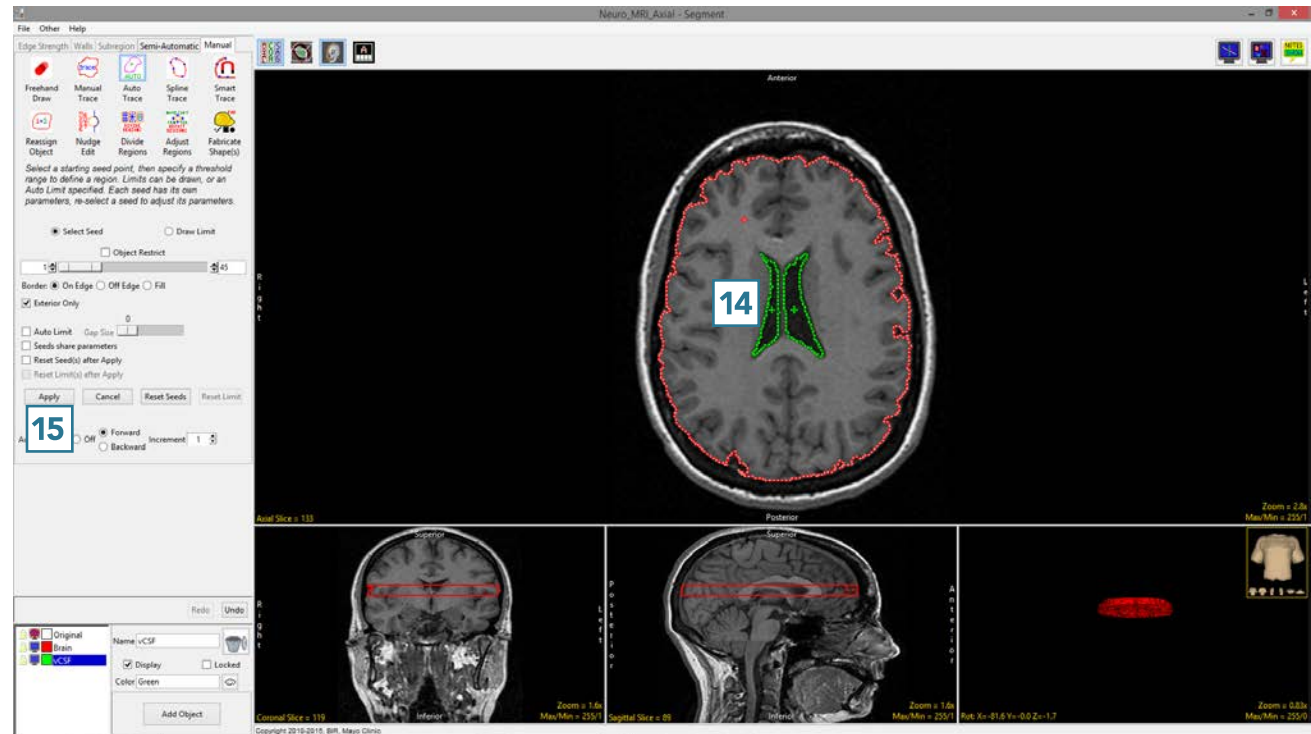
- Select a data set and open Segment.
- Select Manual **1** and choose Auto Trace. **2**
- Set the primary display to Axial **3** and double-click Slice **4** to move to axial slice 122.
- Set a seed pixel in the white matter. **5**
- Rename Object\_2 to Brain **6** and then adjust the minimum and maximum threshold values **7** to define the brain.
- Click Apply **8** to trace the brain on this slice.



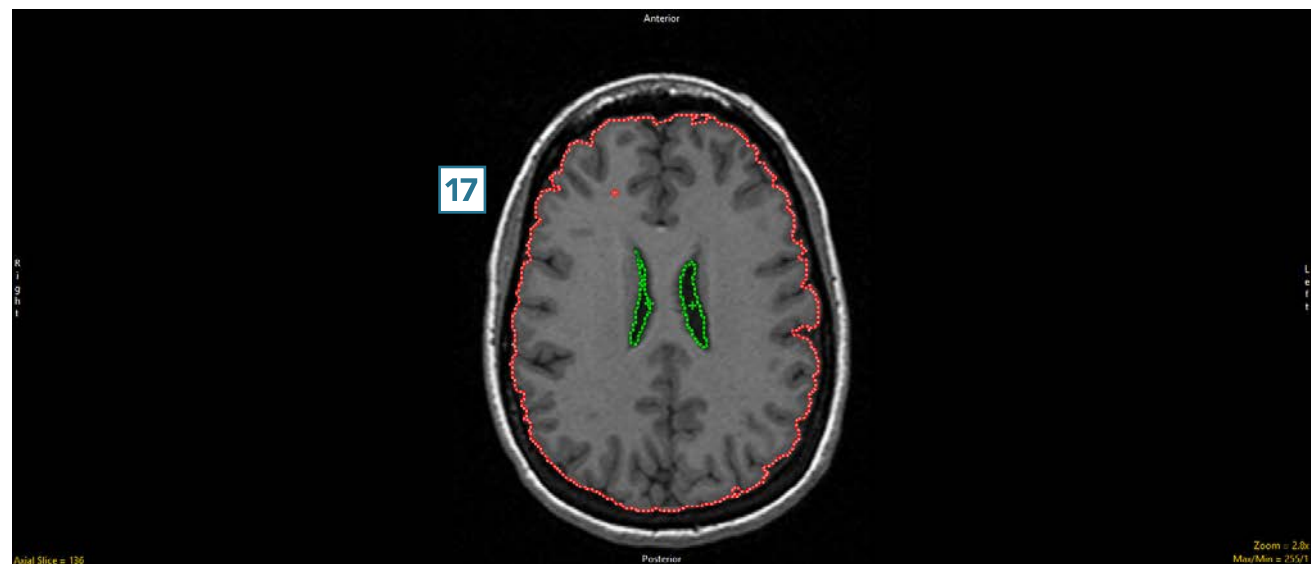
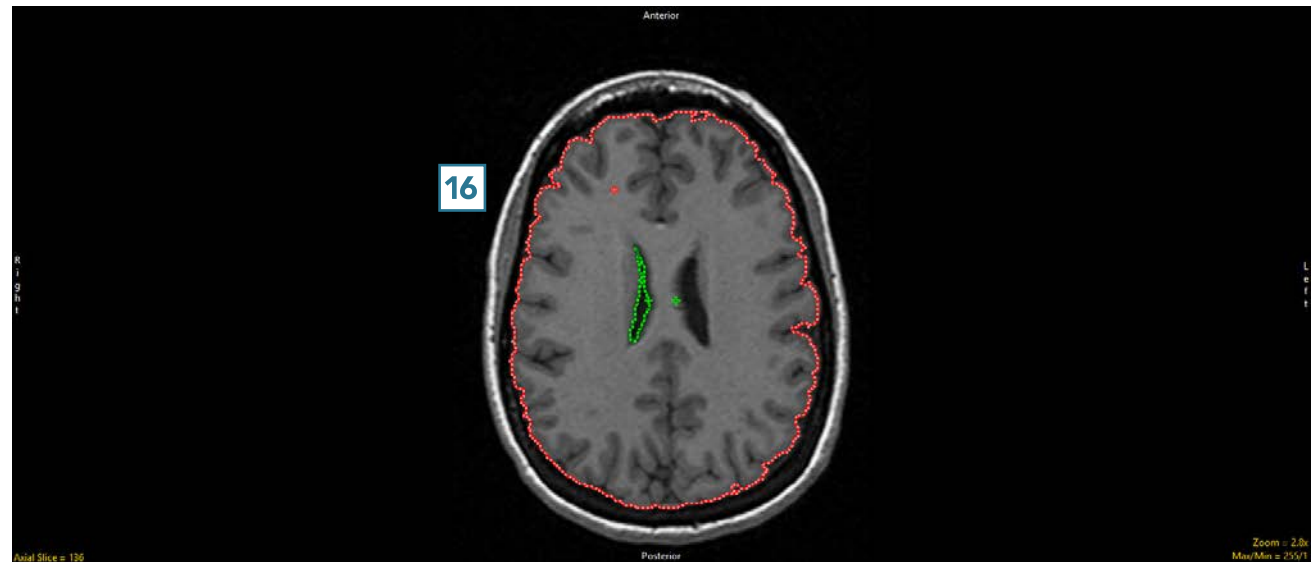
- Scroll forward to slice 123. The + key can also be used instead if your mouse has no scroll wheel.
- Since the seed point and threshold range are automatically carried forward, the brain will be redefined on this slice.
- Set the Auto Advance option to Forward **8** and click Apply. **9** The brain will be traced on this slice and the display will automatically move forward to slice 124.
- Continue to apply the auto trace to the brain up to slice 133. If the initial seed point is copied to a slice where it does not fall within the brain, reset the seed point and threshold range and click Apply to set a new auto trace on that slice.
- Click in the ventricular CSF to set a seed point. **10**
- Add a new Object and rename it vCSF. **11** Note that the second seed point will change color to match the color of the new object. Adjust the threshold range to define the vCSF object. **12**



- Set a second seed point to define the remaining vCSF **14** and click Apply. **15**



- Continue clicking Apply to trace the Brain and vCSF objects. If a seed point is copied to a location where it is no longer on the target object, **16** move the seed point back onto the object **17** and continue to apply the auto trace.
- Stop defining objects at slice 137.
- Select File > Save Object Map to save your work.



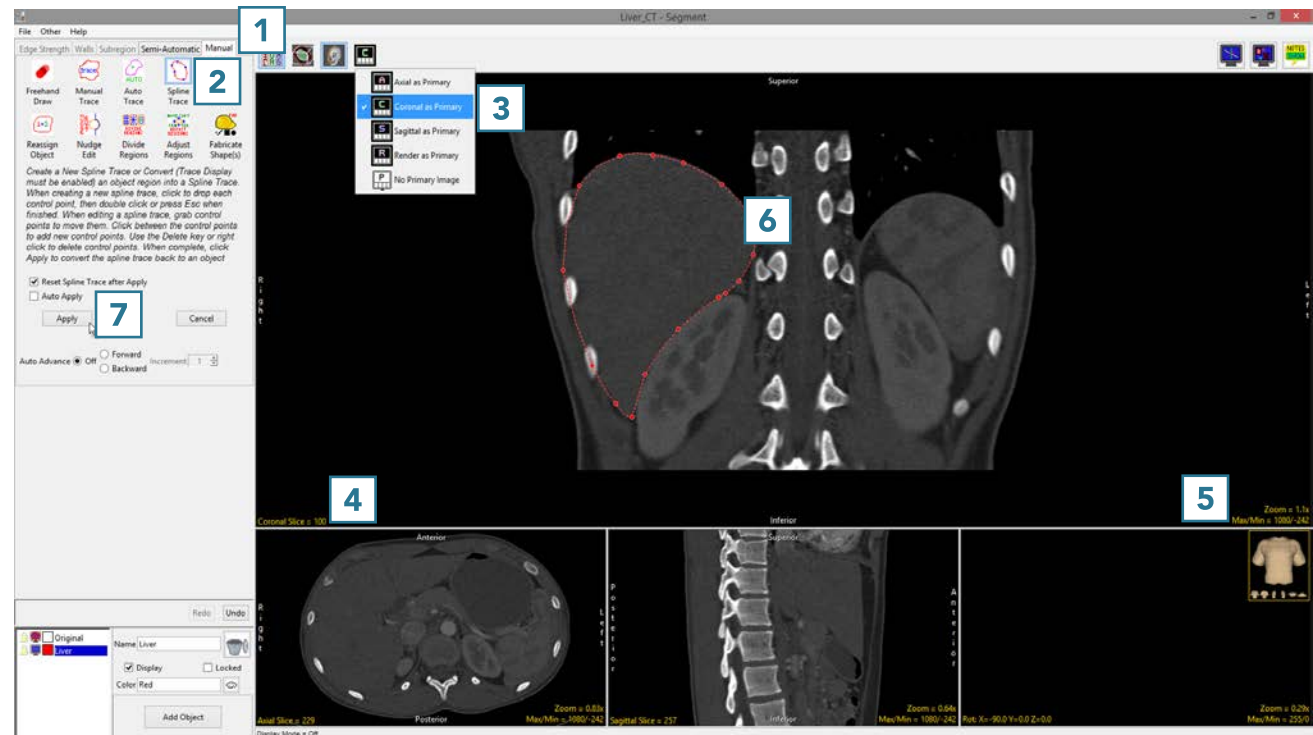


## Spline Trace

The Spline Trace tool allows users to define curved regions of interest. Splines are flexible curve traces with movable control points that are useful for creating smooth edge traces.

## 23. Using Spline Trace to Define a Region of Interest

- Select a data set and open Segment.
- Select Manual **1** and choose Spline Trace. **2**
- Set the primary display to Coronal **3** and double-click Slice **4** to move to coronal slice 100.
- To begin drawing a spline, position the cursor on the image and left-click. **5** Reposition the cursor and left-click to continue drawing the spline around the object of interest. **6**
- Double-click to end and close the spline.
- Note that control points can be moved. Click a control point, drag to a new location and the Spline will update.
- Select Apply **7** to apply the spline trace.
- Use File > Save Object Map to save your work.





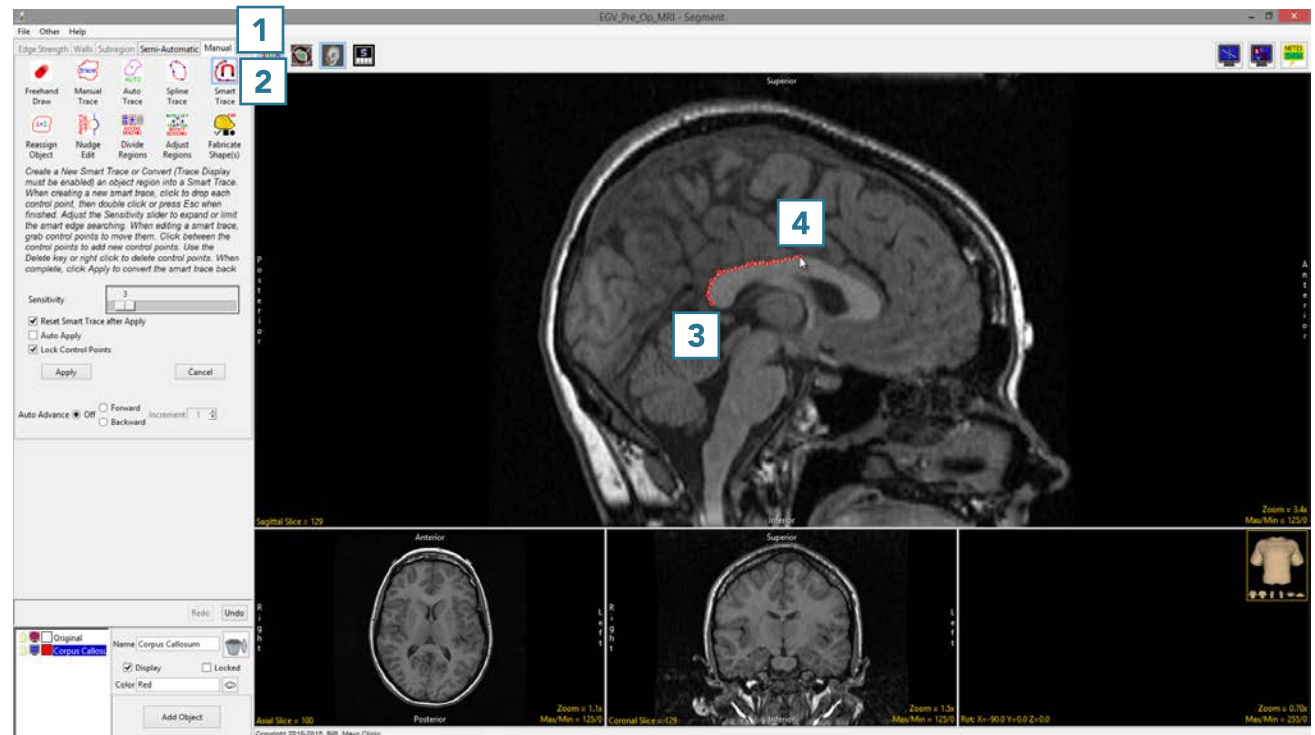


## Smart Trace

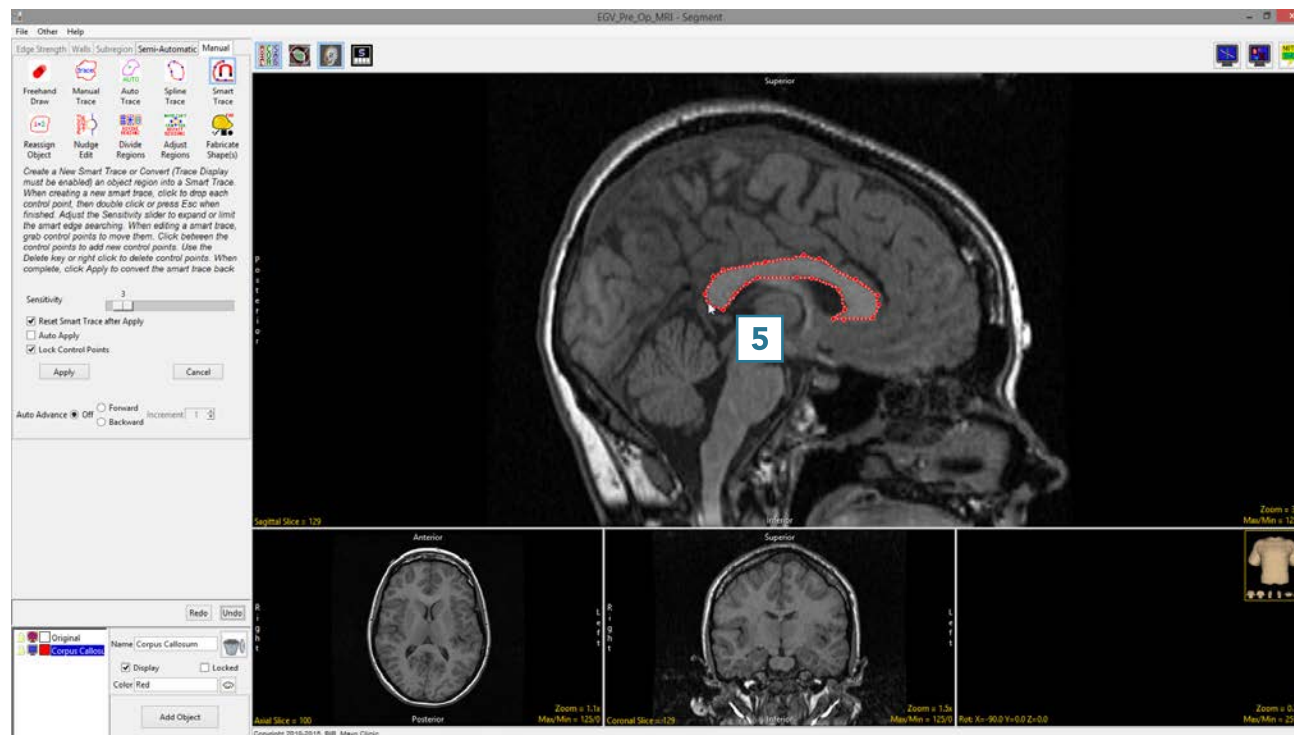
The Smart Trace tool detects regions of high rate of change of voxel intensity (gradient) representing edges. The tool snaps to the edges of these regions. The sensitivity of the smart edge can be adjusted using the slider or the mouse scroll wheel.

## 24. Smart Trace Region Definition

- Select a data set and open Segment.
- Select Manual **1** and choose Smart Trace. **2**
- Left-click in the image to set the first control point. **3**
- Move the cursor along the edge of the object and click to set additional control points. **4** To adjust the sensitivity of the smart edge, use the mouse scroll wheel. Scrolling up will increase the sensitivity and scrolling down will decrease sensitivity.



- When the trace is complete, double-click to close the spline. **5**
- If needed, control points can be moved. Uncheck the Lock Control Points option, click on a control point and drag it to a new location. The Smart Trace will update.
- Control points can be deleted. Select a control point, right-click and select Delete Control Point.
- Select Apply or use the A key to apply the trace.
- Use File > Save Object Map to save your work.



## Reassign Object

The Reassign Object tool allows users to interactively reassign the voxels of one object to another object. First, select the object to which the voxels will be reassigned from the object control window. Then, select a reassignment type. Finally, to establish a seed pixel, click on the object to be reassigned. Object reassignment occurs immediately. Reassignment options are described in Table 7.1.

**Table 7.1: Reassignment Types**

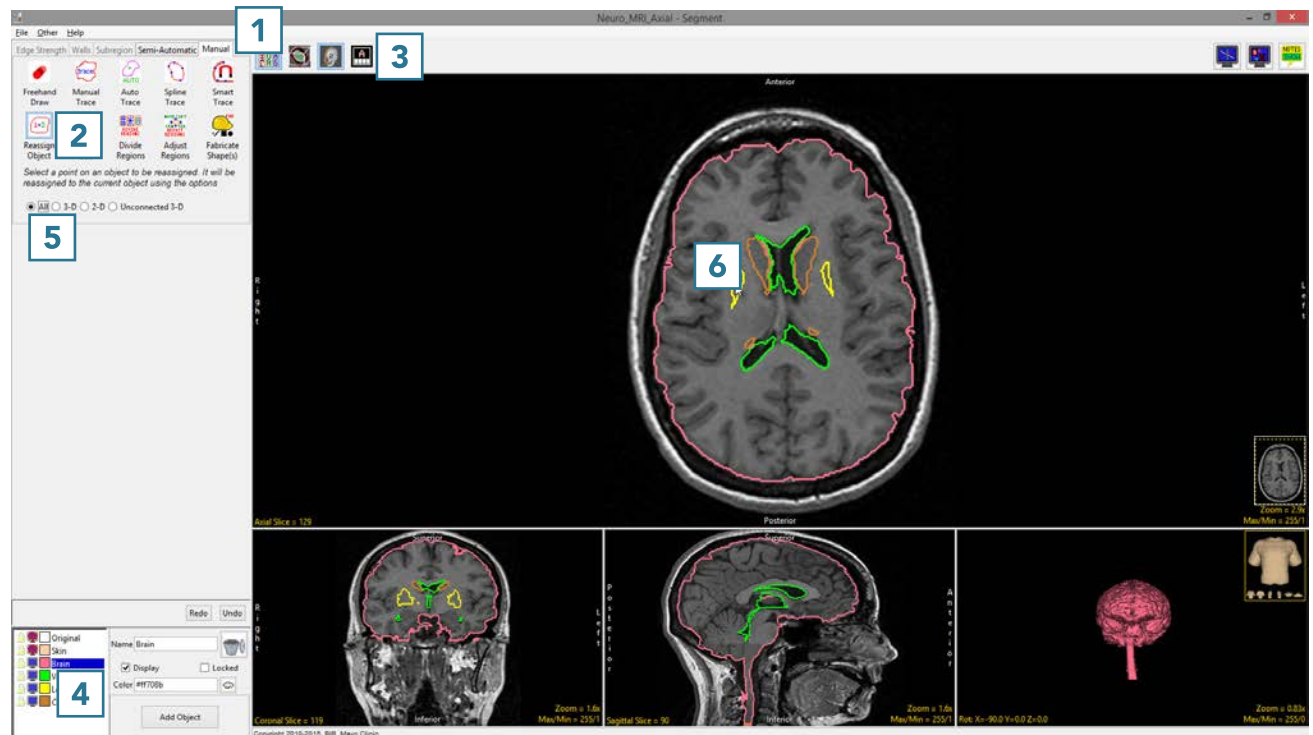
Reassignment Type	Action
All	All voxels in the selected object are reassigned to the current object
3D	All voxels in the selected object that are connected in 3D to the seed pixel are reassigned to the current object
2D	All voxels in the selected object that are connected in 2D to the seed pixel are reassigned to the current object
Unconnected 3D	All voxels in the selected object that are not connected in 3D to the seed pixel are reassigned to the current object

## 25. Reassigning Objects

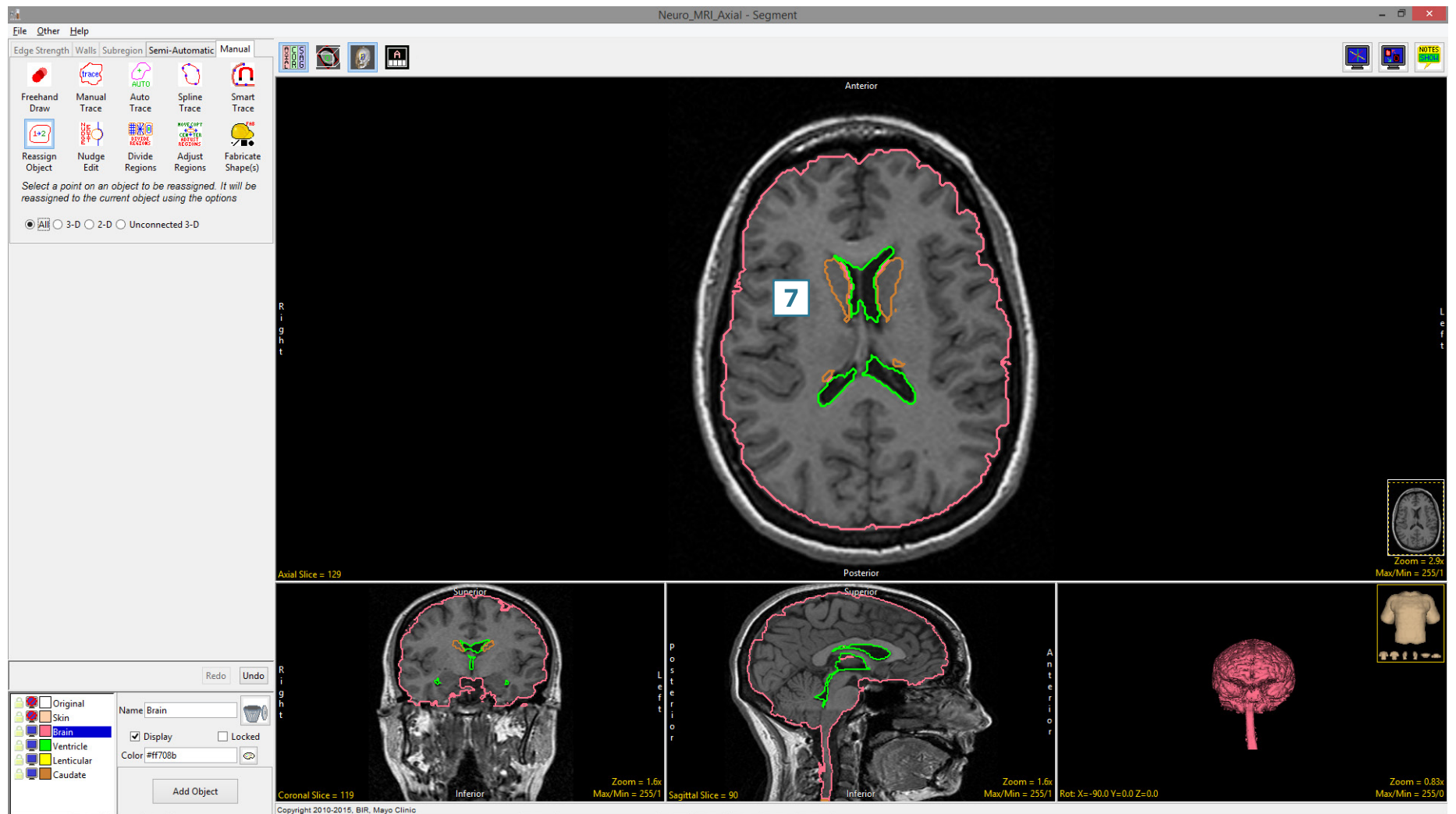
- Select the data set and open Segment.
- Use File > Load Object Map to load the corresponding object map.
- Select Manual **1** and choose Reassign Object. **2**
- Set the primary display to axial **3** and move to axial slice 130.
- Switch the display of the Skin object off and switch on the display of the Lenticular and Caudate objects. Select the Brain object and change the Opacity level of the Brain to 2. **4**
- Set the reassignment type to All **5** and click on the yellow Lenticular object. **6**



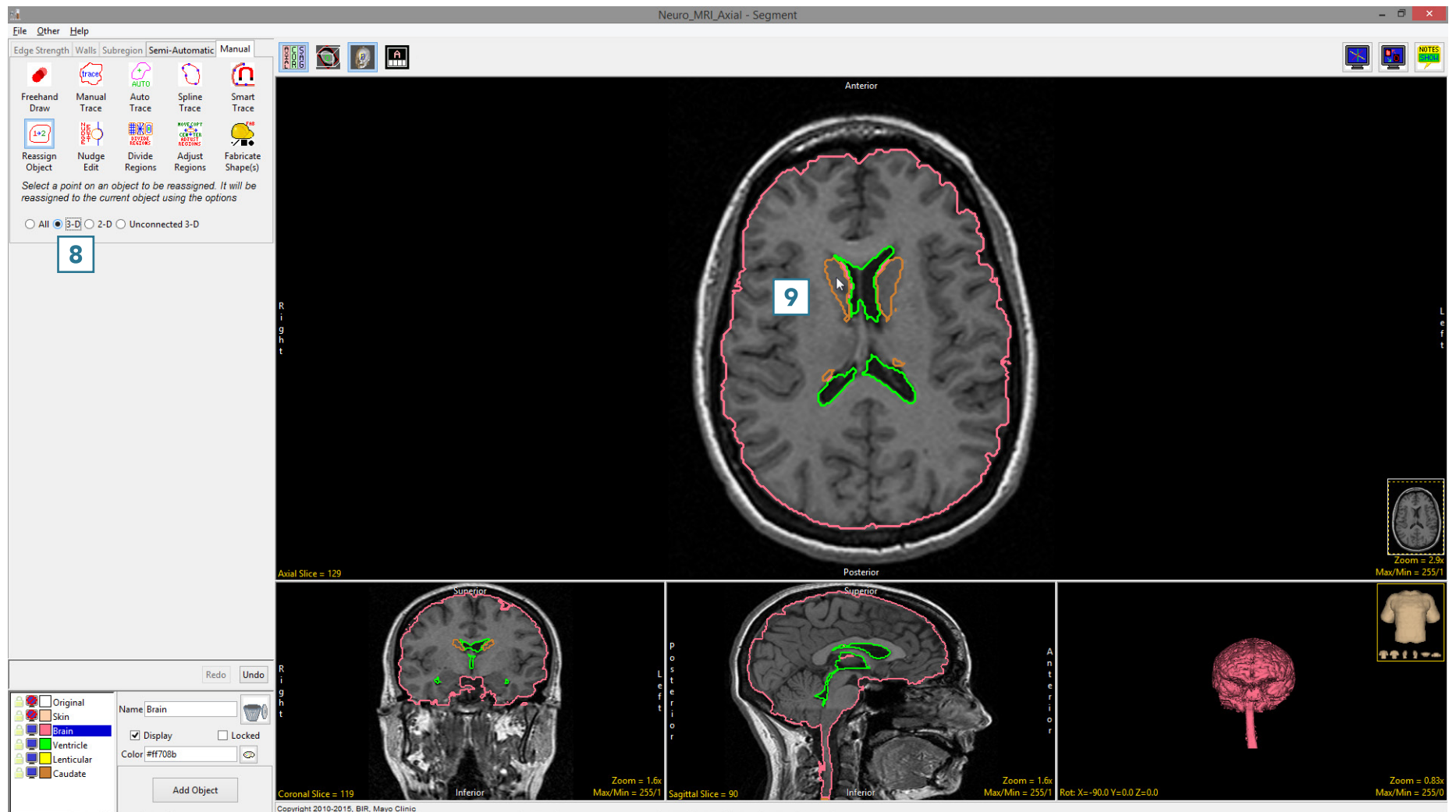
Download the MRI\_3D\_Head data set to follow along  
<http://analyzedirect.com/data/>



Note that all the voxels of the Lenticular object have been reassigned to the Brain object. 7

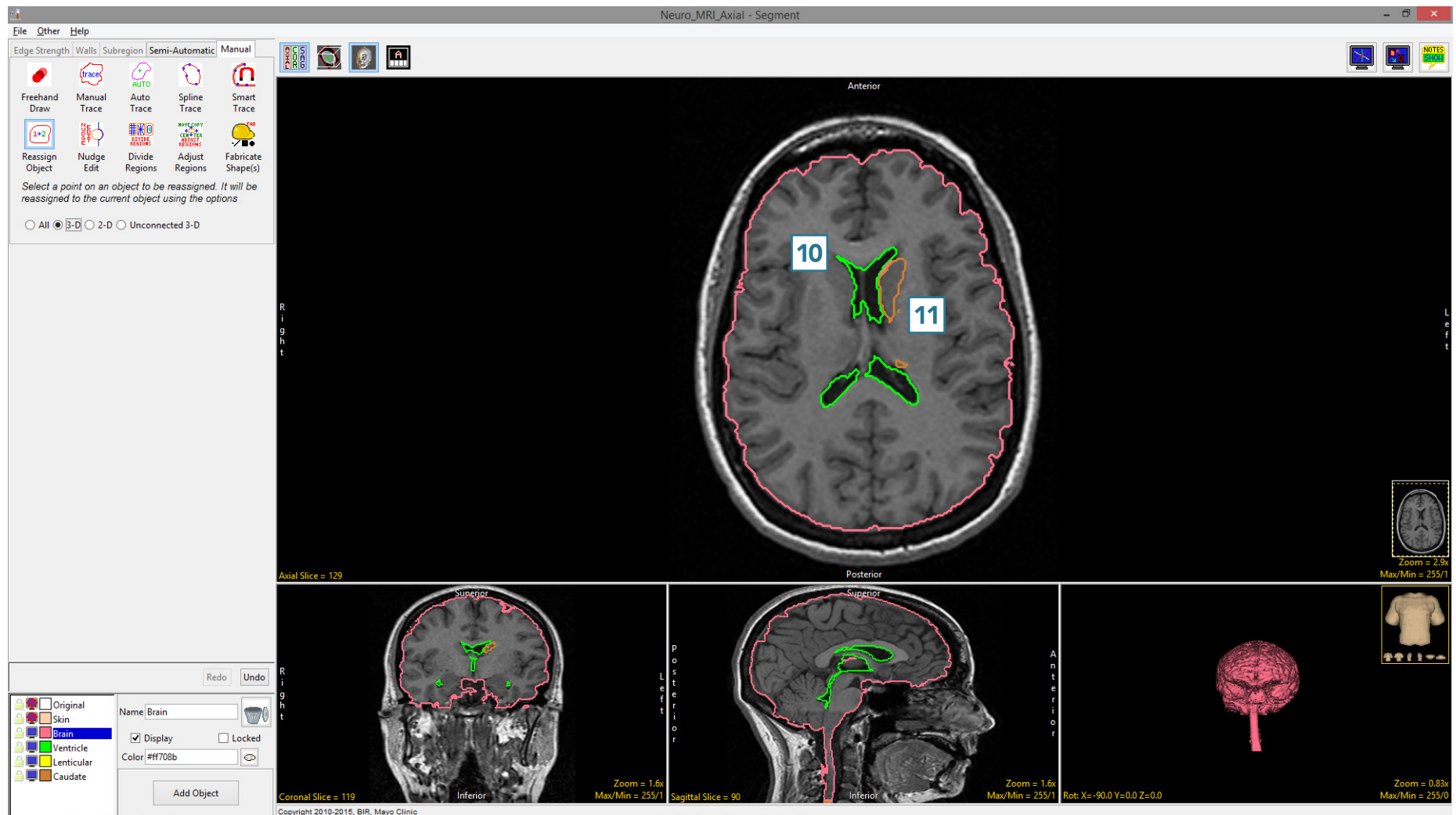


Set the reassignment type to 3D **8** and click on the brown Caudate object on the right side of the brain. **9**

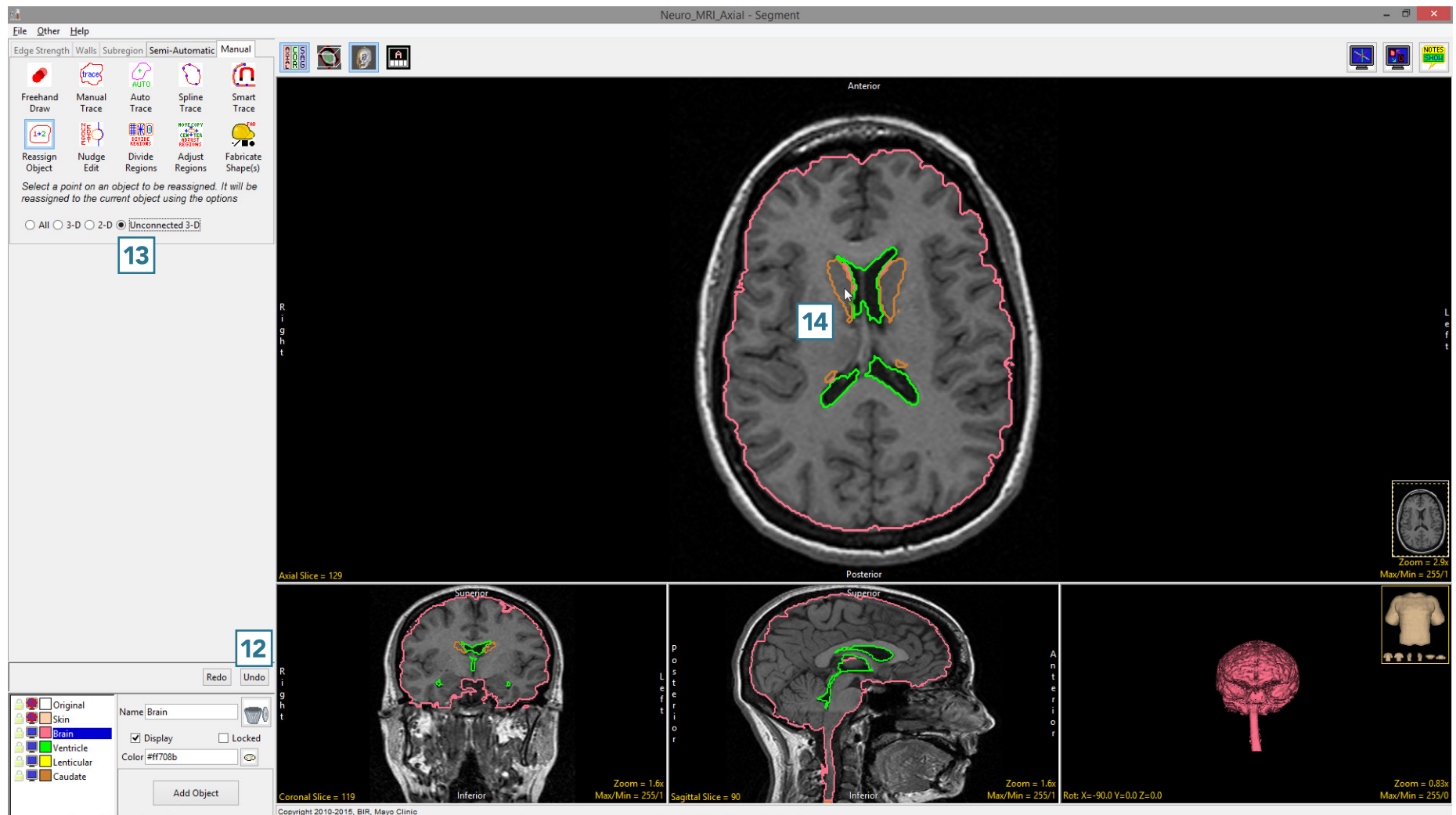




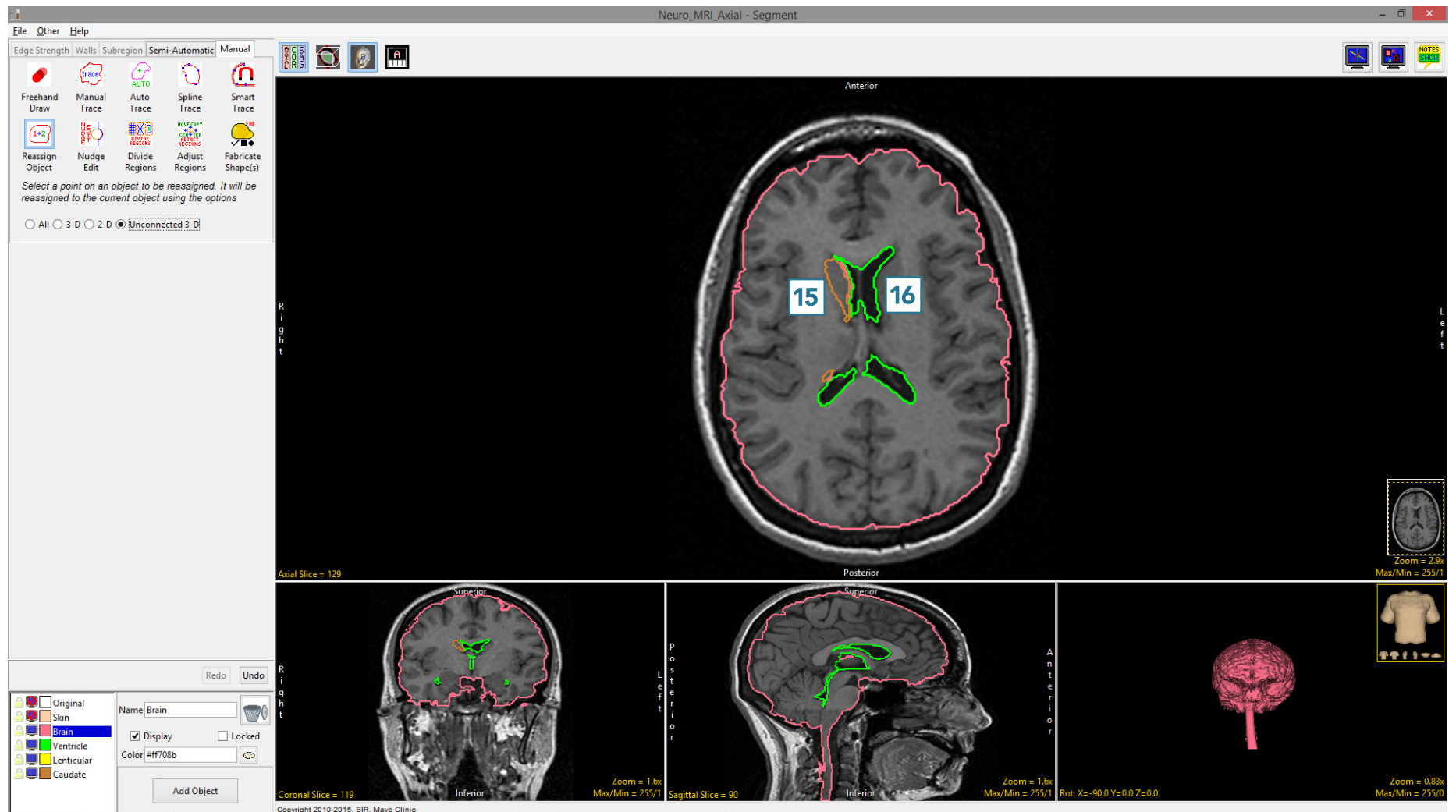
Note that the all the voxels of the Caudate object connected to the seed pixel have been reassigned to the Brain object. **10** As the left caudate nucleus is not connected to the right caudate nucleus, that part of the object remains. **11**



- Click Undo **12** and set the reassignment type to Unconnected 3D. **13**
- Click on the brown Caudate object on the right side of the brain. **14**

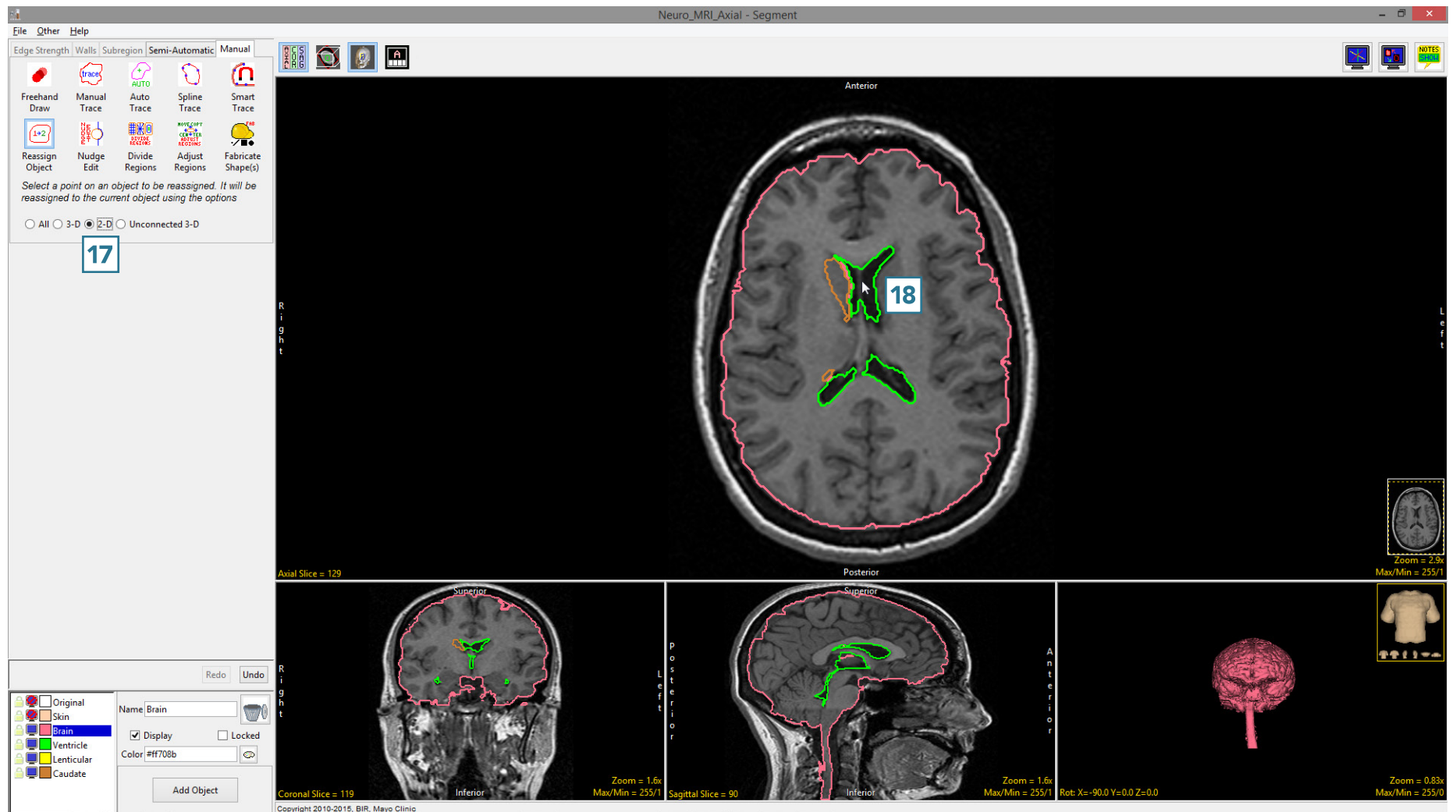


Note that this time, all the voxels assigned to the Caudate object connected to the seed pixel have been kept **15** while those unconnected voxels representing the left caudate nucleus have been reassigned to the Brain object. **16**



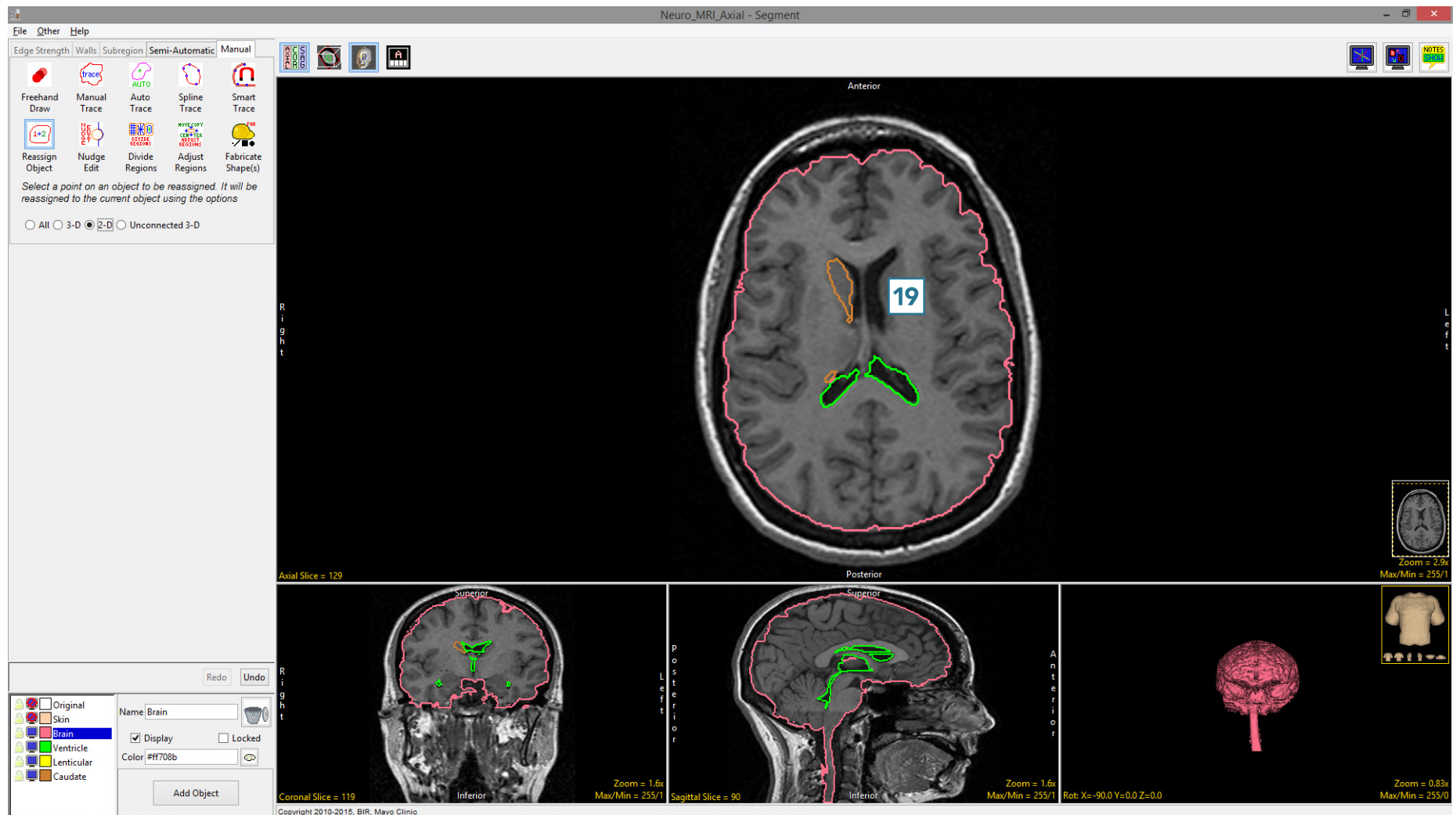
Note that for the All, 3D and Unconnected 3D reassignment types, seed points can be set on the 3D rendering.

- Set the reassignment type to 2D 17 and click on the anterior section of the green Ventricle object. 18





The voxels assigned to the Ventricle object, which are connected to the seed pixel only on this 2D slice have been reassigned to the Brain object. **19**





## Nudge Edit

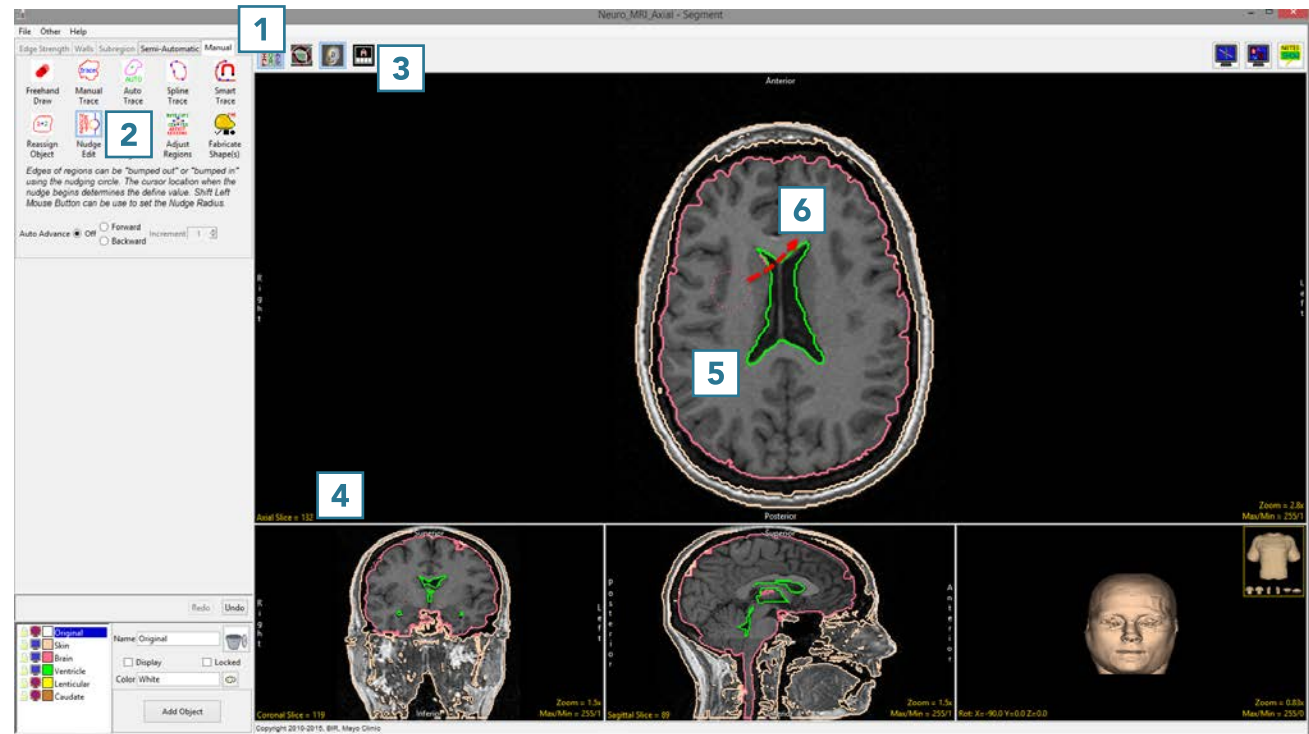
Nudge Edit enables users to manually edit borders of defined regions. The tool allows object borders to be pushed inwards or outwards using an adjustable circular cursor. The size of the cursor can be adjusted using the middle mouse button.

## 26. Editing Object Borders

- Select MRI\_3D\_Head and open Segment.
- Select File > Load Object Maps and load MRI\_3D\_Head.obj.
- Select Manual, **1** then choose Nudge Edit. **2**
- Set the primary display to Axial **3** and move to Axial slice 132. **4**
- To edit the border of the Brain and Ventricle objects click in the brain. The circular nudge tool cursor will appear. **5**

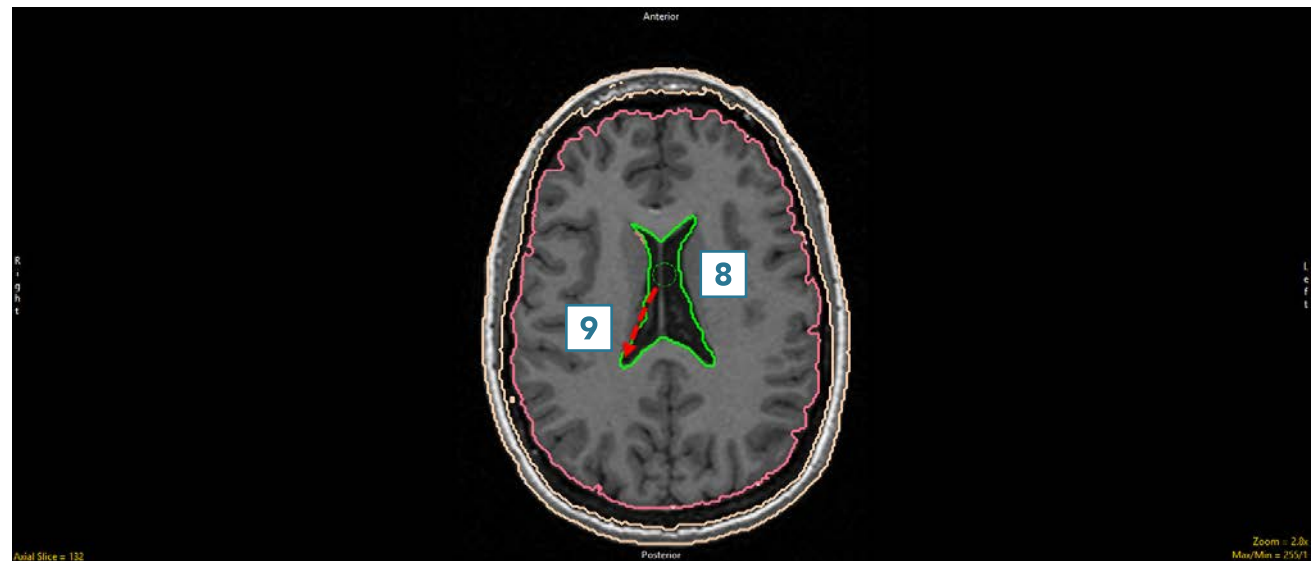
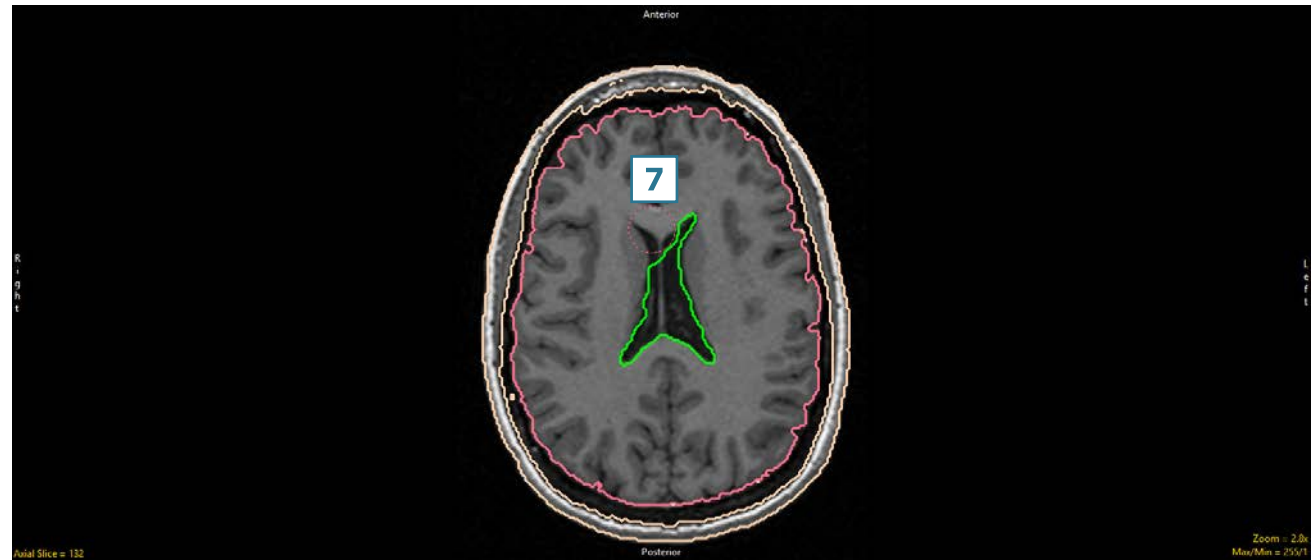
Note the color of the cursor will match the object being nudged.

- Move the cursor to edit the border. **6**

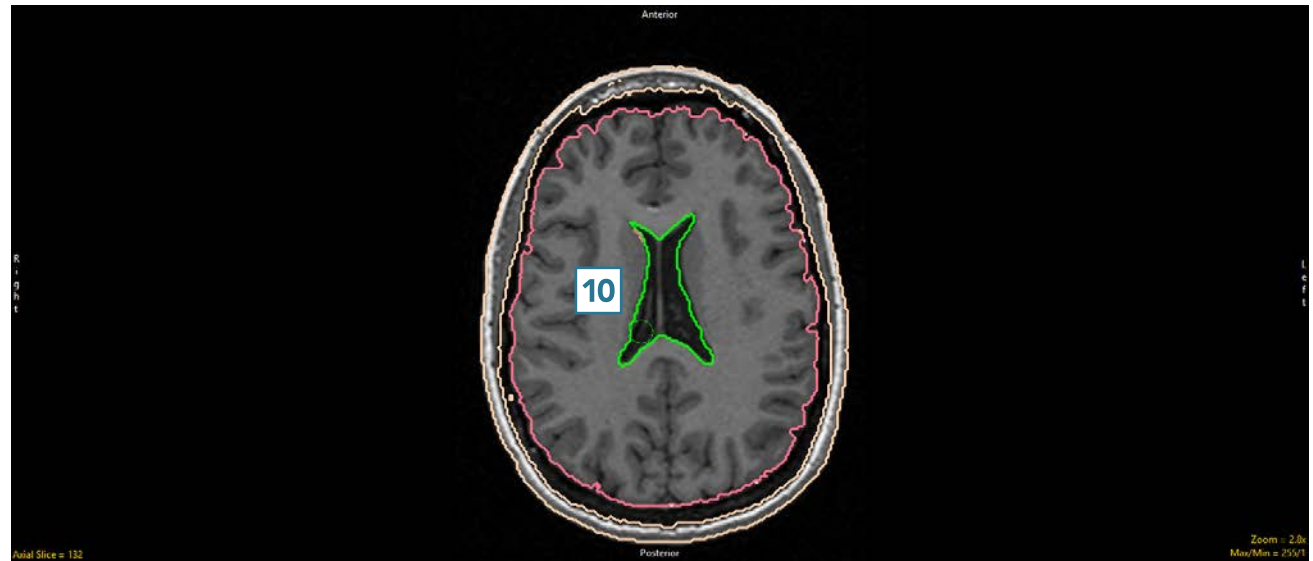




- The borders of the Brain and Ventricle objects will be updated as the cursor moves through. **7**
- Click Undo.
- Using the middle mouse button, change the size of the cursor to 5, then click in the Ventricle object. **8** Push the border of the Ventricle object out to edit the object boundary. **9**



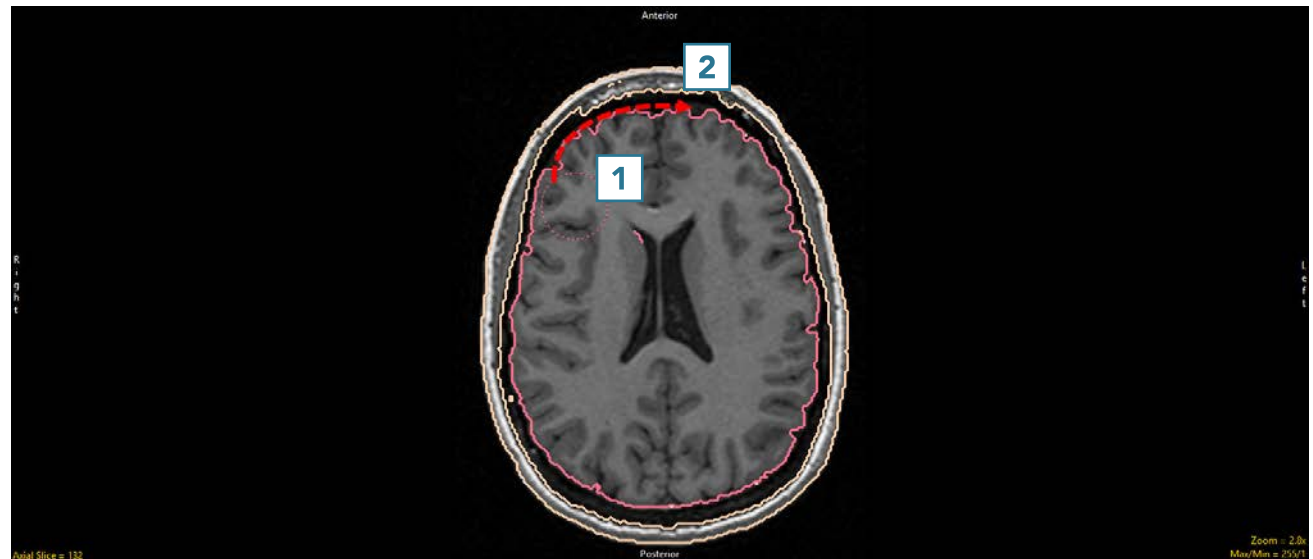
- The borders of the Brain and Ventricle objects will be updated as the cursor moves through. **10**



## 27. Using the Nudge Tool with Locked Objects

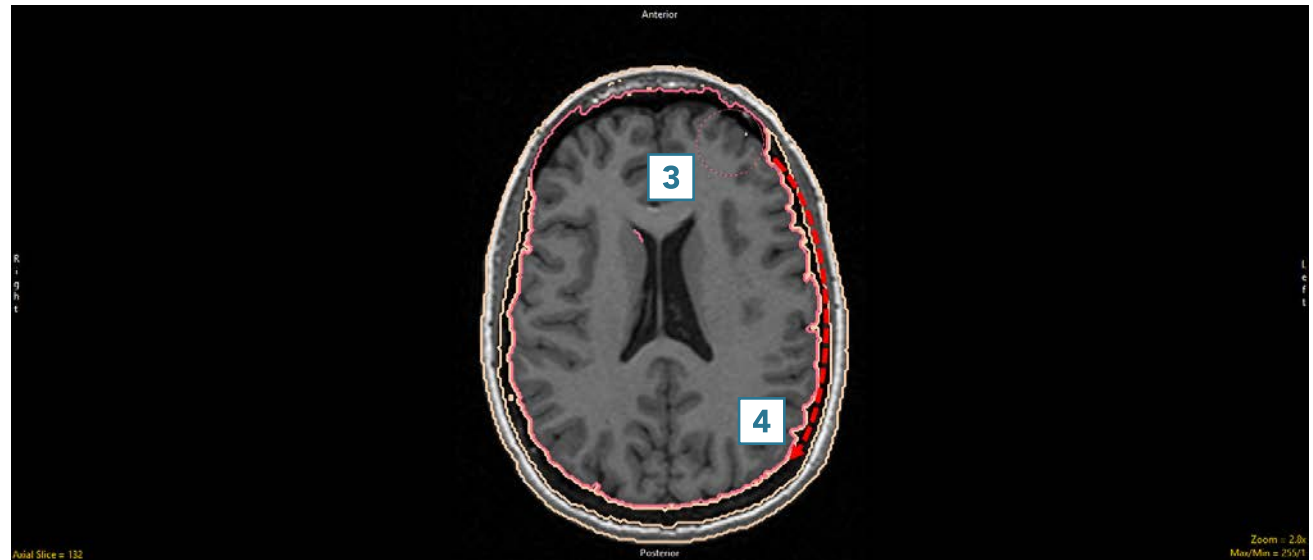
The Nudge Tool can also be used in conjunction with locked objects. For example, if a user decided that they wanted to measure the intracranial area on this slice, after reassigning the Ventricle object on this slice to the Brain object using the 2D object reassignment option (see the Reassign Object tool), the Skin object can be locked and the brain object pushed out using the Nudge tool to the border of the skin object.

- Use the Reassign Object option to reassign the Ventricle object on Axial slice 132 to the Brain object.
- Lock the Skin object.
- Select the Nudge Edit tool.
- Click in the Brain **1** and move the Nudge tool into the intracranial space **2** between the Brain and Skin objects.

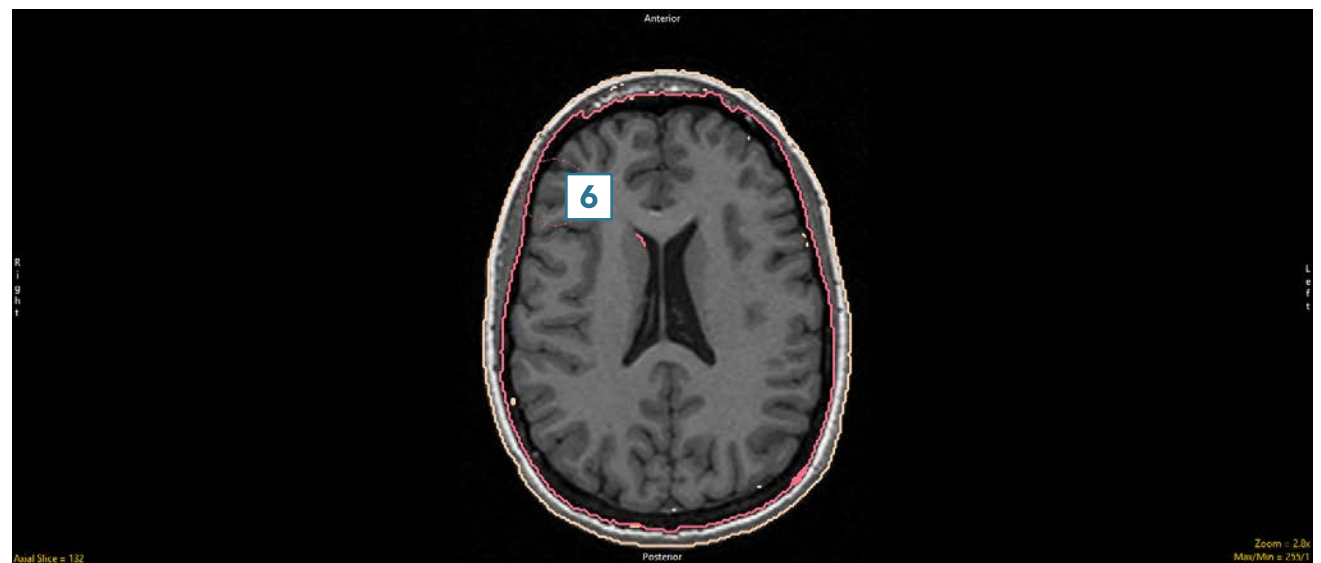
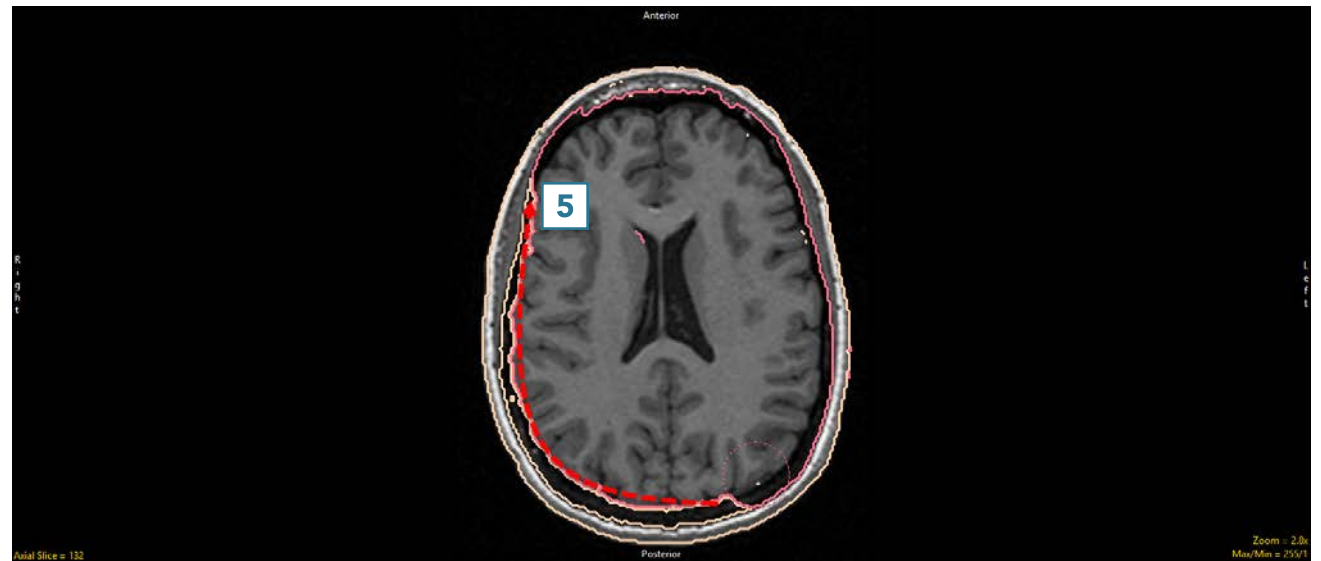


- Note that the Brain object will be pushed into the intracranial space but not into the locked skin object. **3**
- Continue moving the Nudge tool through the intracranial space. **4**

Note that if the cursor moves past the Skin object into the Original object, voxels in the Original object can still be added to the Brain object using the Nudge tool. To prevent this, lock the Original object as well.



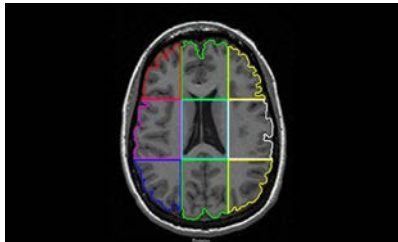
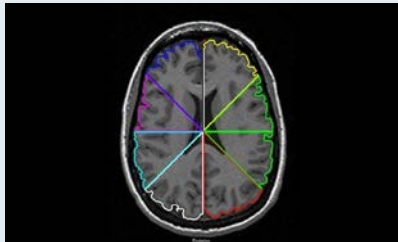
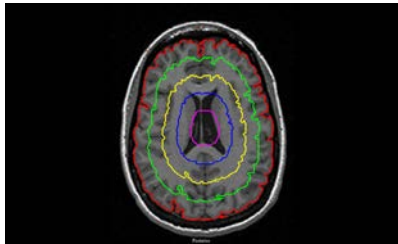
- Continue moving through the intracranial space **5** to complete the edit. **6**



## Divide Regions

The Divide Regions tool allows users to divide objects into subdivisions based upon the division type selected. Users can choose between grid, radial or between borders.

**Table 7.2: Divide Regions**

Divide Type	Function	Example
Grid	Divides selected object into rectangles.	
Radial	Radially divides selected object, splitting the object into pie wedges.	
Between Borders	Divides object into concentric shapes.	



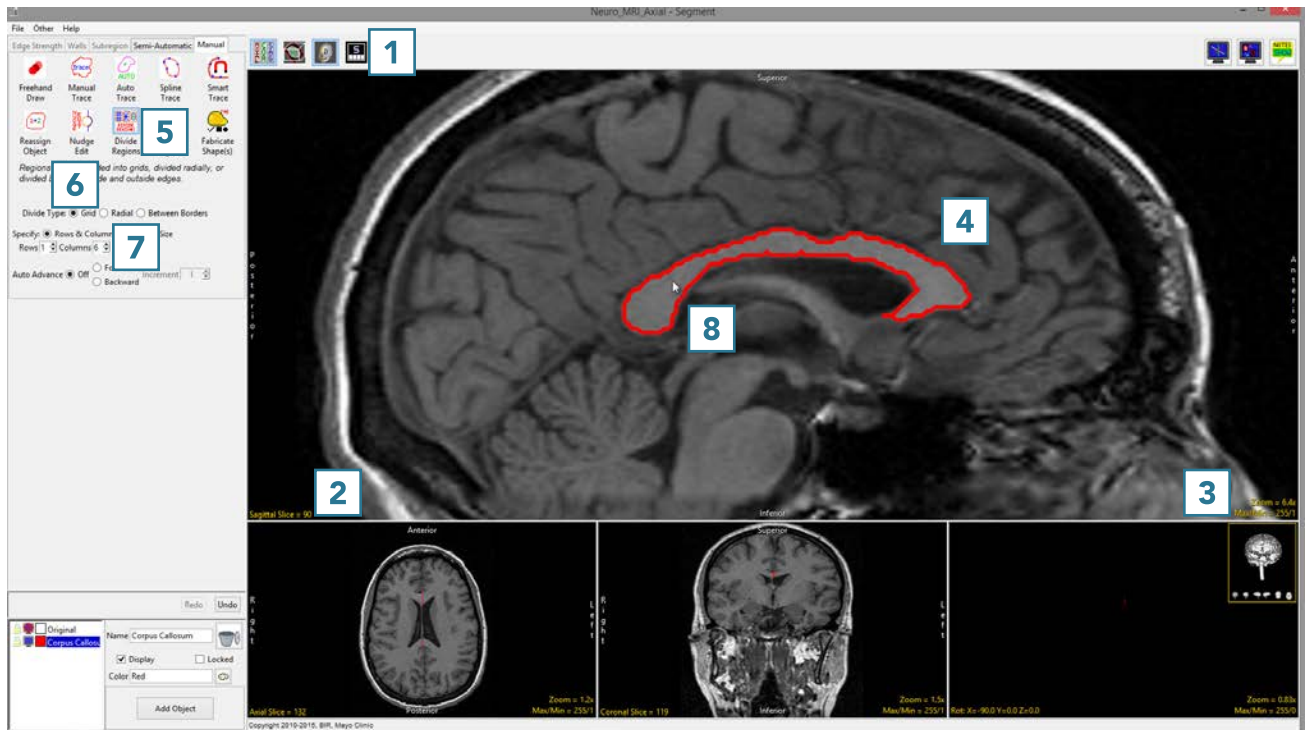


## 28. Grid Division of an Object

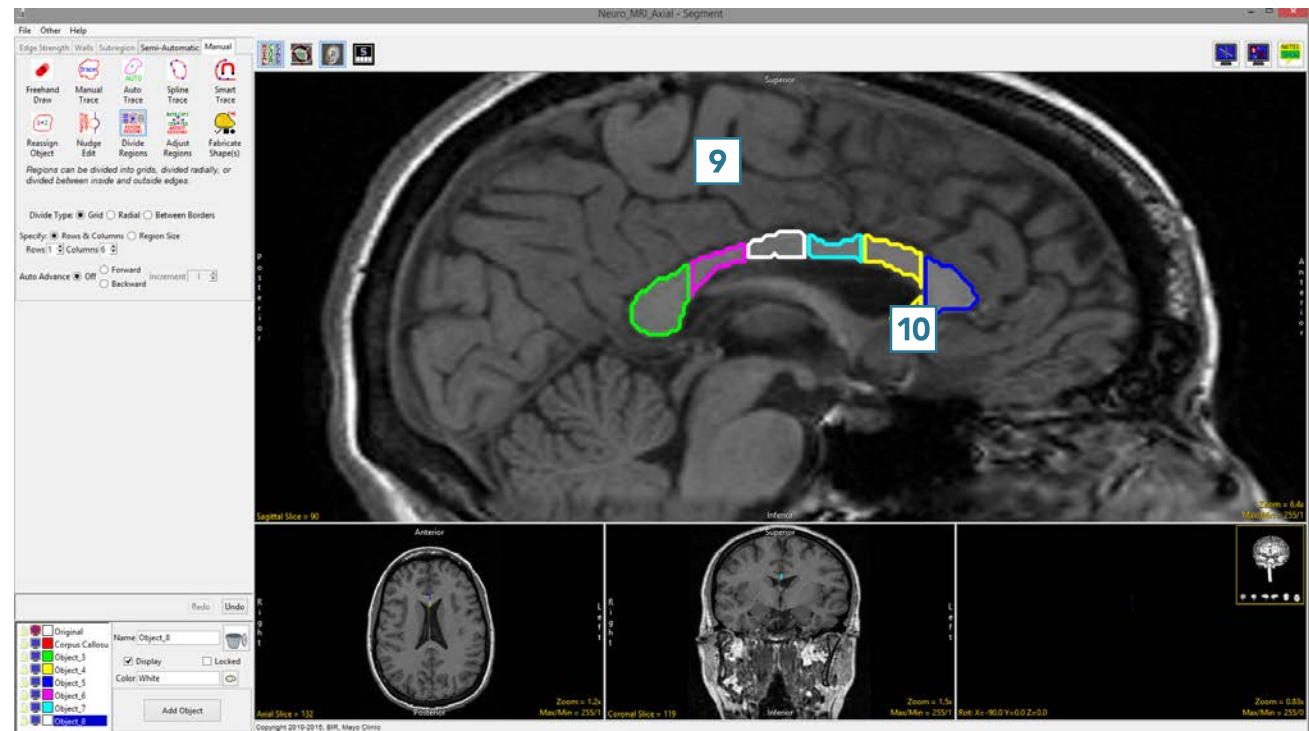
Grid division can be useful for subdividing structures into various anatomical substructures. For example, division of the corpus callosum (CC) on the mid-sagittal slice into its substructures is an important research methodology for assessment of the CC. A method for CC subdivision proposed by Witelson *et al*, "[Hand and sex differences in the isthmus and genu of the human corpus callosum: a postmortem morphological study](#)," provides an easy methodology for CC subdivision using AnalyzePro and has subsequently become the de facto standard for the procedure.

- 

<http://analyzedirect.com/data/>



- The CC will be divided into 6 Subregions. **9**
- Note that the Rostrum **10** will need to be assigned to a separate object. This can be achieved using the 2D reassignment option in the Reassign Object tool. Objects can be given the correct structural names (Splenium, Isthmus, Posterior Midbody, Anterior Midbody, Rostral Body, Genu and Rostrum) using the Object Control window.
- Use File > Save Object Map to save your work.



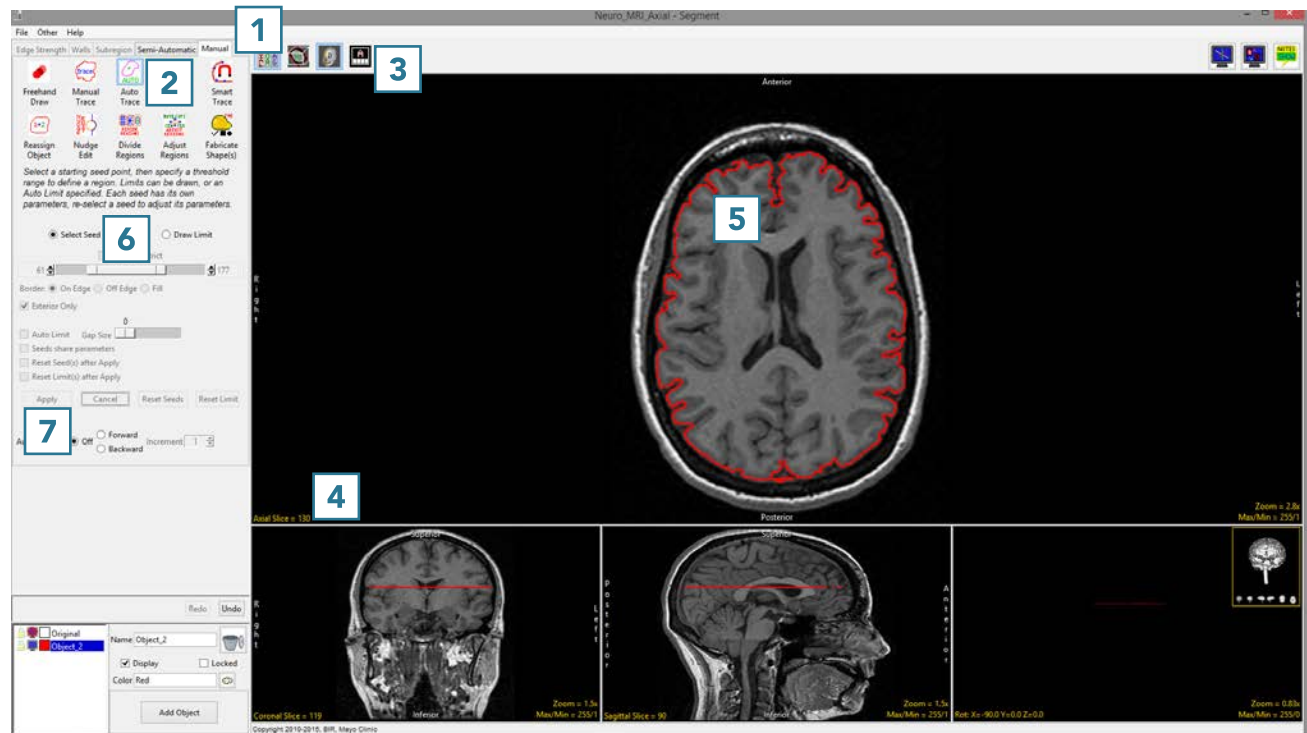
## 29. Radial Division of an Object

Like grid division, radial division of objects can be useful for subdividing structures into various substructures.

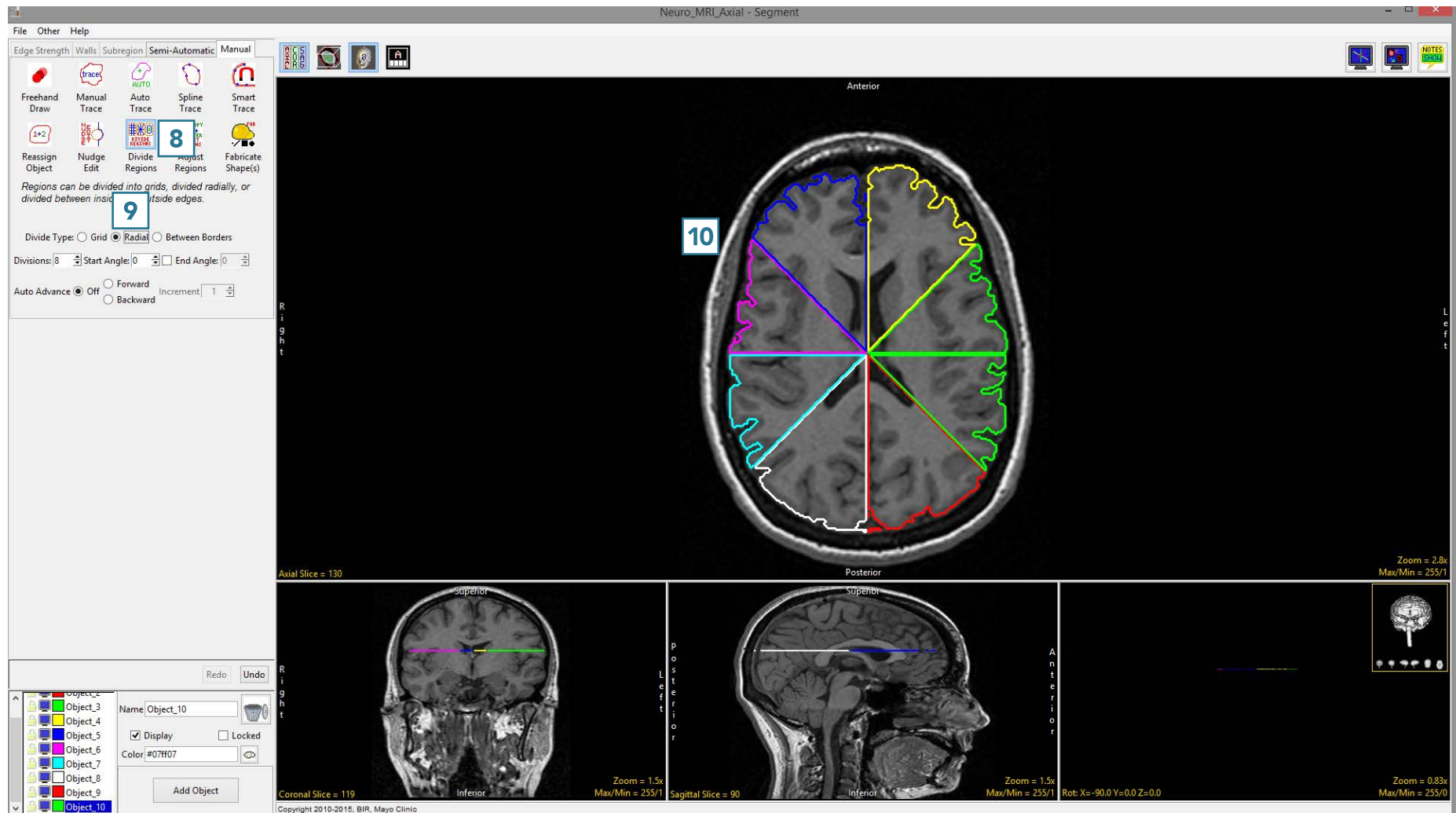
- Select MRI\_3D\_Head and open Segment.
- Select Manual **1** and choose Auto Trace. **2**
- Set the primary display to Axial **3** and use Slice **4** to move to axial slice 130.
- Set a seed pixel in the white matter **5** and adjust the minimum and maximum threshold values **6** to define the brain. A min value of 45 and max value of 125 works well for this data set.
- Click Apply **7** to define the brain.



Download the MRI\_3D\_Head data set to follow along  
<http://analyzedirect.com/data/>



- Select the Divide Regions tool **8** and set the Divide Type to Radial. **9**
- With Division set to 8, click anywhere in the brain to divide the object into 8 radial divisions. **10**





## Dividing Regions Between Borders

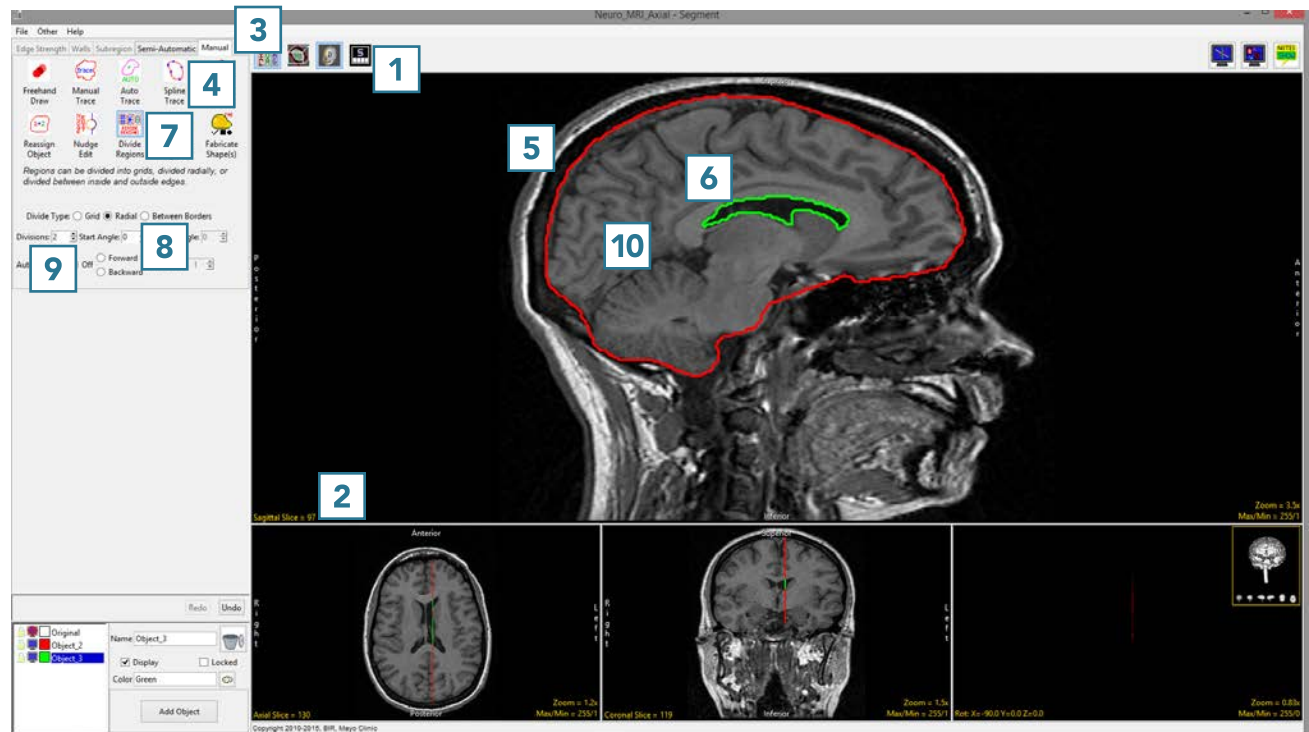
The Divide Regions Between Borders division type allows users to create a concentric set of objects. The tool will divide the area between an inner and outer border into the number of regions specified by the user, which is achieved by interpolating new borders between the inner and outer border.

## 30. Dividing Regions Between Borders – Interpolating Between Objects

- Select MRI\_3D\_Head and open Segment.
- Set the primary display to Sagittal **1** and use Slice **2** to move to sagittal slice 96.
- Select Manual **3** and choose Spline. **4**
- Use the Spline tool to define a region of interest around the brain. **5**
- Add a new object and define a region of interest around the ventricles. **6**
- Select the Divide Regions tool **7** and set the Divide Type to Between Borders. **8**
- Set the Divisions to 2. **9**
- Click anywhere in the brain between the red brain border and the green ventricle border. **10**

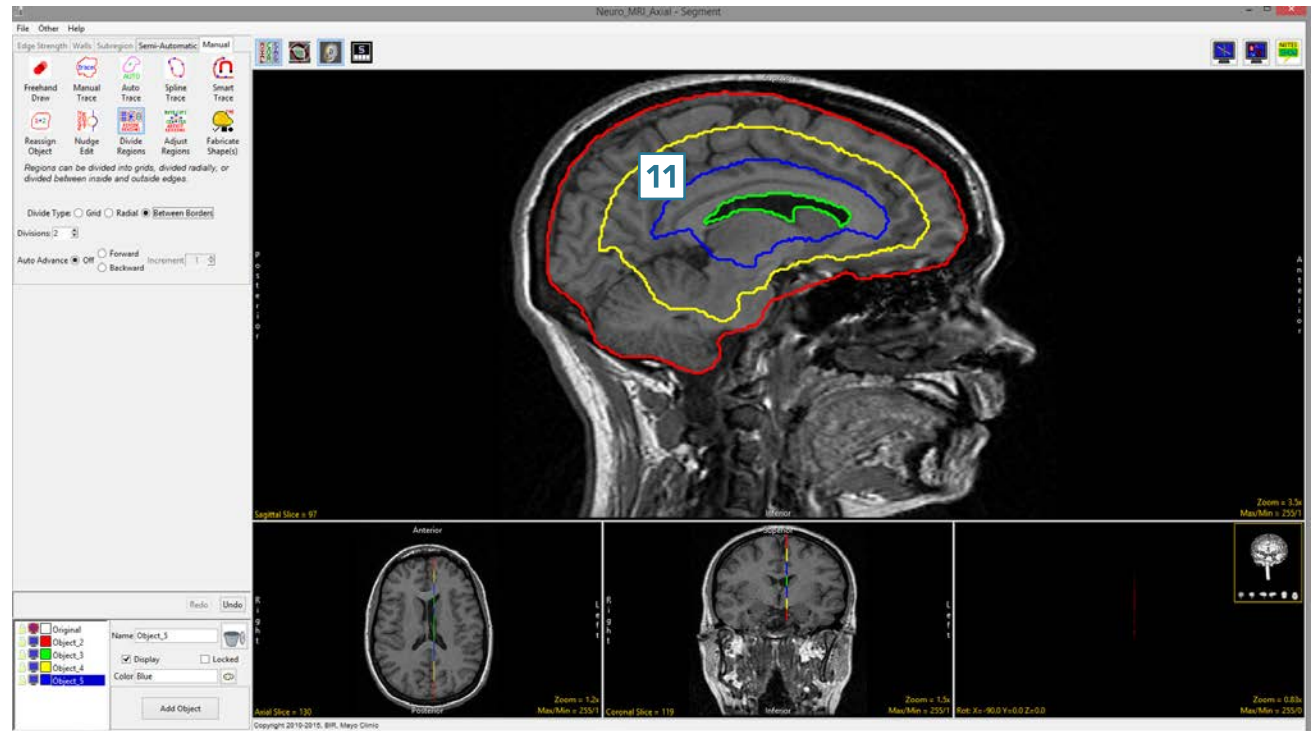


Download the MRI\_3D\_Head data set to follow along  
<http://analyzedirect.com/data/>





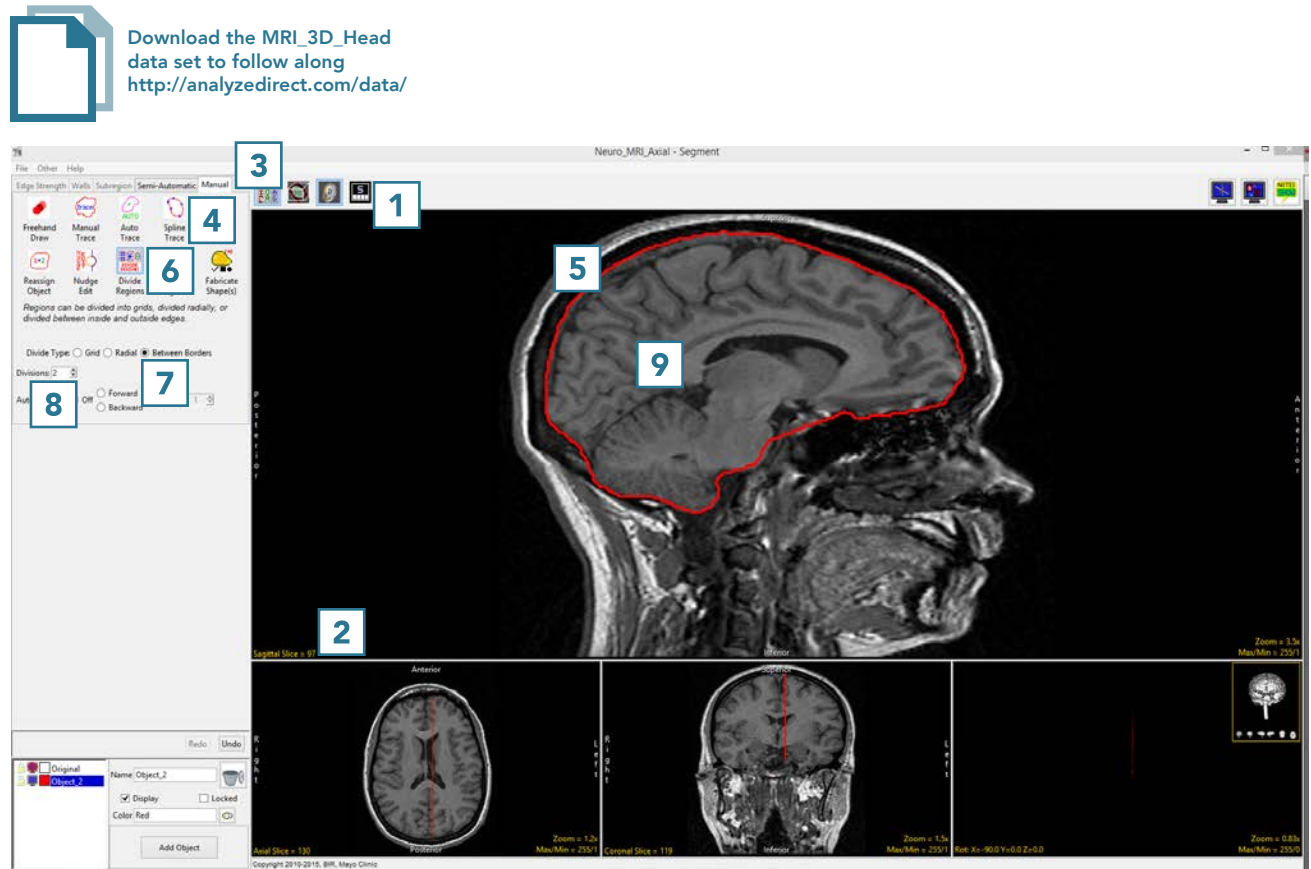
- 2 new regions will be interpolated between the brain and ventricles. **11**



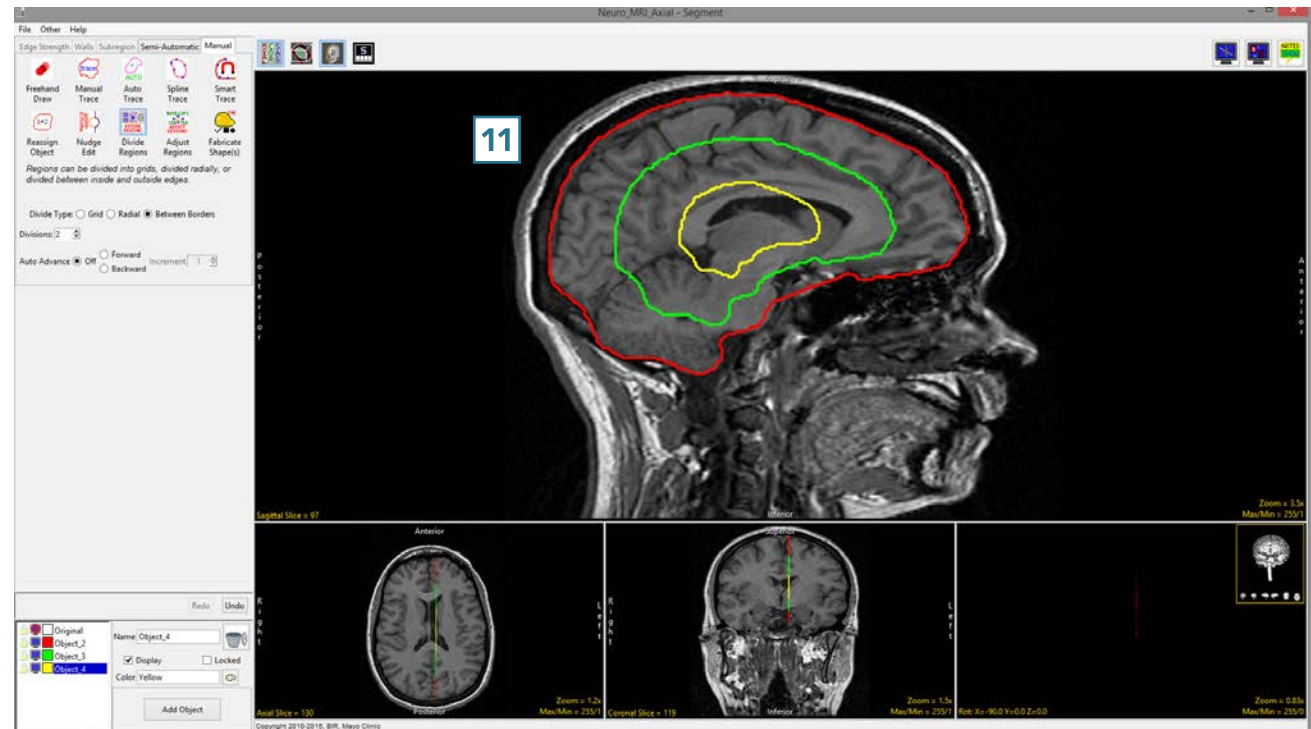
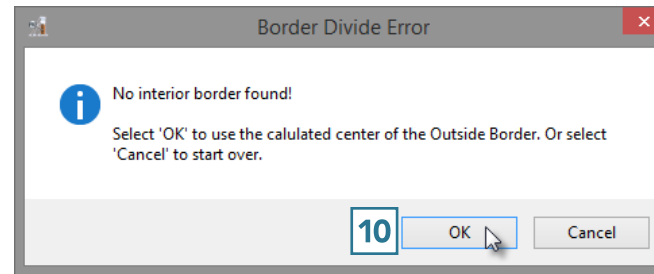
## 31. Dividing Regions Between Borders – Interpolating Within an Object

If there is no inner border defined when using the Divide Objects Between Border division type, the tool will calculate the center of the object and use this as an interpolation point, creating new interior object borders from the outer border.

- Select MRI\_3D\_Head and open Segment.
- Set the primary display to Sagittal **1** and use Slice **2** to move to sagittal slice 96.
- Select Manual **3** and choose Spline. **4**
- Use the Spline tool to define a region of interest around the brain. **5**
- Select the Divide regions tool **6** and set the Divide Type to Between Borders. **7**
- Set the Divisions to 2. **8** Click anywhere in the brain. **9**



- The tool will detect that there is no interior border and return a Border Divide Error. Click OK **10** to enable the tool to use the center of the outside border as an interpolation point to substitute the interior border.
- The object will be subdivided into regions interpolated from the outer border and the new regions will look like smaller versions of the outer border. **11**





## Adjust Regions

The Adjust Regions tool allows users to interactively manipulate regions. Users can rotate, translate, scale and deform objects.

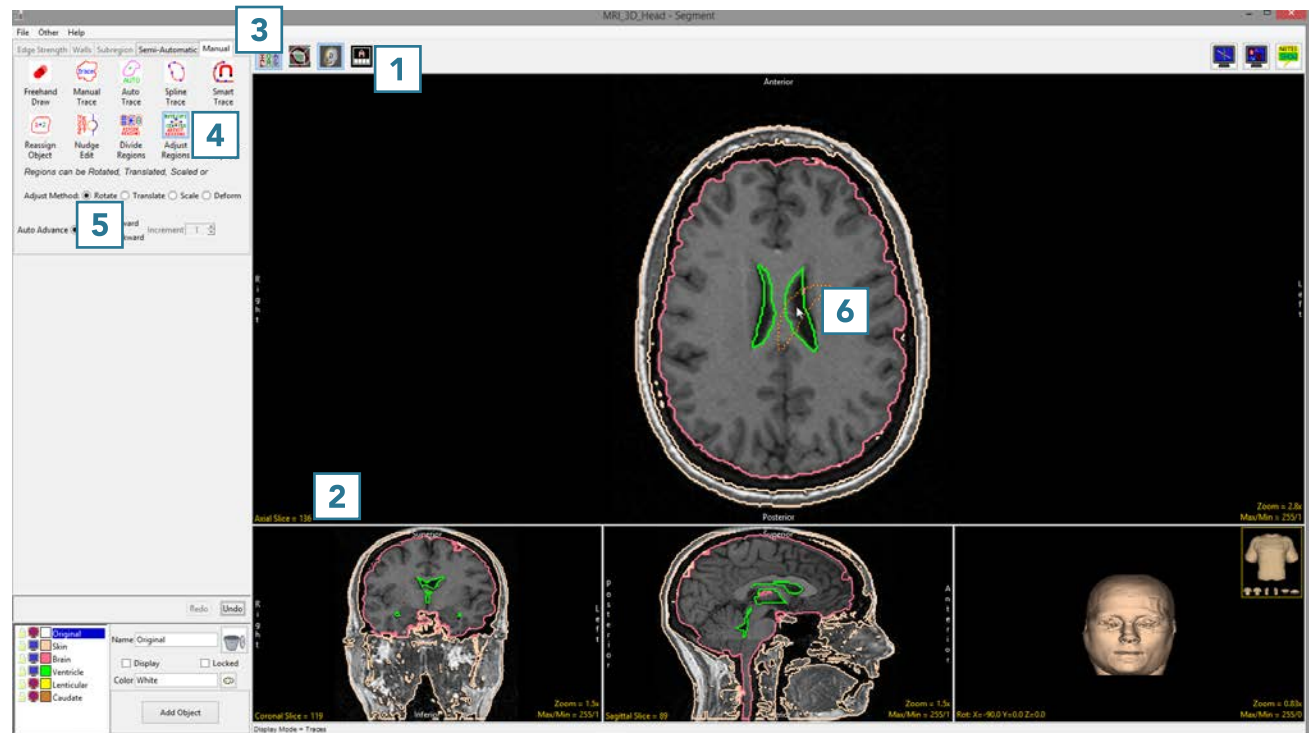
**Table 7.3: Adjust Regions**

Adjust Method	Function
Rotate	Rotates selected region clockwise or counterclockwise.
Translate	Translates selected region to a new location. Users can drag the region or a copy of the region to a new location. Objects can also be recentered around the brightest pixel in the object.
Scale	Increases or decreases the size of the region in the horizontal and/or vertical direction.
Deform	Deforms the selected object.

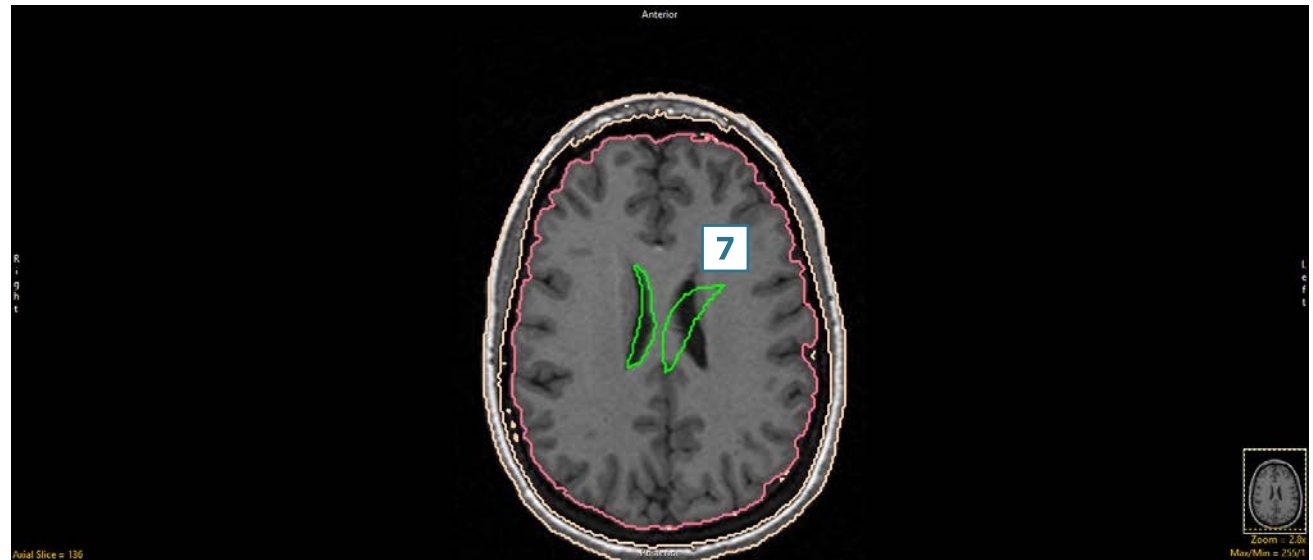
- Select MRI\_3D\_Head and open Segment.
- Select File > Load Object Maps and load MRI\_3D\_Head.obj.
- Set the primary display to Axial 1 and move to Axial slice 136. 2
- Select Manual 3 and choose Adjust Regions. 4
- Set the Adjust Method to Rotate. 5
- Click in an object to select it and move the mouse up or down to rotate the object. 6



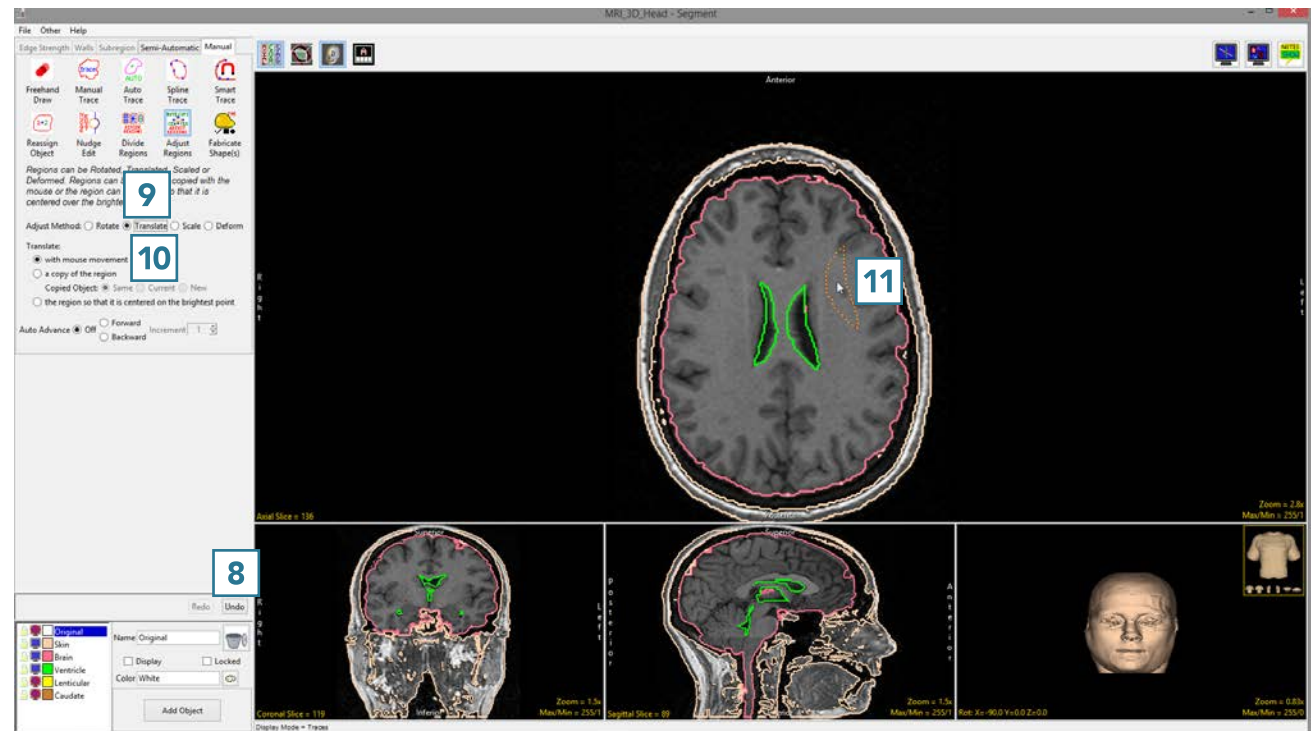
Download the MRI\_3D\_Head data set to follow along  
<http://analyzedirect.com/data/>



- Release the mouse button to end the rotation and commit the rotation to the object. **7**

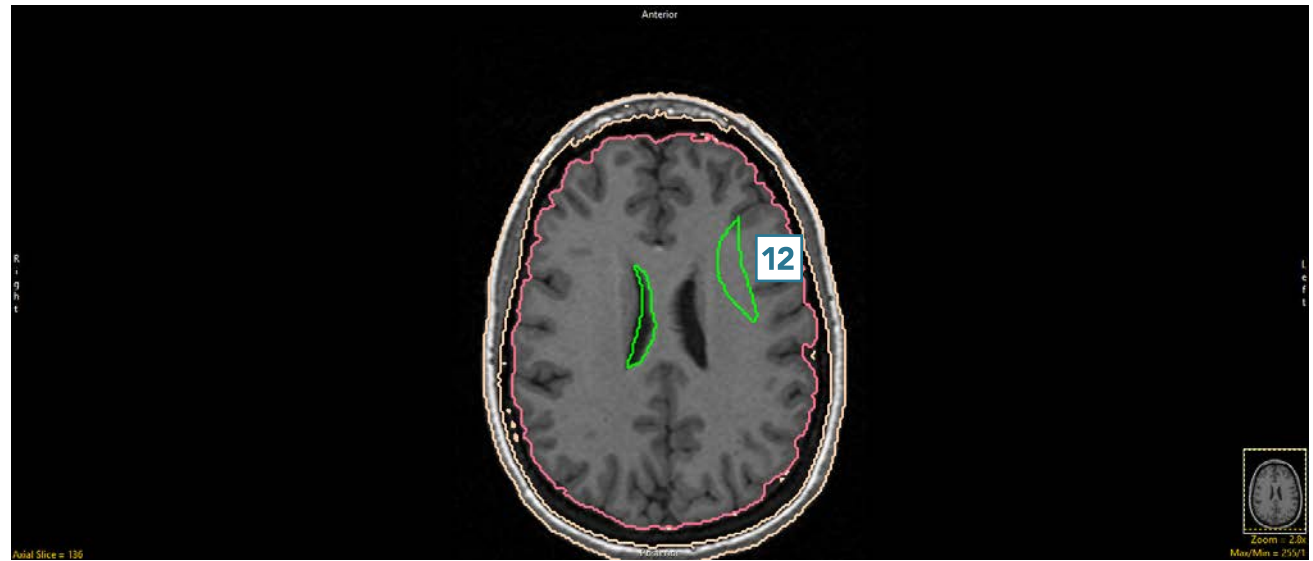


- Click Undo **8** and set the Adjust Method to Translate. **9**
- With the Translate option set to with mouse movement, **10** click in an object and drag to a new location. **11**

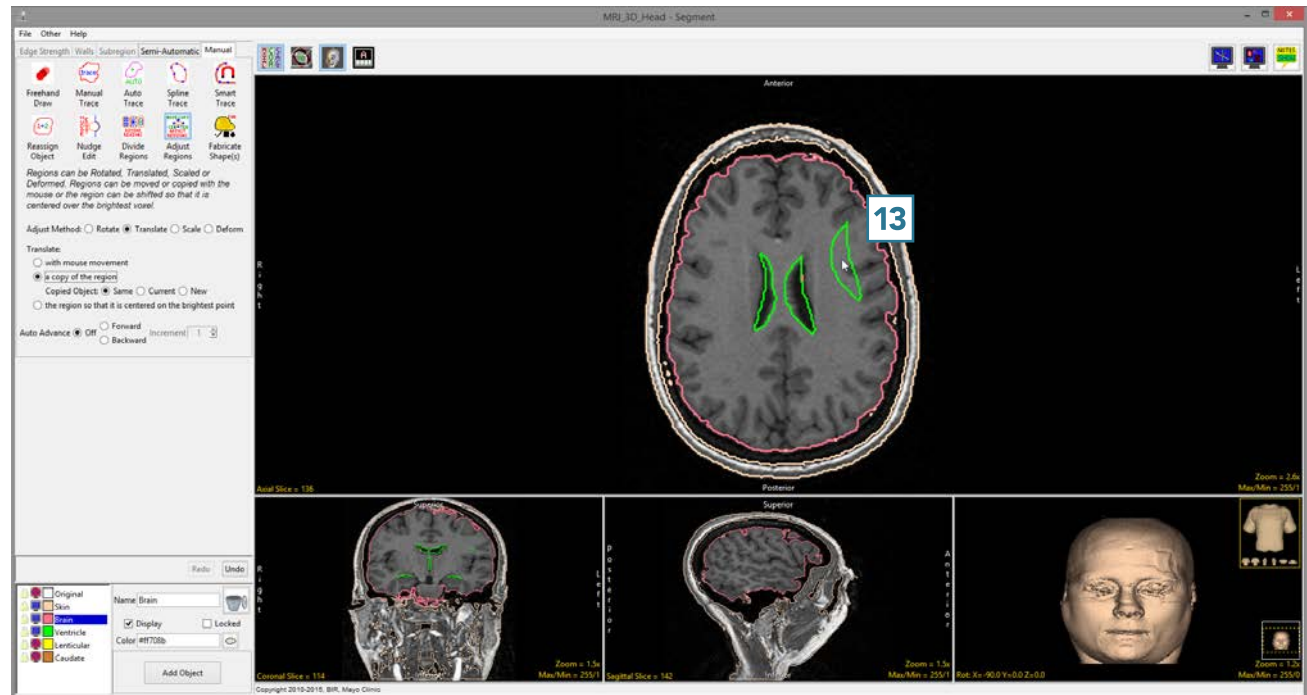




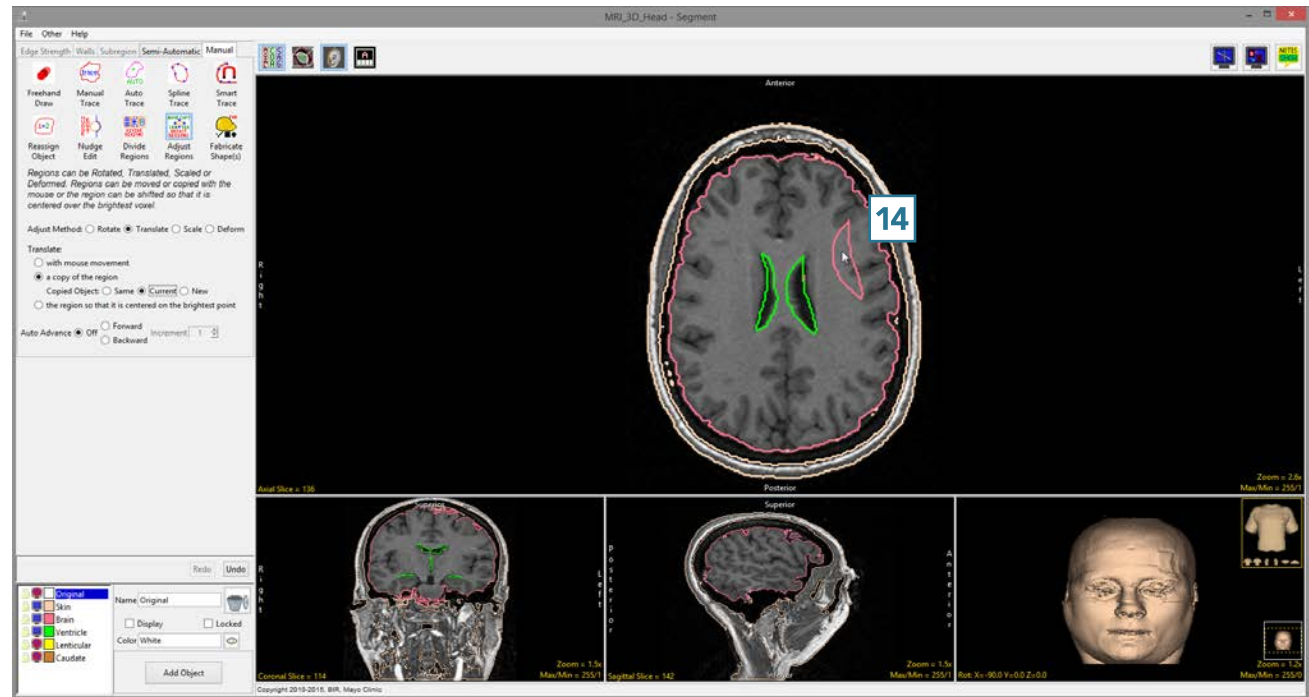
- Release the mouse button to end the translation. The object will be moved to the new location. **12**



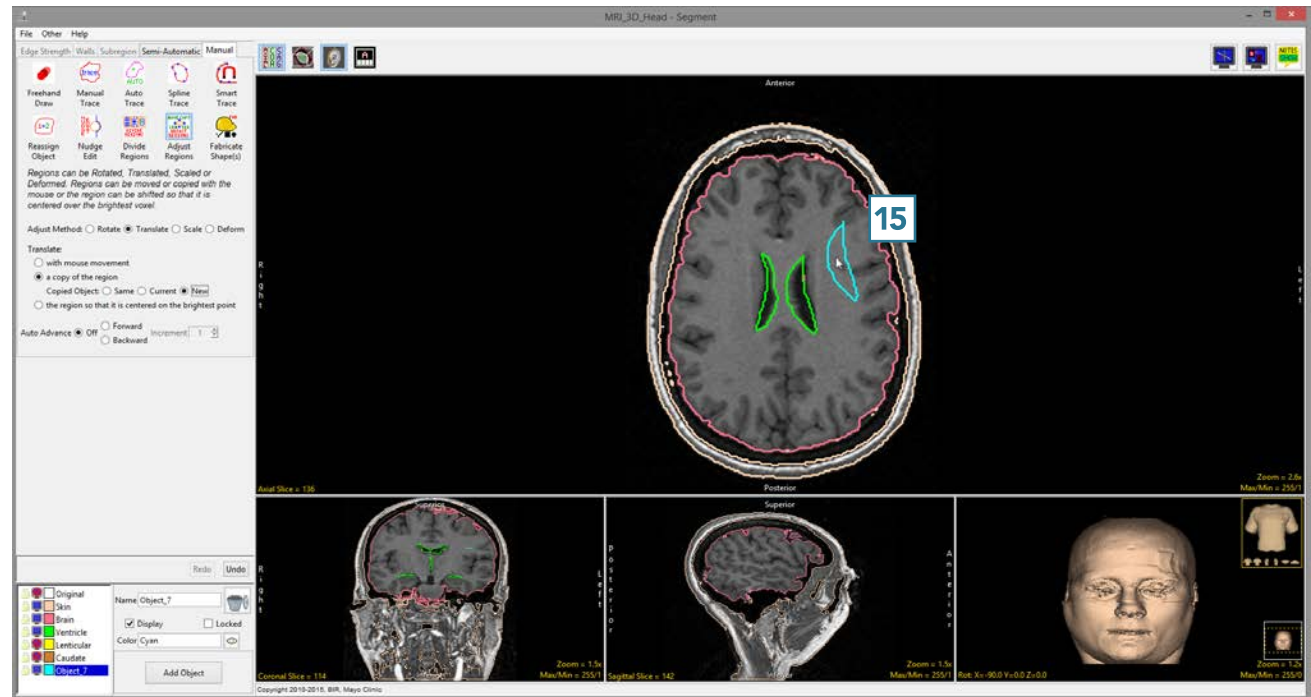
- Setting the Translate option to 'a copy of the region' will allow you to make a copy of the selected object and move to a new location.
- Setting Copied Object to Same assigns voxels in the new region to the same object as the parent region. **13**



- Setting Copied Object to Current assigns voxels in the new region to the object currently selected in the Object Control window. **14**

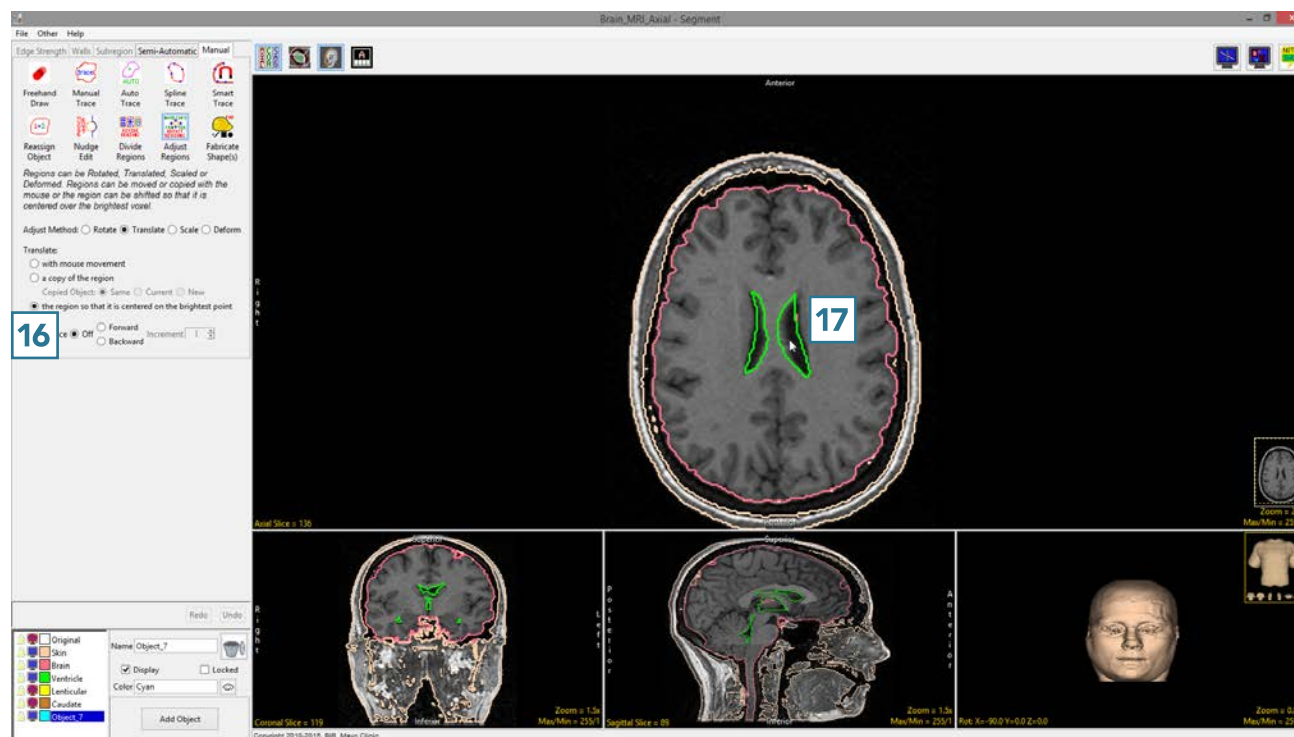


- Setting Copied Object to New assigns voxels in the new region to a new object. **15**

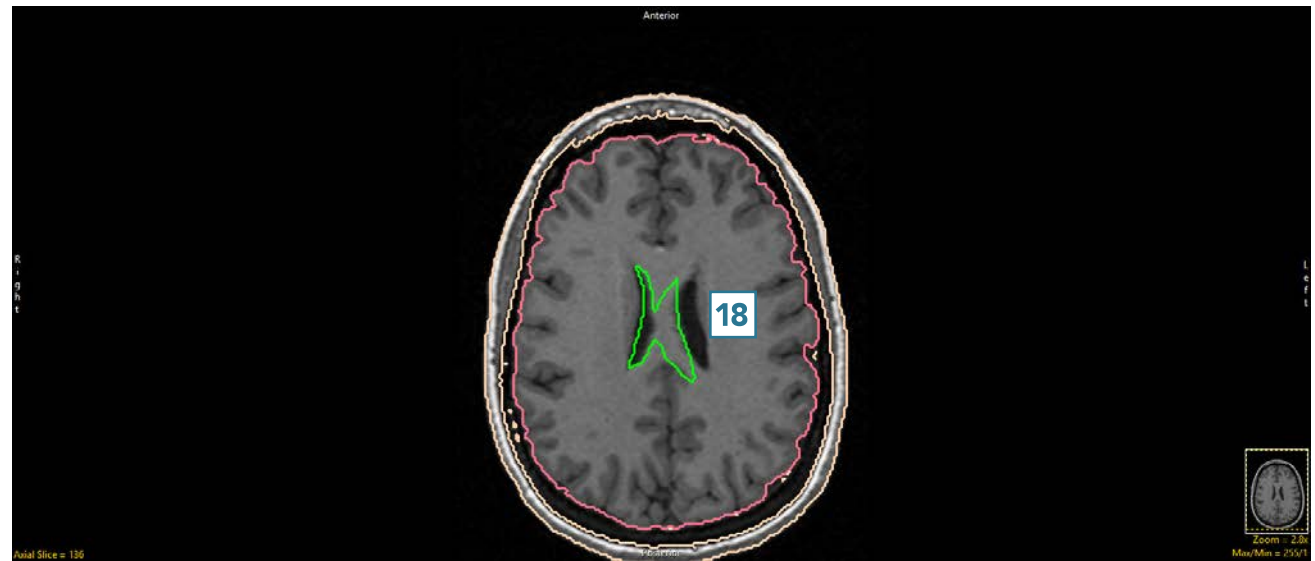


The Translate Adjust Method also allows users to Translate the region so that it is centered on the brightest point. With this option, the tool calculates the brightest pixel in the object and sets that as the center of the object, translating the object appropriately.

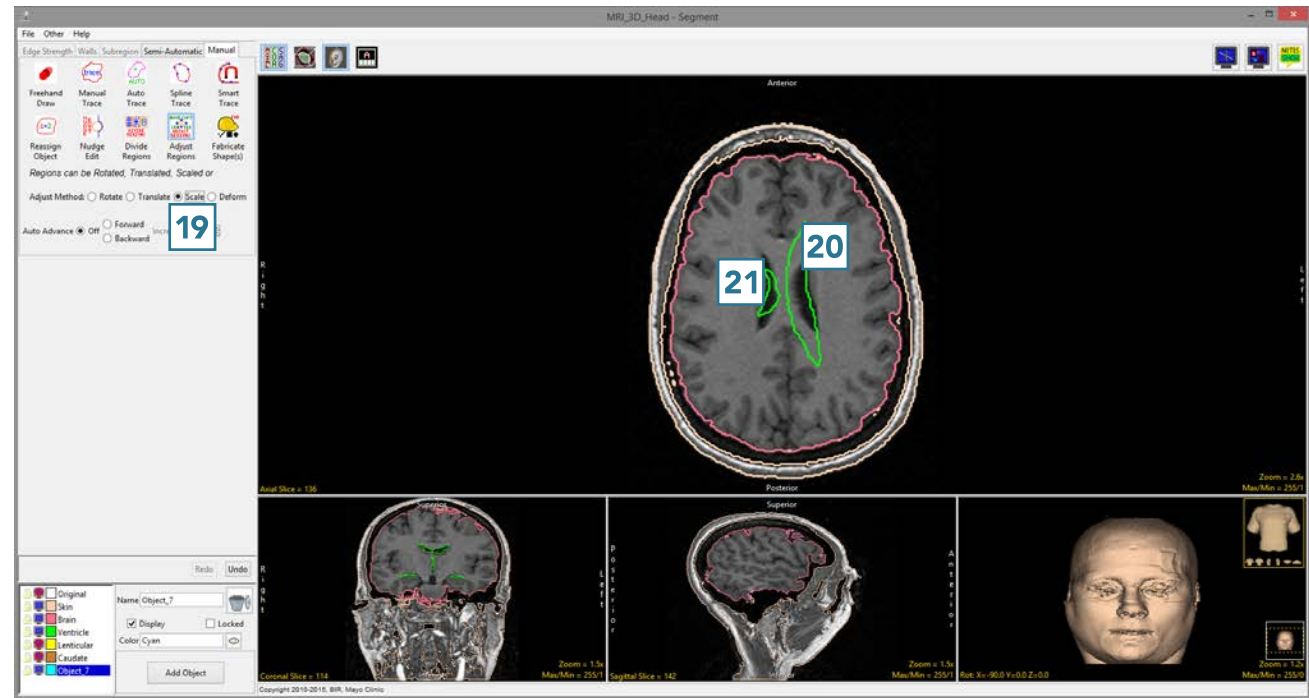
- Set the Translate method to the region so that it is centered on the brightest point. **16**
- Click in an object. **17**



- The region will instantly be recentered around the brightest point in the object. **18**

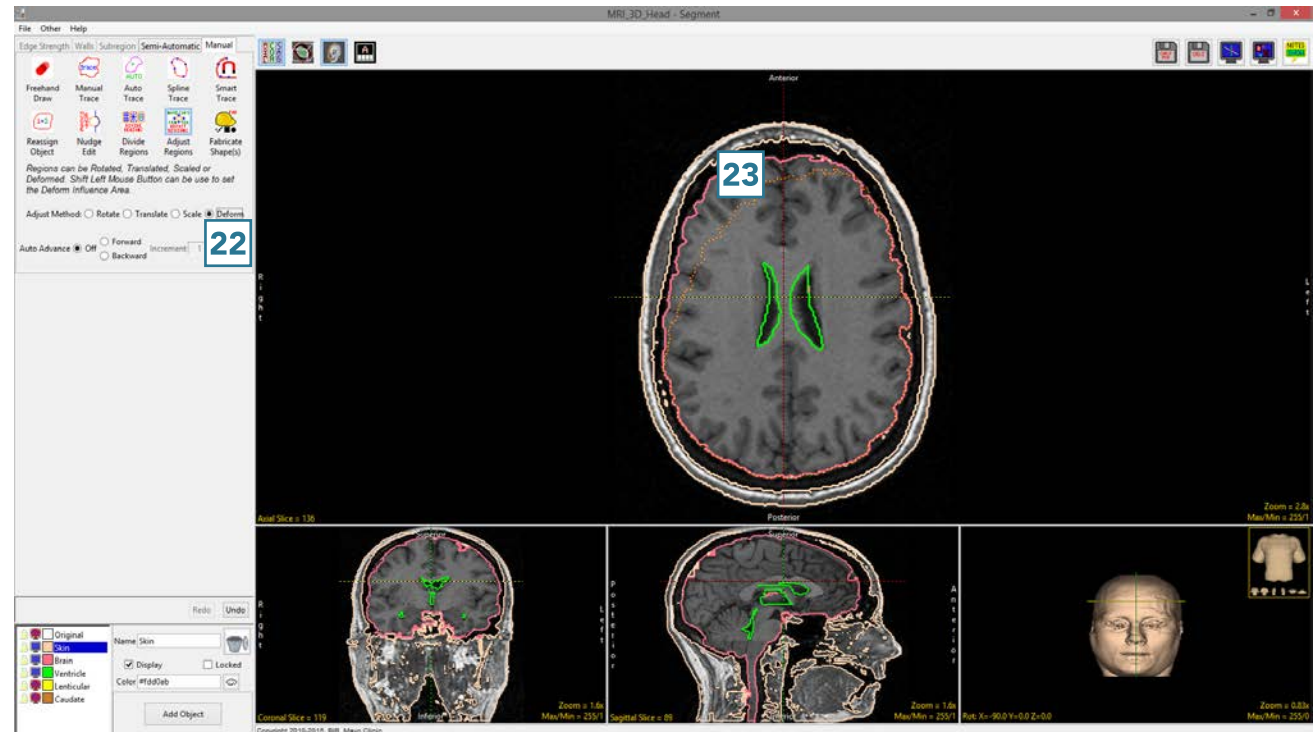


- Click Undo.
- Set the Adjust Method to Scale. **19**
- Click in an object and move your mouse to increase the scale of the selected object. **20**
- Moving the mouse up and down adjusts the scale in the vertical direction. Moving the mouse left and right adjusts the scale in the horizontal direction. Moving the mouse diagonally adjusts the scale of the object while preserving the shape. Release the button to commit the scale manipulation to the object.
- Click in an object and then move your mouse to decrease the scale of the selected object. **21**
- Release the button to commit the scale manipulation to the object.





- Undo the previous manipulations.
- Set the Adjust Method to Deform. [22]
- Click in an object and move your mouse to experiment with the deformations available. [23]  
In this example the user is deforming the border of the brain object.
- Releasing the mouse button will apply the deformation to the object.



## Fabricate Shape(s)

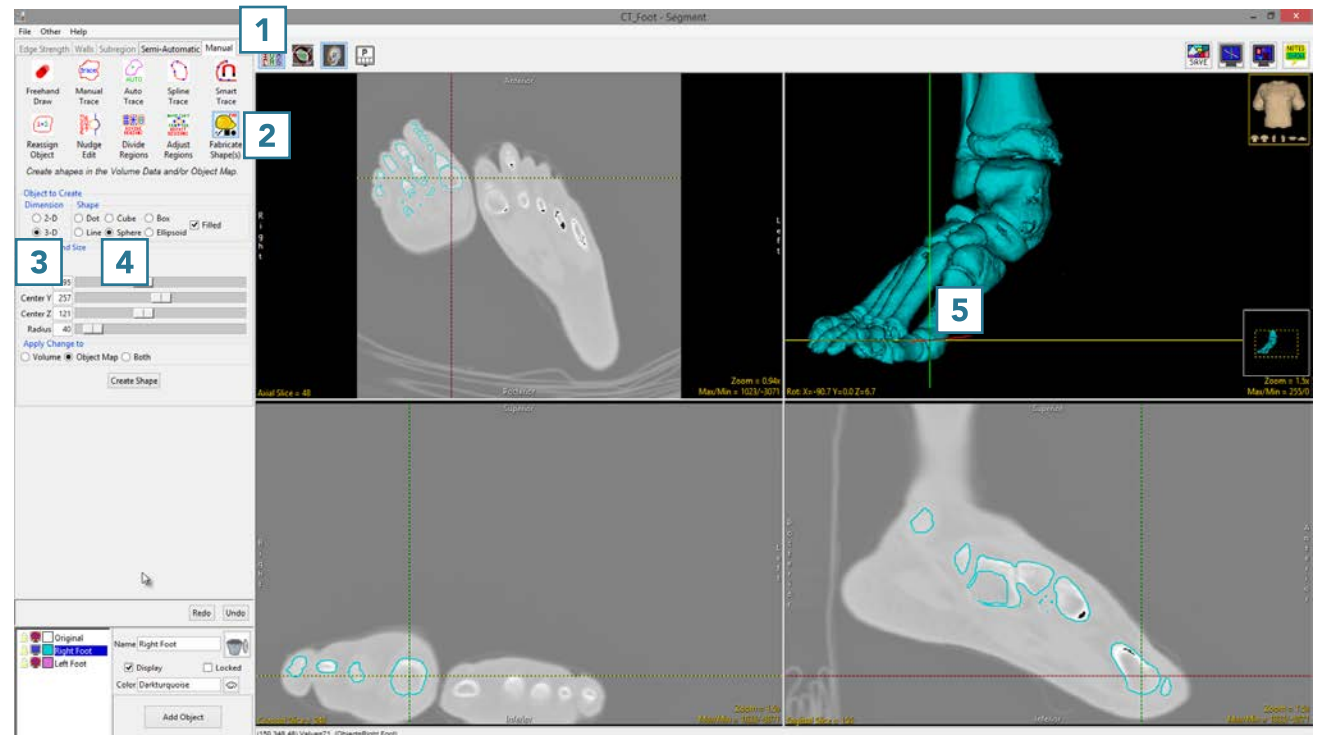
The Fabricate Shape(s) tool allows users to create 2D and 3D objects in the object map or input grayscale data. The tool provides options for users to create shapes interactively or by loading a list of coordinates defined in a text file.



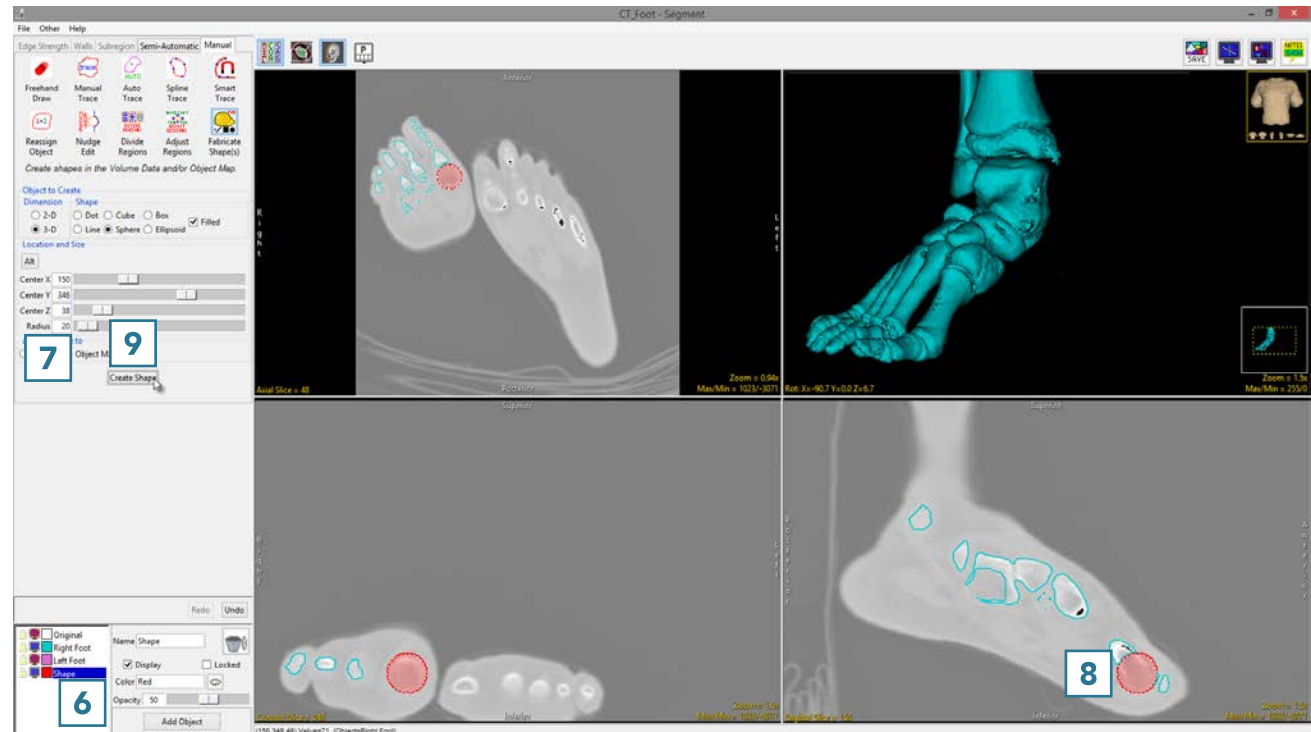
Download the CT\_Foot data set to follow along  
<http://analyzedirect.com/data/>

## 32. Creating a Shape

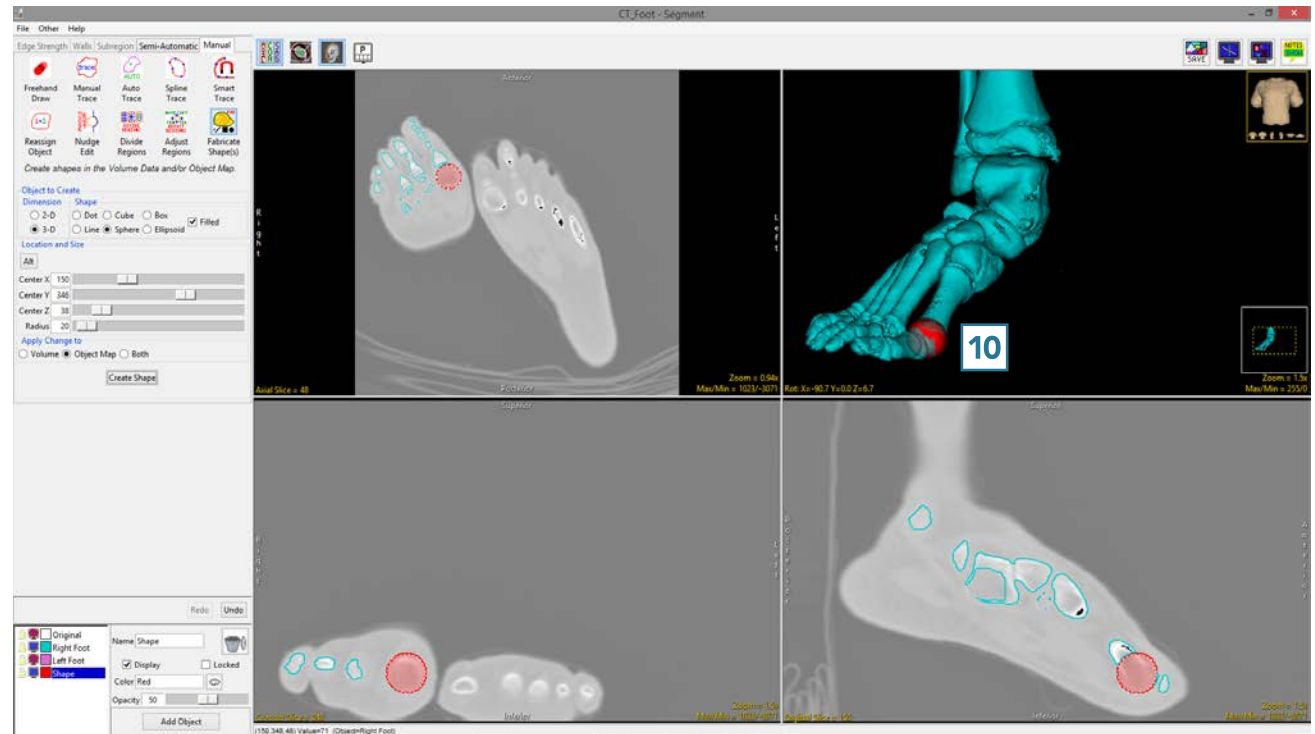
- Select CT\_Foot and open Segment.
- Select File > Load Object Maps and load CT\_Foot.obj.
- Select Manual **1** and choose Fabricate Shape(s). **2**
- Set the Dimension to 3D **3** and set the Shape to Sphere. **4**
- Use the linked cursor to navigate to the location where you would like to create the new shape. **5**



- Add a new object, name it and assign a color. **6**
- Change the Radius of the sphere **7** and drag the 2D shape template in any of the images to the location you where you want to create the shape. **8**
- Select Create Shape. **9**



- The shape will be created and added to the object map. Right-click on the rendering and select Transparency for a clearer view of the object in 3D. **10**

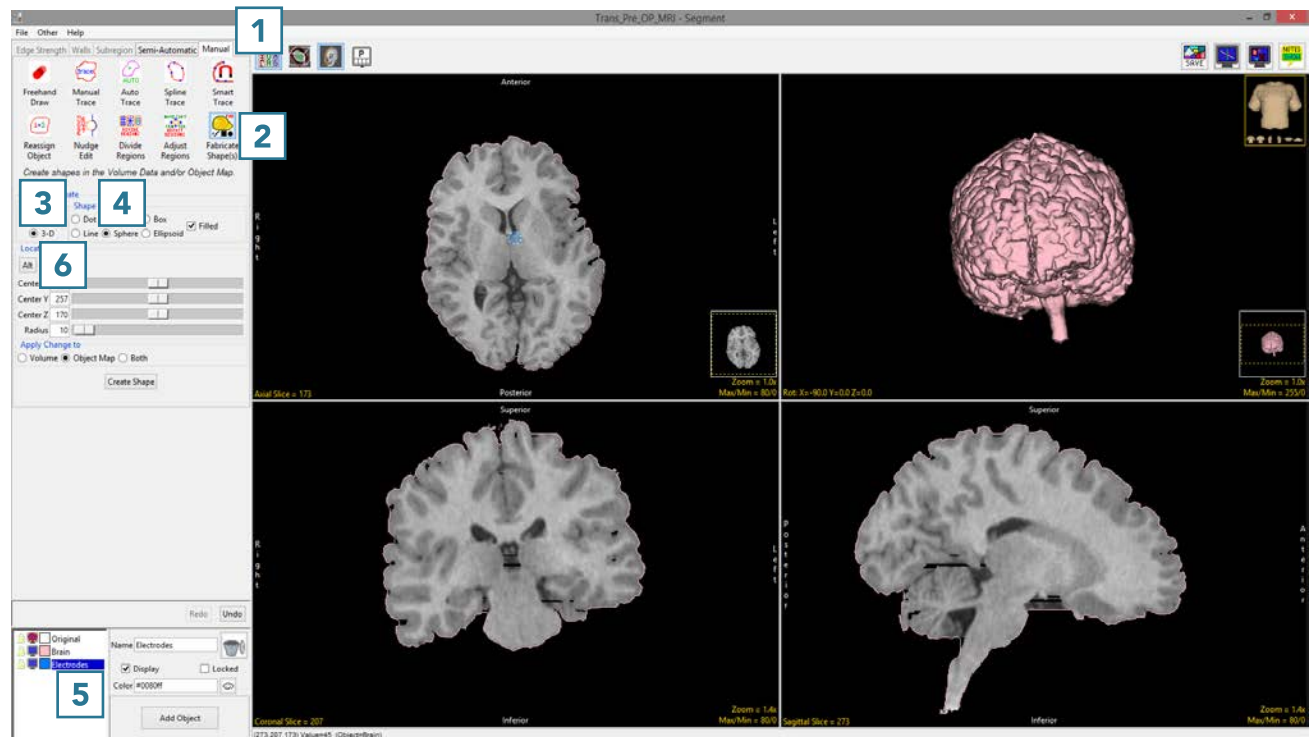


### 33. Creating Objects from a Text File

- Select Trans\_Pre\_OP\_MRI and open Segment.
- Select File > Load Object Maps and load Trans\_Pre\_OP\_MRI\_brain.obj.
- Select Manual **1** and choose Fabricate Shape(s). **2**
- Set the Dimension to 3D **3** and set the Shape to Sphere. **4**
- Add a new object, name it Electrodes and assign a color to the object. **5**
- Click on the Alt button **6** and select File.

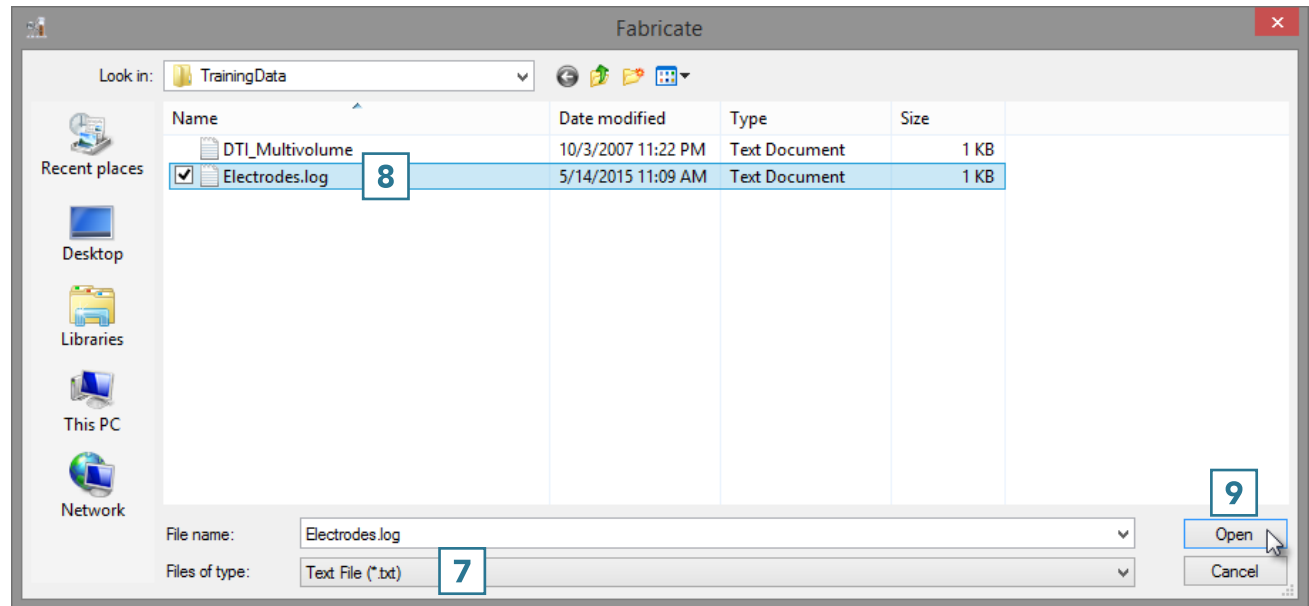


Download the Trans\_Pre\_OP\_MRI data set to follow along  
<http://analyzedirect.com/data/>

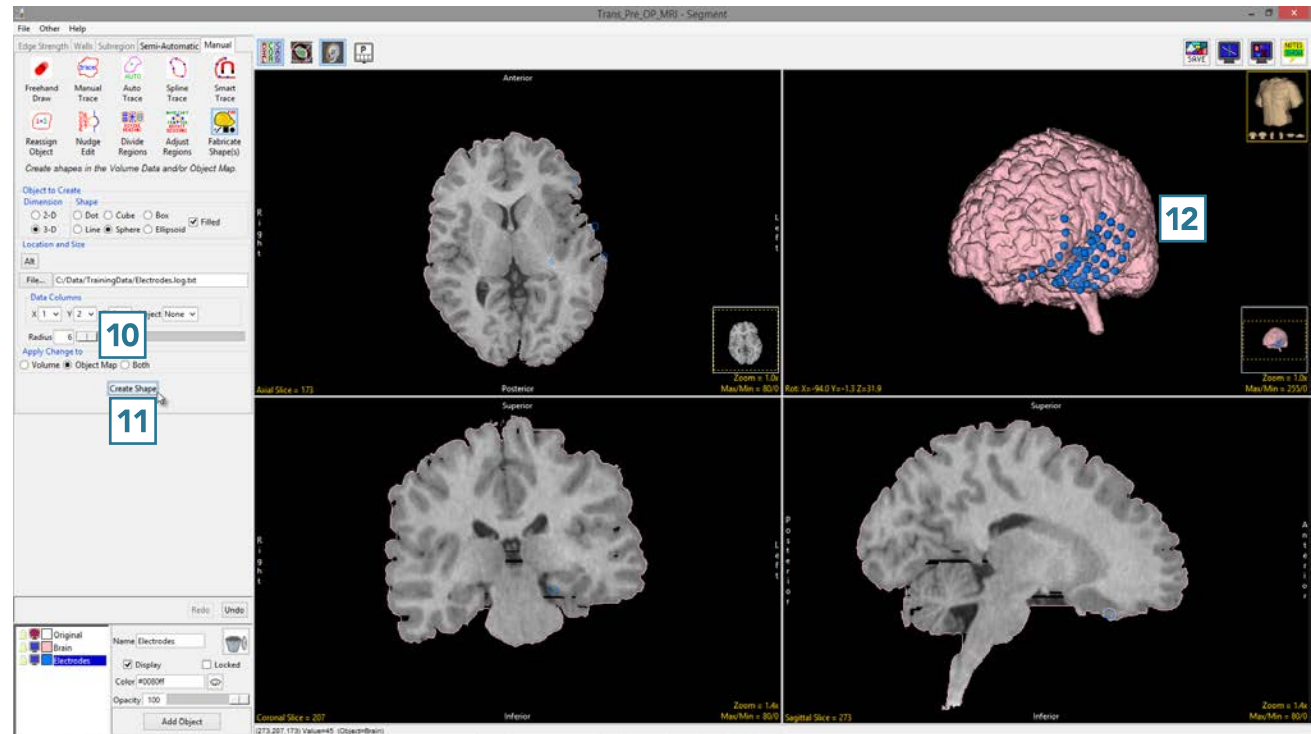




- In the window returned set Files of type to Text File (\*.txt). **7**
- Select Electrodes text file **8** and click Open. **9**



- Set the Radius to 6 **10** and click Create Shape. **11**
- Once created, the new shapes will be added to the object map and can be viewed overlaid on the 2D images and in the 3D rendering. **12**
- Right-click on the rendering and select Transparency for a clearer view of the objects in 3D.
- Select File > Save Object Map and save your object map as Trans\_Pre\_OP\_MRI\_brain\_and\_electrodes.obj.







# Manual Tools for 3D Editing

Some of the manual tools have the capability to be used to edit objects in 3D. This is achieved by drawing directly on the 3D rendering.



Download the CT\_Foot data set to follow along  
<http://analyzedirect.com/data/>

## 34. 2D Manual Trace Editing of Object Maps

- Select CT\_Foot and open Segment. **1**
- Set the primary display to Render. **1**
- Select Semi-Automatic **2** and choose Threshold Volume. **3**
- Set a Threshold range **4** to isolate the bones of both feet and click Threshold Object. **5**



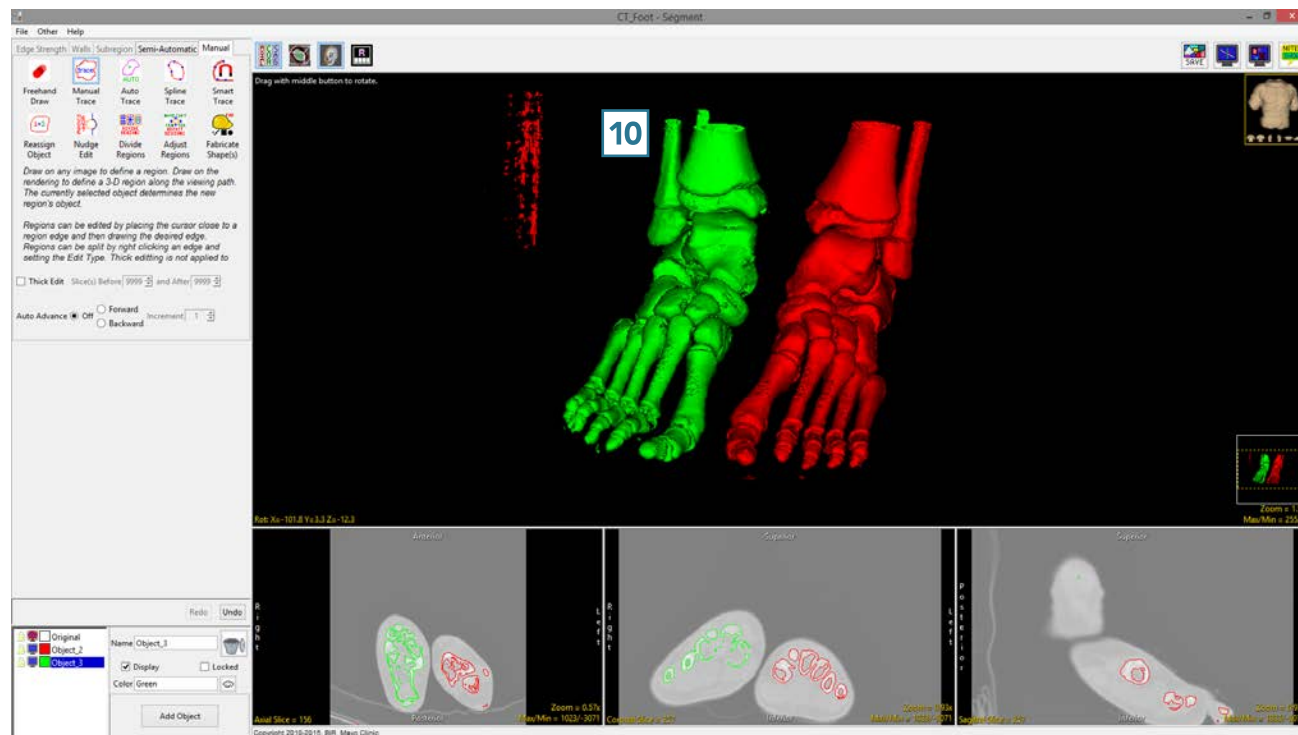


- Select Manual **6** and choose Manual Trace. **7**
- Add a new object. **8**
- Move the cursor to the Rendering and trace around the right foot. **9**





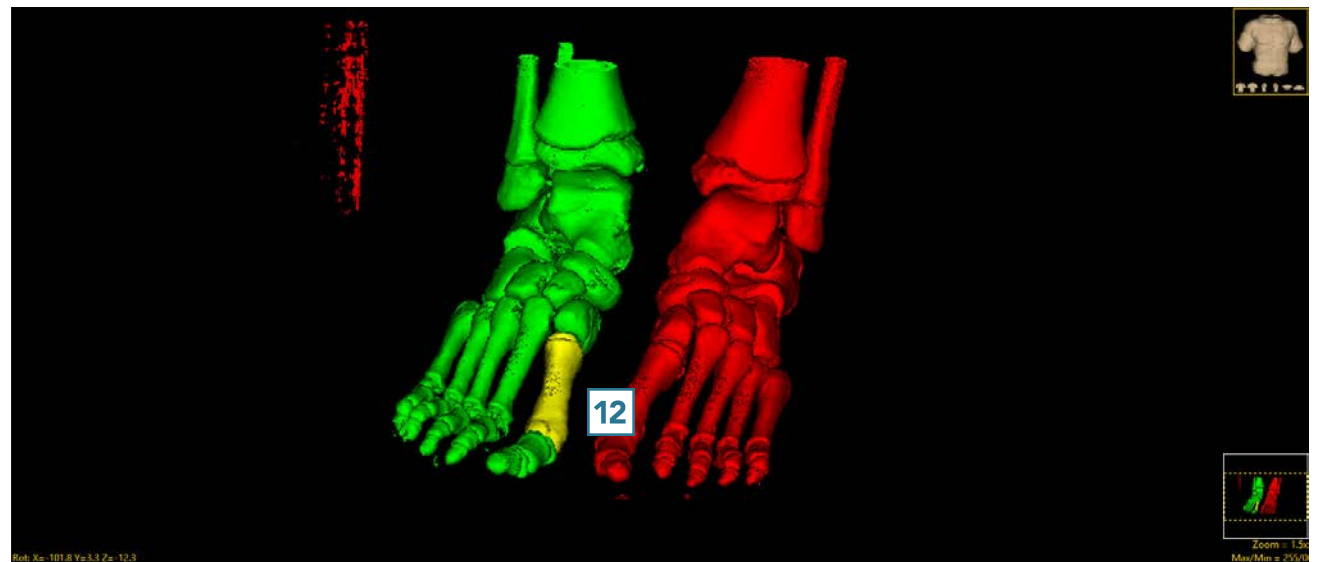
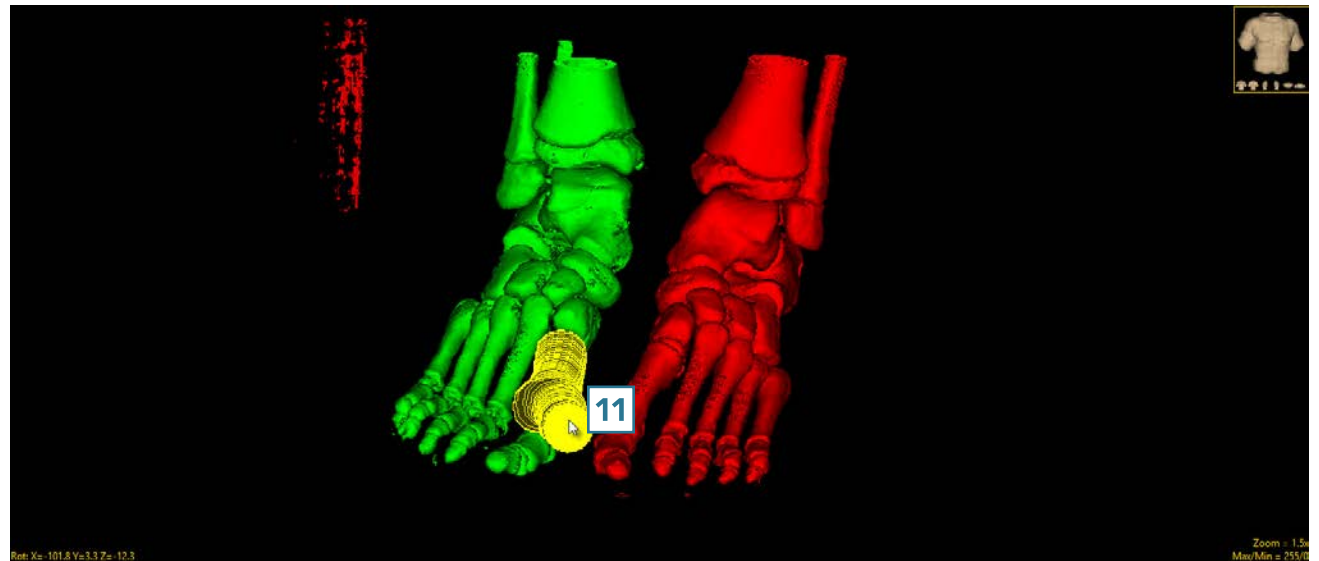
- Complete the trace and release the left mouse button. All voxels not assigned to the Original object within the trace will be assigned to the selected object. **10**





## 35. 2D Freehand Draw Editing of Object Maps

- Add a new object.
- Select the Freehand Draw trace and trace over one of the bones in the right foot. **11**
- Everything under the region will be assigned to the selected object. **12**

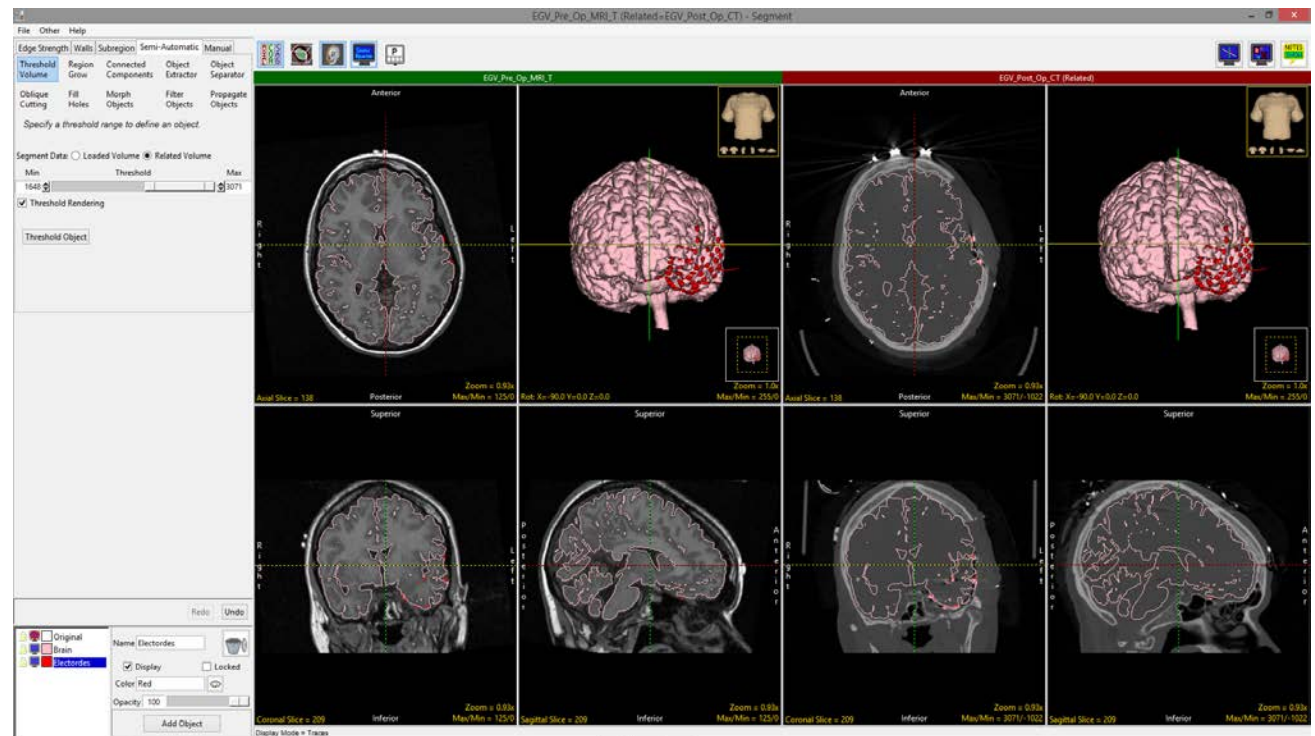




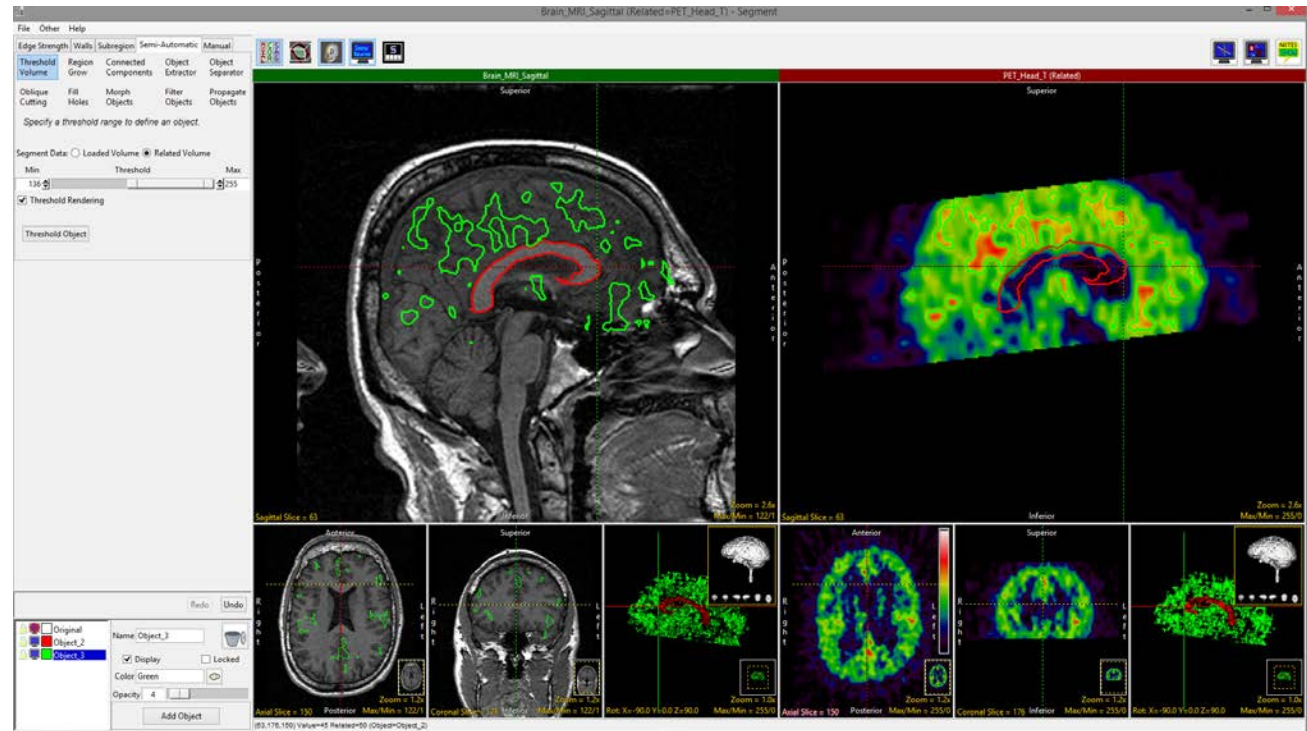
# Dual Input Segmentation

Segment allows users to load two registered input data sets. The ability to load related volumes is powerful and allows users to segment structures from either data set.

- Load registered pre-operative MRI and post-operative CT.
- Segment the brain from the MRI and electrodes from the CT.



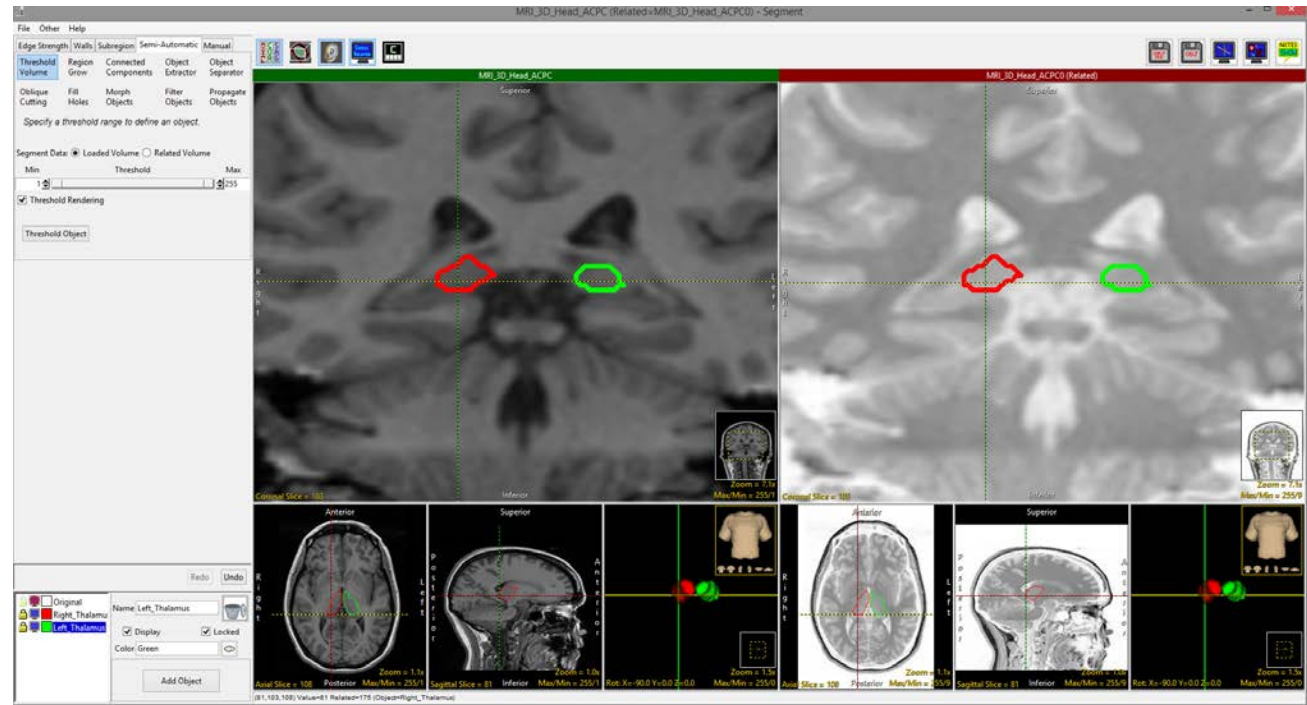
- Load registered structural MRI and functional PET data. Structural regions can be delineated on the MRI and viewed on the PET, while regions of activity or uptake can be viewed on the functional data and displayed on the MRI.







- Loading two copies of the same input data set allows users to adjust or invert intensity display values on the related volume. This can be leveraged to assist with the segmentation of brain structures such as the thalamus.





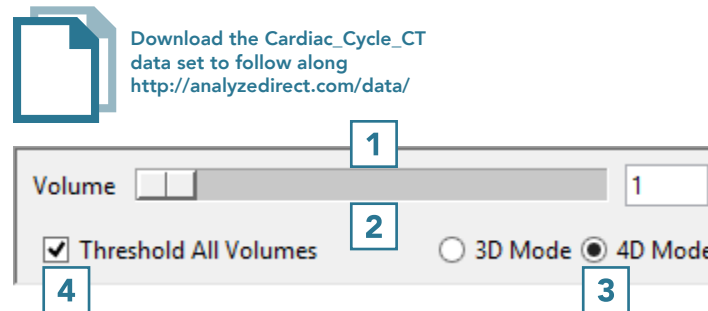


# 4D Segmentation

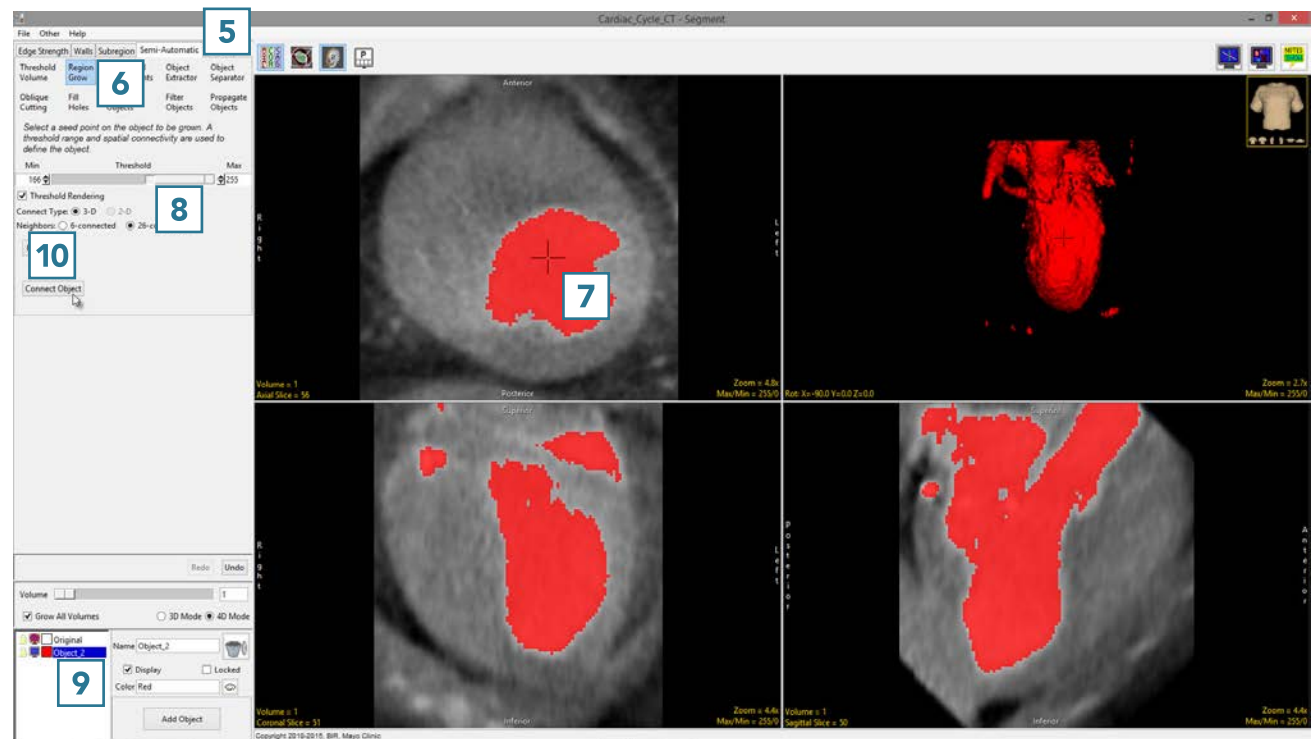
Segment supports 4D multivolumes. Users can use all of the segmentation tools to derive 2D, 3D, or 4D regions of interest. Segmentation using many of the Semi-Automatic tools can be configured to automatically propagate to the next 3D volume in the 4D multivolume as soon as the first segmentation is complete.



- Load the Cardiac Cycle CT data set into AnalyzePro.
- Select the multivolume and open Segment.
- A Volume control window will be available above the object control window. **1**
- The slider **2** allows users to navigate through the 3D volumes in the multivolume.
- The window also provides the user with options to create a 3D or 4D object map **3** and to enable or disable the currently selected semi-automatic segmentation tool to be applied to all volumes in the multivolume. **4**

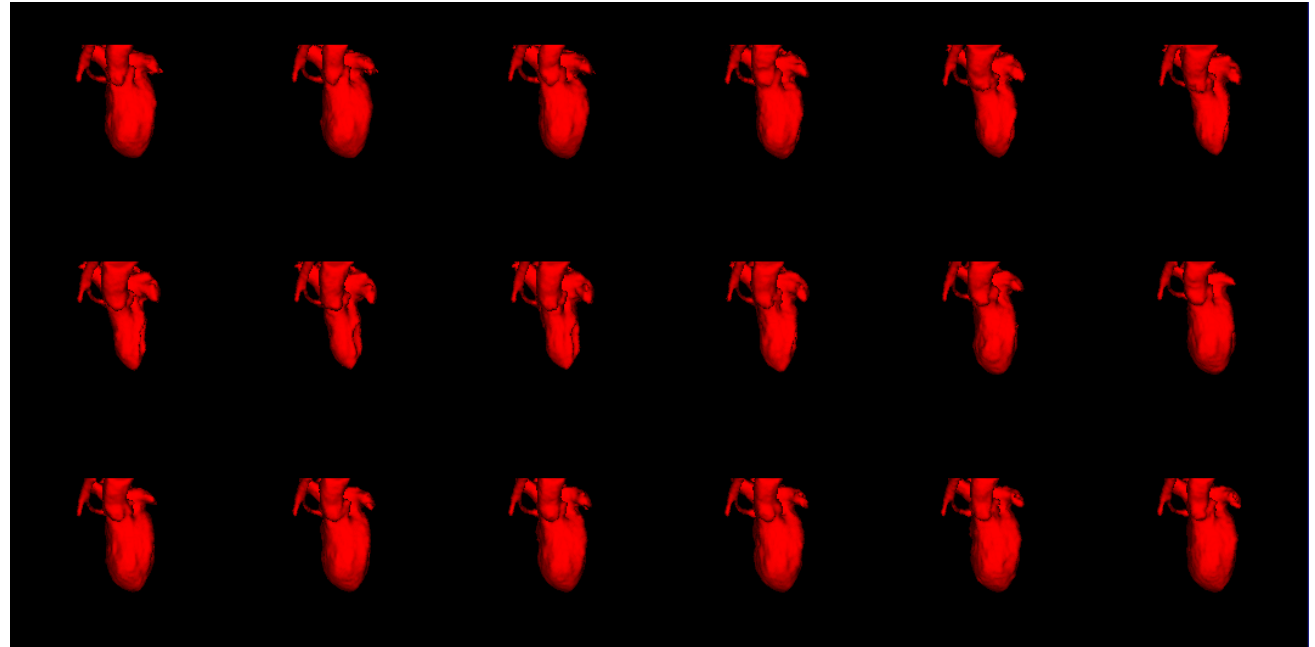


- Select Semi-Automatic **5** and choose Region Grow. **6**
- Set a seed point in a blood pool **7** and set a threshold range to isolate the object of interest. **8**
- Confirm mode is set to 4D and the Grow All Volumes option is checked. **9** Click Connect Object. **10**





Segment will isolate the object from the first volume of the multivolume. After segmentation is complete, the parameters used to isolate the object from the first volume will be copied to the next volume and the blood pool will be segmented on the second volume. This will continue until all volumes have been processed. Use the volume slider to navigate through the multivolume to review the segmentation results.





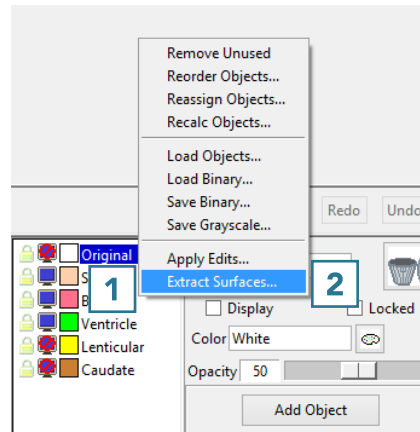
# Generating Surface Files from Objects

Segment provides users with the ability to export surface files for segmented structures.

- Select MRI\_3D\_Head and open Segment.
- Select File > Load Object Maps and load MRI\_3D\_Head.obj.
- Right click on the object list 1 and select Extract Surface. 2



Download the MRI\_3D\_Head data set to follow along <http://analyzedirect.com/data/>





- Select the objects that you will use to generate a surface file. **3**
- The output surface name will be the same as the object name. If desired, rename the output surface file name. **4**
- Select the surface generation method. **5**
- Set the Output Directory. **6**
- Choose the output format. **7**
- Click Extract Surface(s). **8**
- When surface generation is complete a notification will be returned letting you know that the selected surfaces have been generated and saved. Click OK **9** to close the window.

