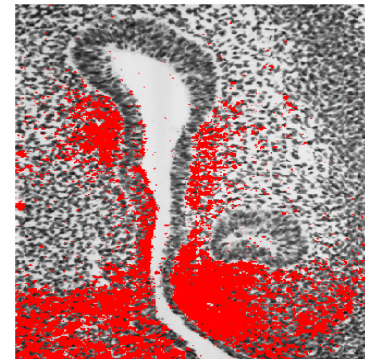
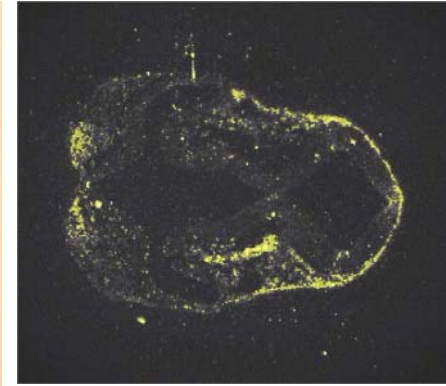
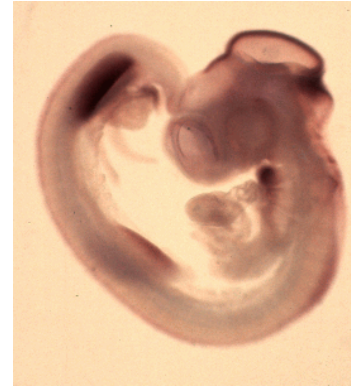
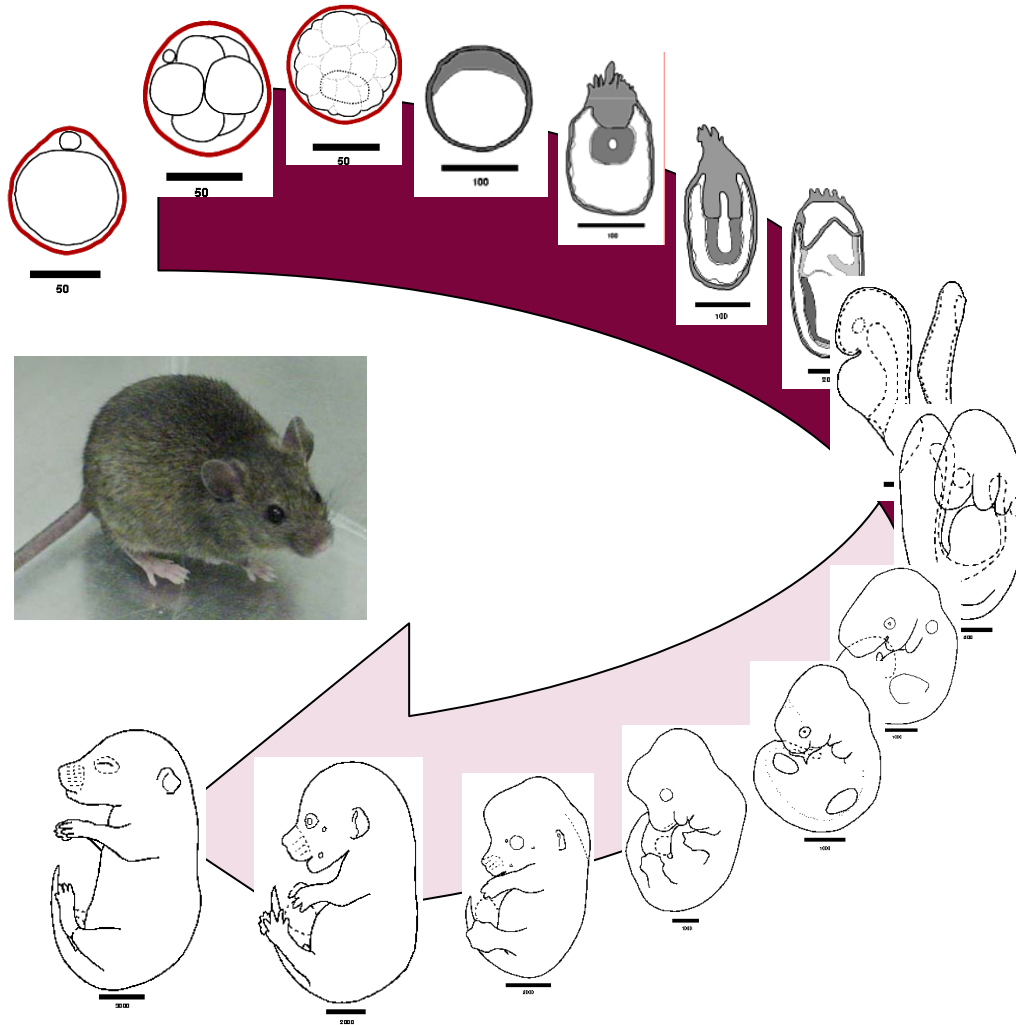


Mining Spatio-Temporal Gene-Expression Data

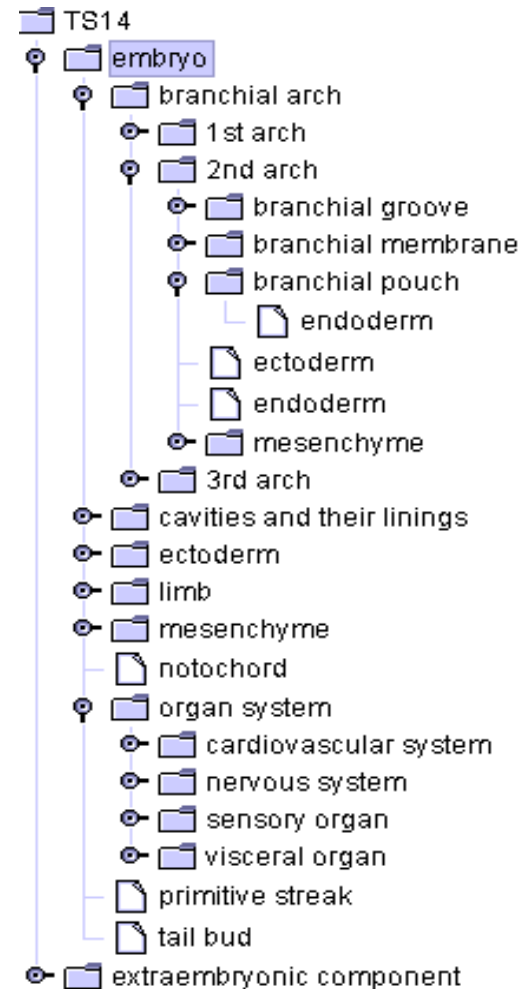
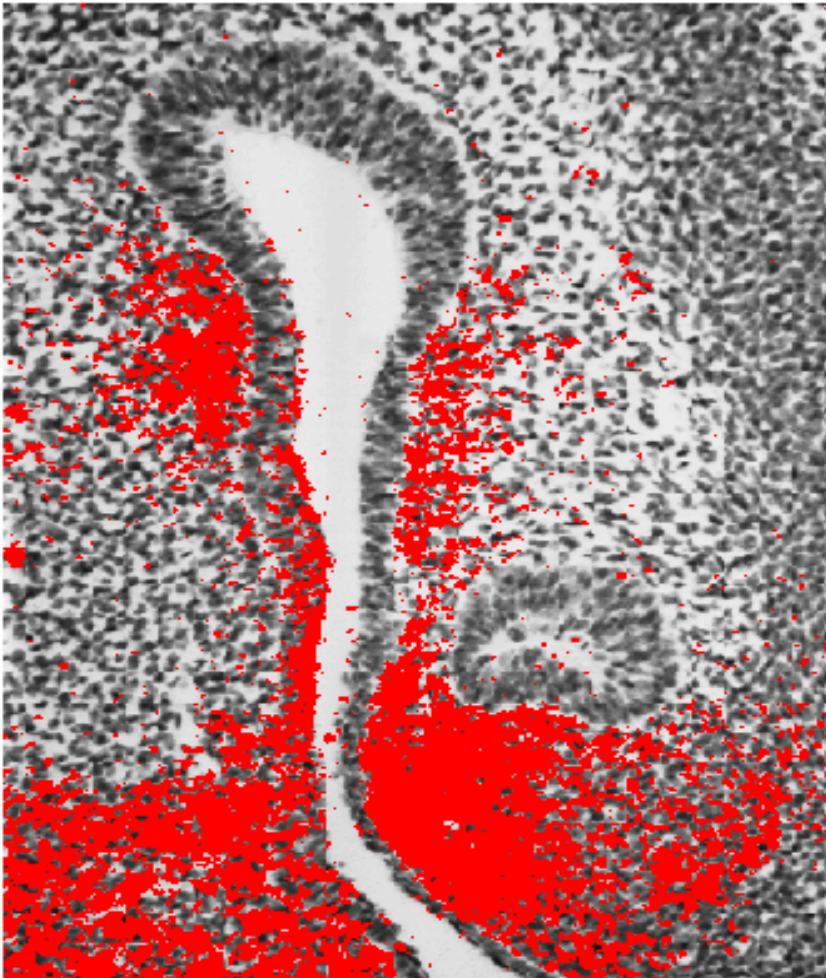
Richard Baldock

*MRC Human Genetics Unit,
Crewe Road, Edinburgh.*

Development and Gene-Expression



Words are not enough

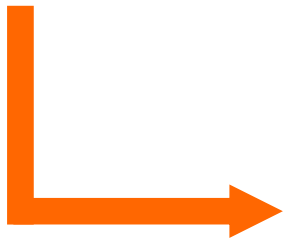
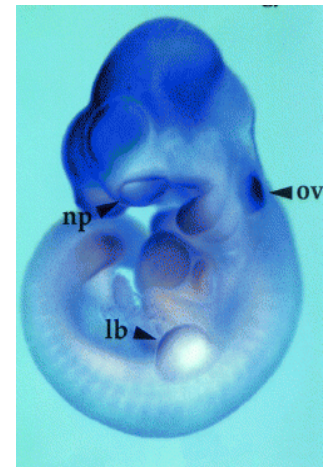
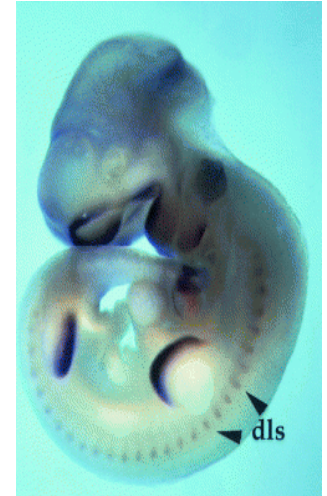


mouse E12.5 nasal region  Msx1 mRNA

Spatio-Temporal DB for Biology

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

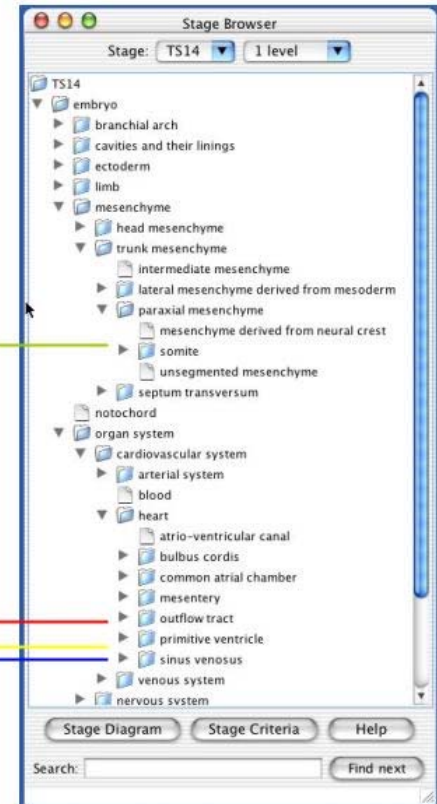
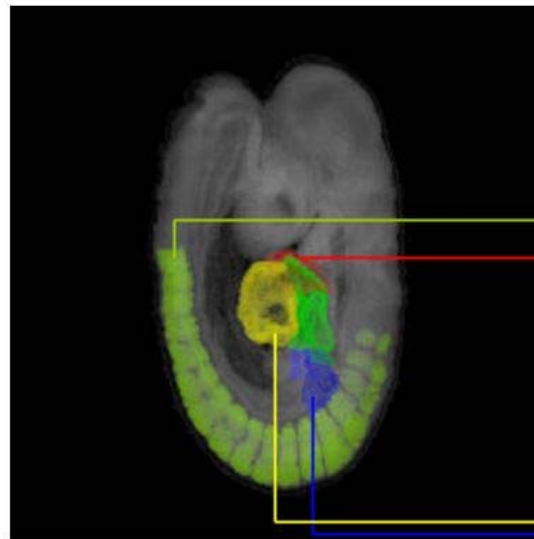
Spatial mapping
image data

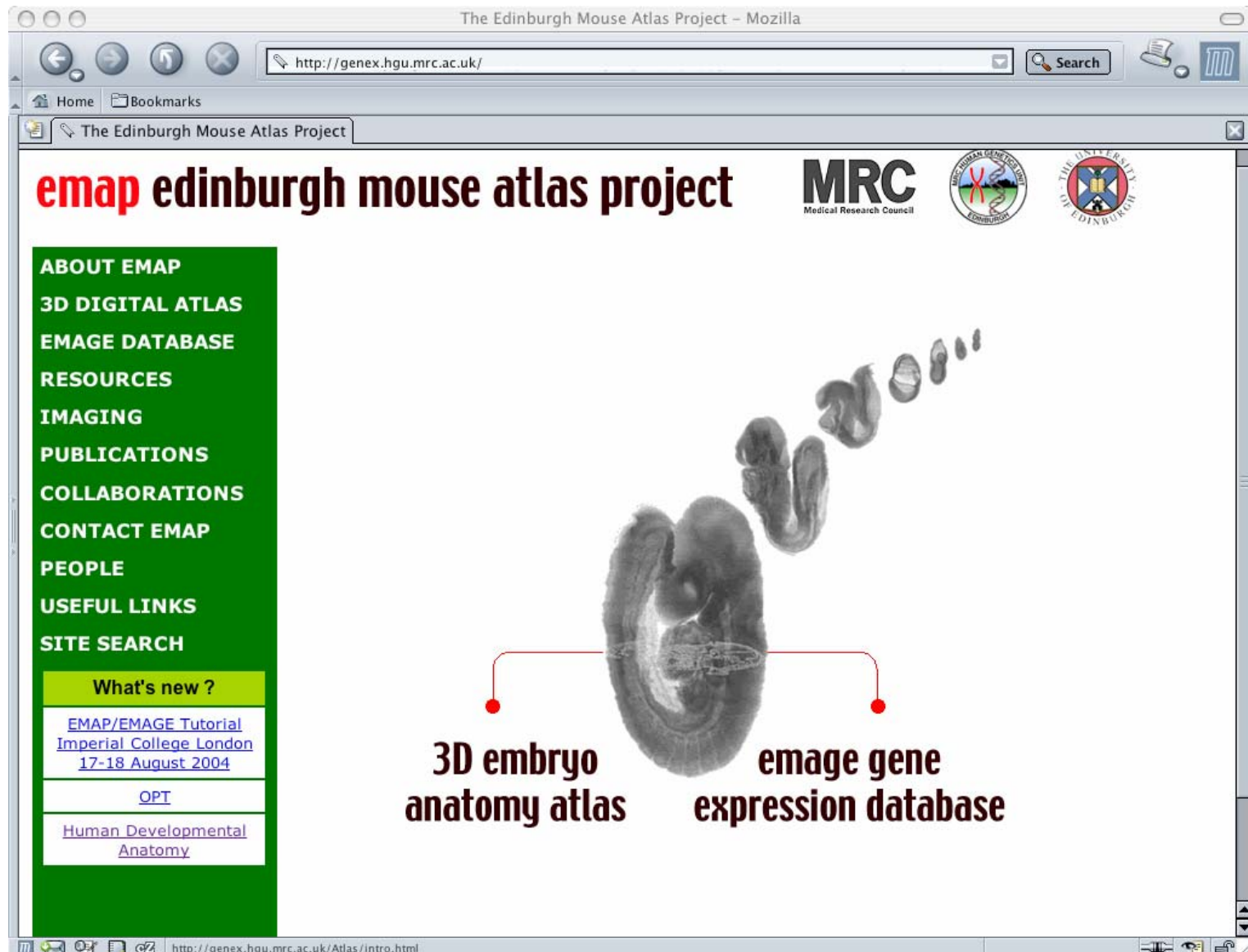


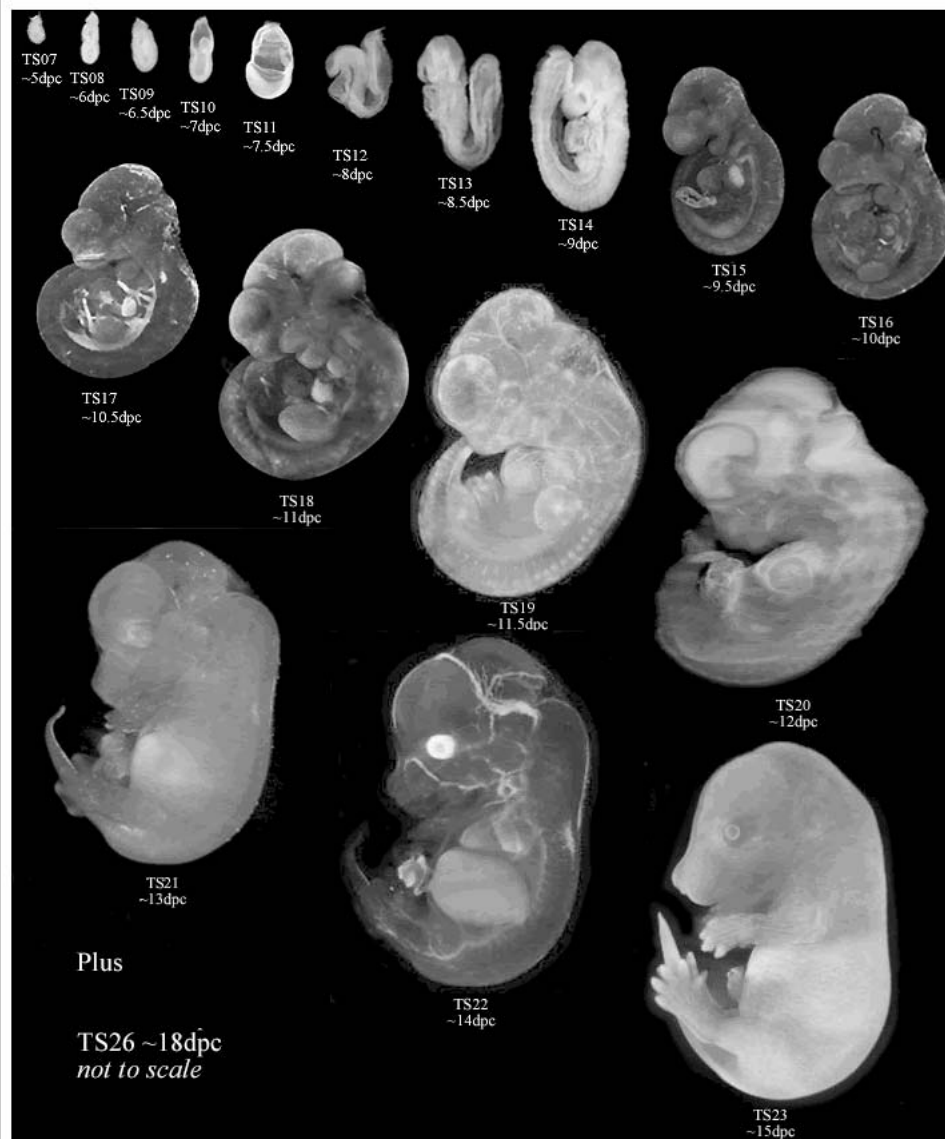
gene expression database

Framework: Edinburgh Mouse Atlas (emap)

QuickTime™ and a YUV420 codec decompressor are needed to see this picture.







emap models available:



Select the embryo you want

Theiler Staging:

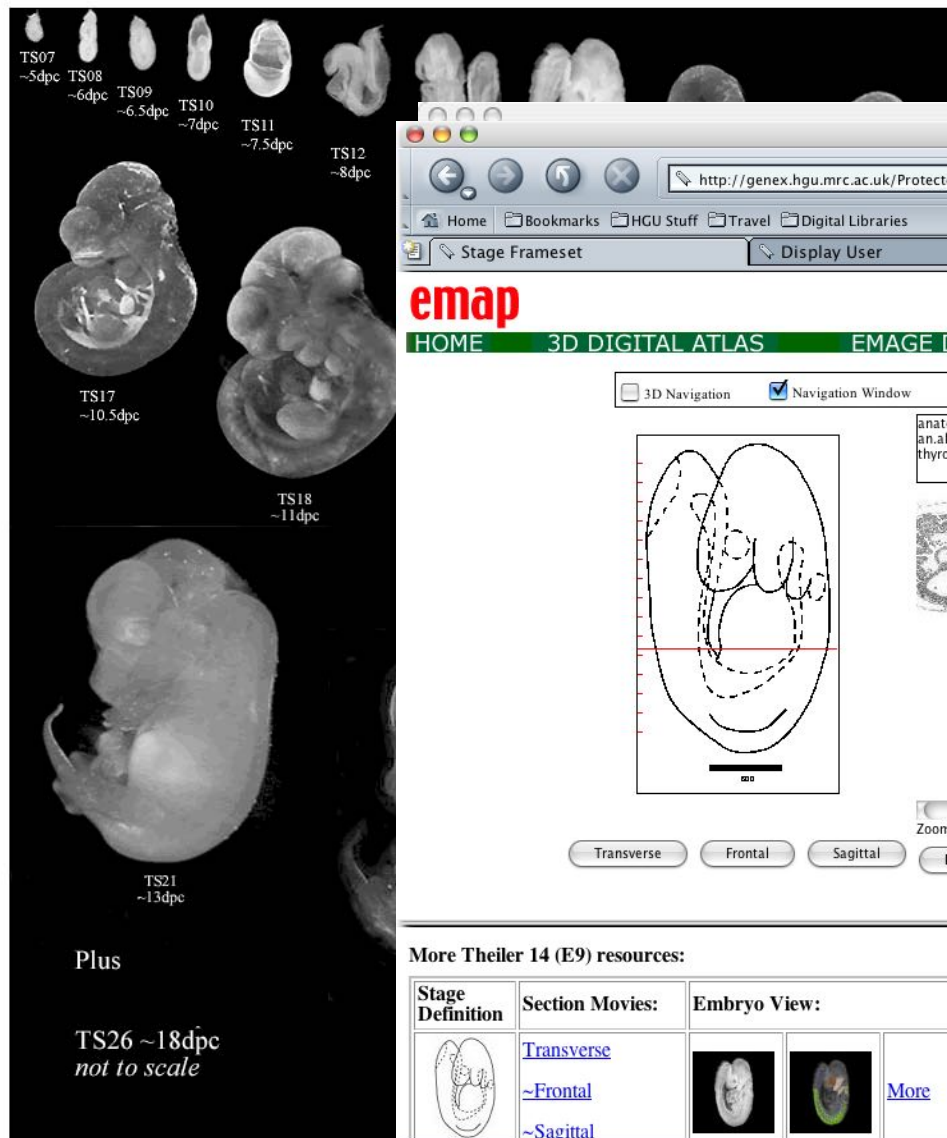
Individual Stages

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

All Stages

Criteria Summary table
Pictorial stage index
Text anatomy index
Anatomy Database

[FAQs](#)



Stage Frameset - Mozilla
Stage Frameset - Mozilla

http://genex.hgu.mrc.ac.uk/Protected/DemoPages/Atlas/SBFrames.html?14

Home Bookmarks HGU Stuff Travel Digital Libraries

Stage Frameset Display User

emap 3D digital atlas | TS14

HOME 3D DIGITAL ATLAS IMAGE DATABASE RESOURCES CONTACT SITE SEARCH

☐ 3D Navigation ☒ Navigation Window ☒ Section Window ☒ Anatomy Window Carnegie Stage TS14

anatomy.embryo.organ system.visceral org
an.alimentary system.gut.foregut.gland.
thyroid primordium

gland
thyroid primordium
associated
endoderm
pharyngeal region
rest of foregut
foregut-midgut junct
hindgut diverticulum
midgut
gut lumen*
mouth-foregut junction
oral region
genital system
streak
extraembryonic component*

Search in
EMAGE
CND
MAGE(Sage data)

Zoom: 28 Find:

Transverse Frontal Sagittal Deselect No component selected

More Theiler 14 (E9) resources:

[Information on this model](#) [Help with the Browsers](#) [FAQ](#)

Stage Definition	Section Movies:	Embryo View:	High-resolution Section Images:	Anatomy Nomenclature Database	CD-ROM
	Transverse ~Frontal ~Sagittal	 More		Java Browser Plain Text XML	

emap

emap gene expression database

HOME 3D DIGITAL ATLAS EMAGE DATABASE RESOURCES CONTACT SITE SEARCH



ABOUT
ON-LINE SUPPORT
USER COURSES
CONTACT
SUBMIT DATA
JOIN USER GROUP
FAQ

WHAT'S NEW?
Java Program v3.0

WEB SEARCH EMAGE

Simple search capabilities

- Search EMAGE by name of anatomical structure

SEARCH



EMAGE JAVA PROGRAM

Advanced Search capabilities

- Search EMAGE by spatial region
- Search by Gene to show regions of expression
- Search by name of anatomical structure
- Search by Gene to list names of expressing tissues
- Browse all EMAGE data (Sort by Gene or Theiler Stage)
- Make local databases for in-lab data management

PREVIEW INSTALL Once installed: START



Web page contact: genexweb@hqu.mrc.ac.uk Last modified: 08/03/2005
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emage: browse data

Browse Central DataBase

Sort by: ☐ Gene ☒ Stage

Stage(22) Entries(2005)

- ts03(1) Entries(2)
- ts04(1) Entries(1)
- ts06(1) Entries(2)
- ts07(6) Entries(6)
- ts08(10) Entries(14)
- ts09(20) Entries(35)
- ts10(21) Entries(32)
- ts11(57) Entries(92)
- ts12(52) Entries(86)
- ts13(13) Entries(17)
 - Bmp4 Entries(1)
 - Egr2 Entries(2)
 - Epha4 Entries(3)
 - Foxa2 Entries(1)
 - Gsc Entries(1)
 - Igf2 Entries(1)
 - Mafb Entries(1)
 - Ncam1 Entries(1)
 - Pax6 Entries(1)
 - Pitx1 Entries(1)
 - Shh Entries(1)
 - Wnt1 Entries(2)
 - Wnt2 Entries(1)
- ts14(62) Entries(78)
- ts15(195) Entries(354)
- ts16(187) Entries(207)
- ts17(482) Entries(585)
- ts18(262) Entries(281)
- ts19(49) Entries(64)
- ts20(77) Entries(107)
- ts21(10) Entries(15)
- ts22(11) Entries(13)
- ts23(5) Entries(5)

Page 1 Page 2

EMAGE:378 ts13 Wnt2

EMAGE:429 ts13 Wnt1

EMAGE:436 ts13 Wnt1

EMAGE:584 ts13 Gsc

EMAGE:696 ts13 Mafb

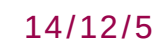
EMAGE:721 ts13 Shh

EMAGE:862 ts13 Igf2

EMAGE:863 ts13 Pitx1

Submission Collection

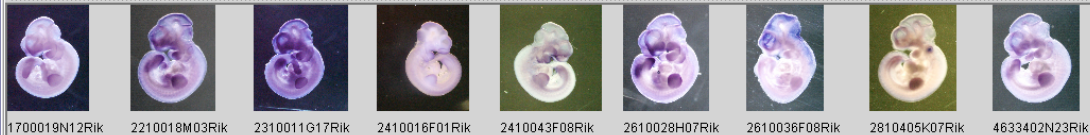
R A Baldock



emage: Query by space

QuickTime™ and a
Animation decompressor
are needed to see this picture.

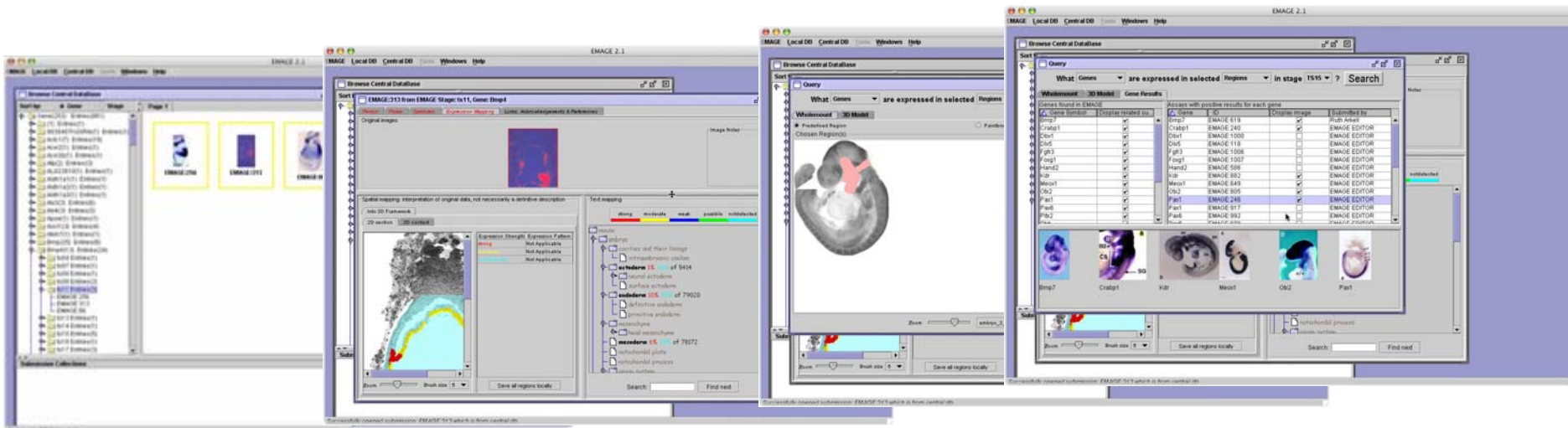
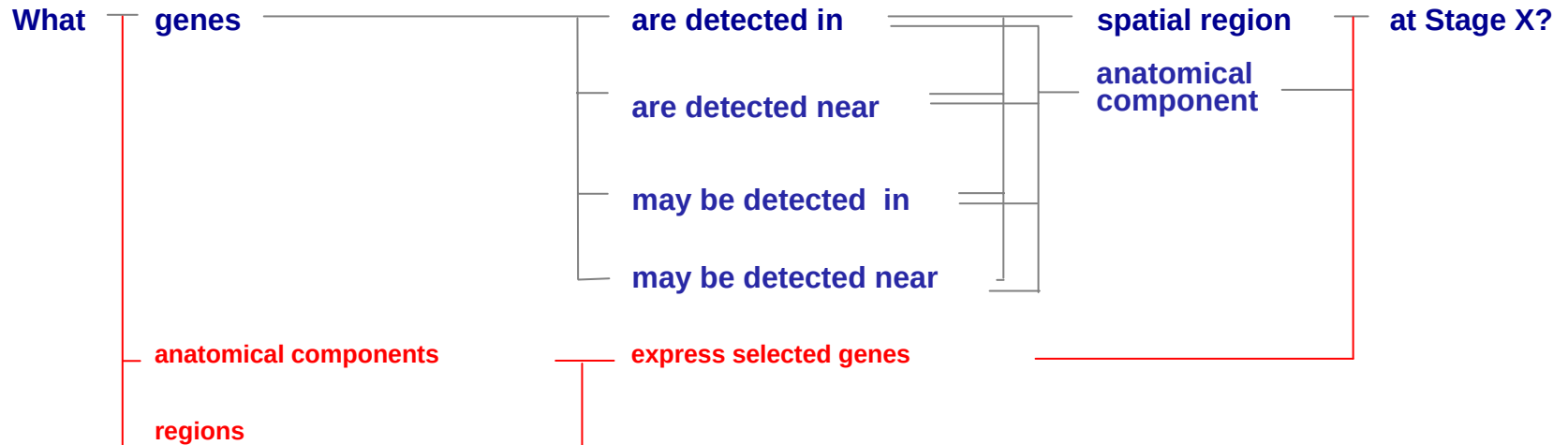
Wholemount			3D Model			Gene Results		
Genes found:			Assays with positive results:					
Gene Symbol	Display related su...		Gene	ID	Display image	Submitted by		
Elf4	☒		1700019N12Rik	EMAGE:1361	☒	EMAGE EDITOR		
Elk1	☒		2210018M03Rik	EMAGE:1936	☒	EMAGE EDITOR		
Elk3	☒		2310011G17Rik	EMAGE:1501	☒	EMAGE EDITOR		
Elk4	☒		2410016F01Rik	EMAGE:1613	☒	EMAGE EDITOR		
En1	☒		2410043F08Rik	EMAGE:1632	☒	EMAGE EDITOR		
Esrl	☒		2610028H07Rik	EMAGE:1953	☒	EMAGE EDITOR		
Esrb	☒		2610036F08Rik	EMAGE:1578	☒	EMAGE EDITOR		
Esrg	☒		2810405K07Rik	EMAGE:1937	☒	EMAGE EDITOR		
Ets2	☒		4633402N23Rik	EMAGE:1967	☒	EMAGE EDITOR		
Evi1	☒		4732460K03Rik	EMAGE:1980	☐	EMAGE EDITOR		
Evx2	☒		5830435C13Rik	EMAGE:1712	☐	EMAGE EDITOR		
Fhl2	☒		9630027K23Rik	EMAGE:2032	☐	EMAGE EDITOR		
Fhl3	☒		Alx	EMAGE:1527	☐	EMAGE EDITOR		
Fmn	☒		Alx3	EMAGE:1668	☐	EMAGE EDITOR		
Foxa2	☒		Alx3	EMAGE:123	☐	EMAGE EDITOR		
Foxb1	☒		Alx4	EMAGE:1461	☐	EMAGE EDITOR		
Foxc1	☒		Arid4b	EMAGE:1974	☐	EMAGE EDITOR		
Foxc2	☒		Ascl3	EMAGE:2042	☐	EMAGE EDITOR		
Foxd4	☒		Atf2	EMAGE:1544	☐	EMAGE EDITOR		
Foxf1a	☒		Atf4	EMAGE:1546	☐	EMAGE EDITOR		
Foxf2	☒		B430306D02Rik	EMAGE:1705	☐	EMAGE EDITOR		
Foxj2	☒		B430306D02Rik	EMAGE:1706	☐	EMAGE EDITOR		
Foxj3	☒		Barhl1	EMAGE:1739	☐	EMAGE EDITOR		
Foxl1	☒		Bamx2	EMAGE:1740	☐	EMAGE EDITOR		
Foxp2	☒		Raz1a	EMAGE:1718	☐	EMAGE EDITOR		



1700019N12Rik 2210018M03Rik 2310011G17Rik 2410016F01Rik 2410043F08Rik 2610028H07Rik 2610036F08Rik 2810405K07Rik 4633402N23Rik

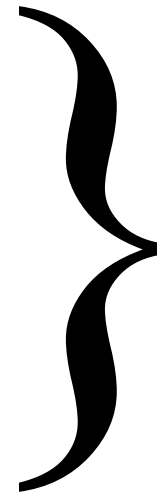
Gene Expression Data Base

- Query: by both space and text...



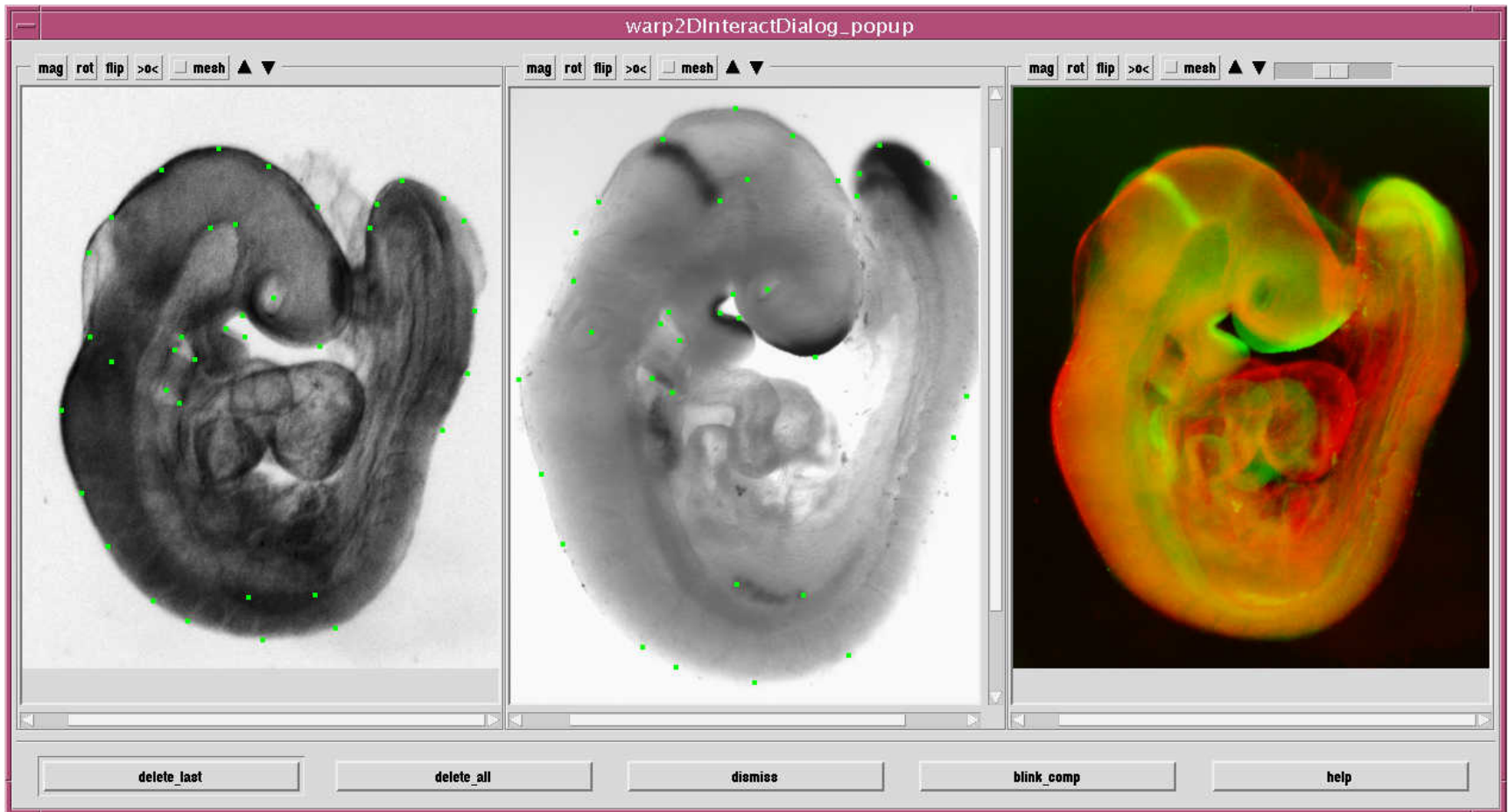
Data Mapping

- Text
- Manual delineation
- Warping
 - Radial-basis functions
 - Piece-wise linear for efficiency
 - Triangular/Tetrahedral mesh
 - Manual correspondences
 - Automatic pre-pass
 - Iterated Closest Point
 - Global-local iterated mapping
- 3D - manual tie-points
 - Piece-wise mapping
 - Constrained warping

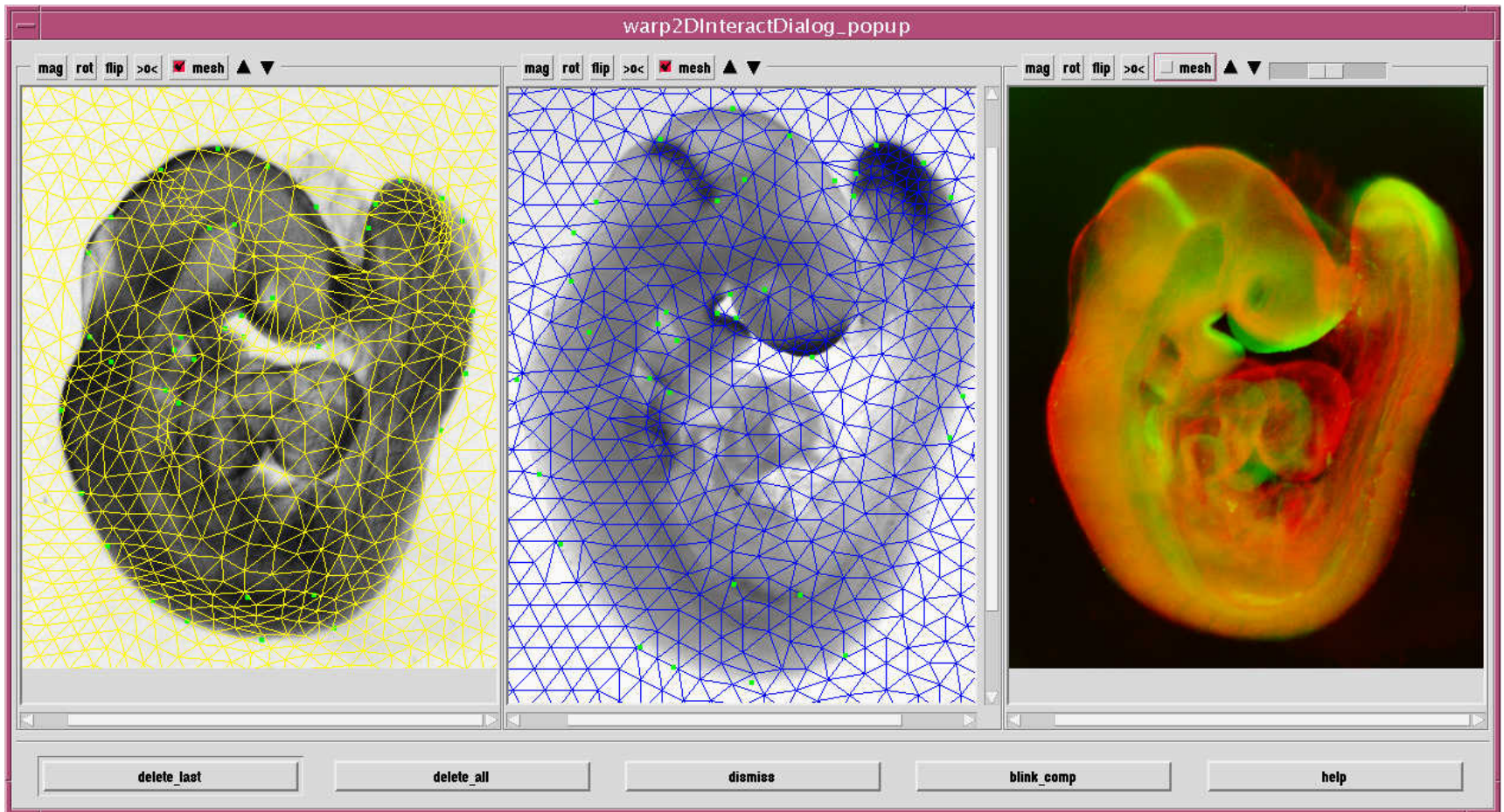


**Interactive
response**

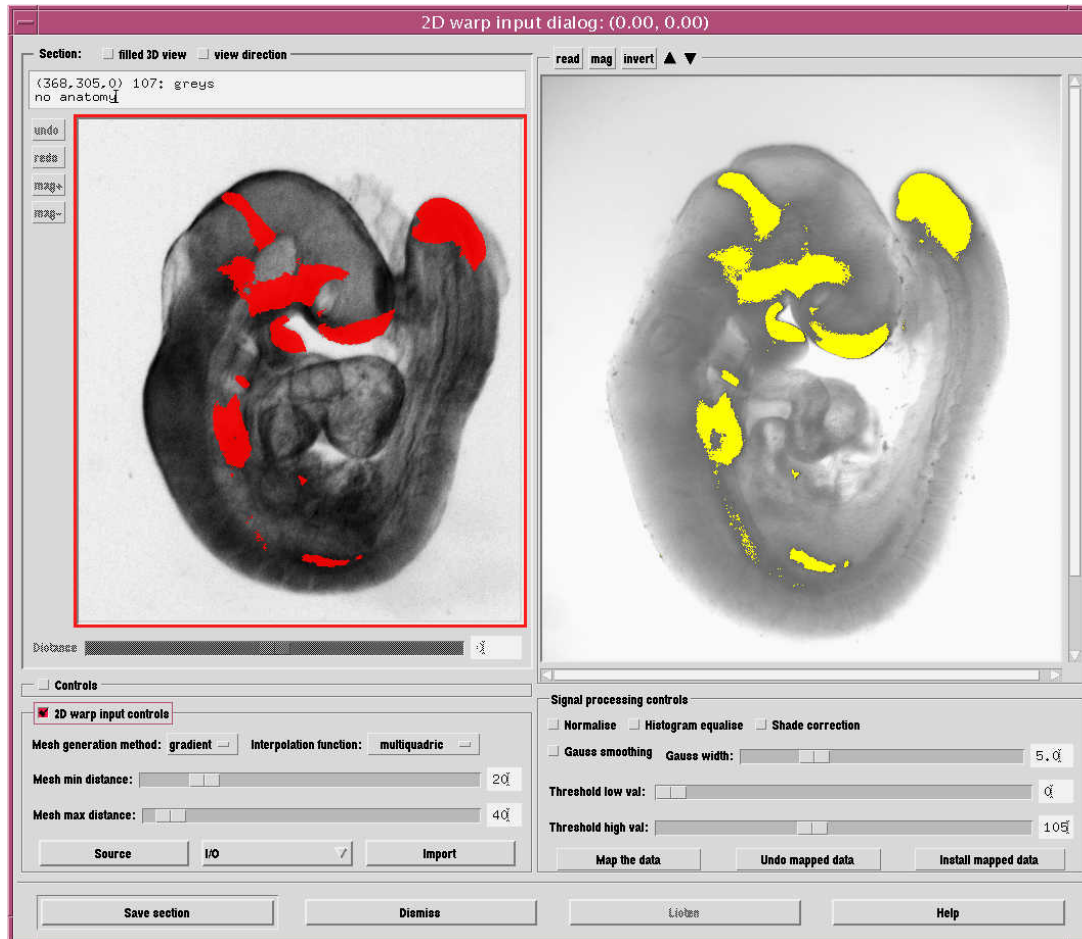
Data Mapping - manual



Data Mapping - Manual

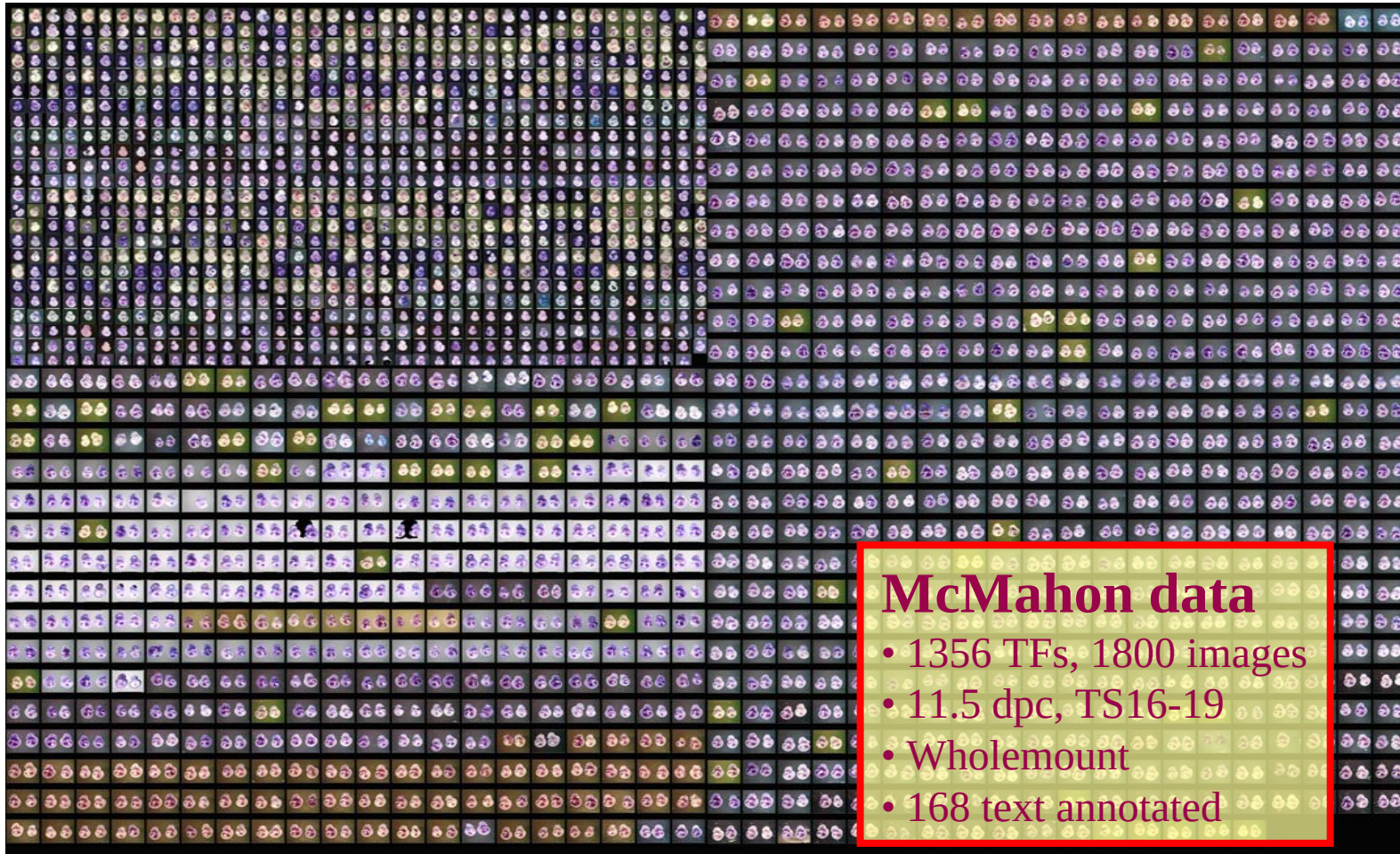


Data Mapping - Manual

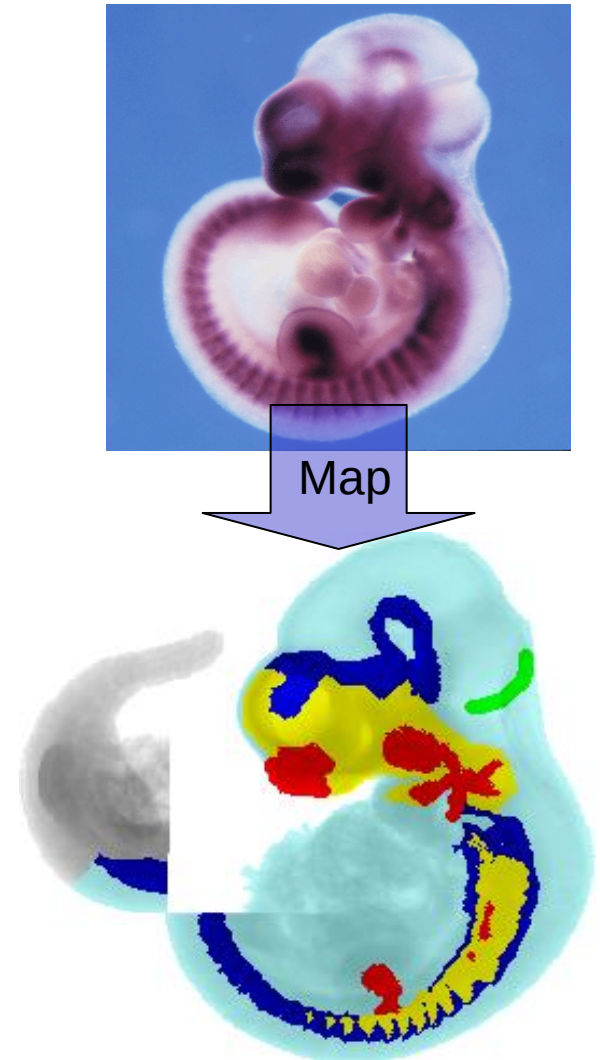
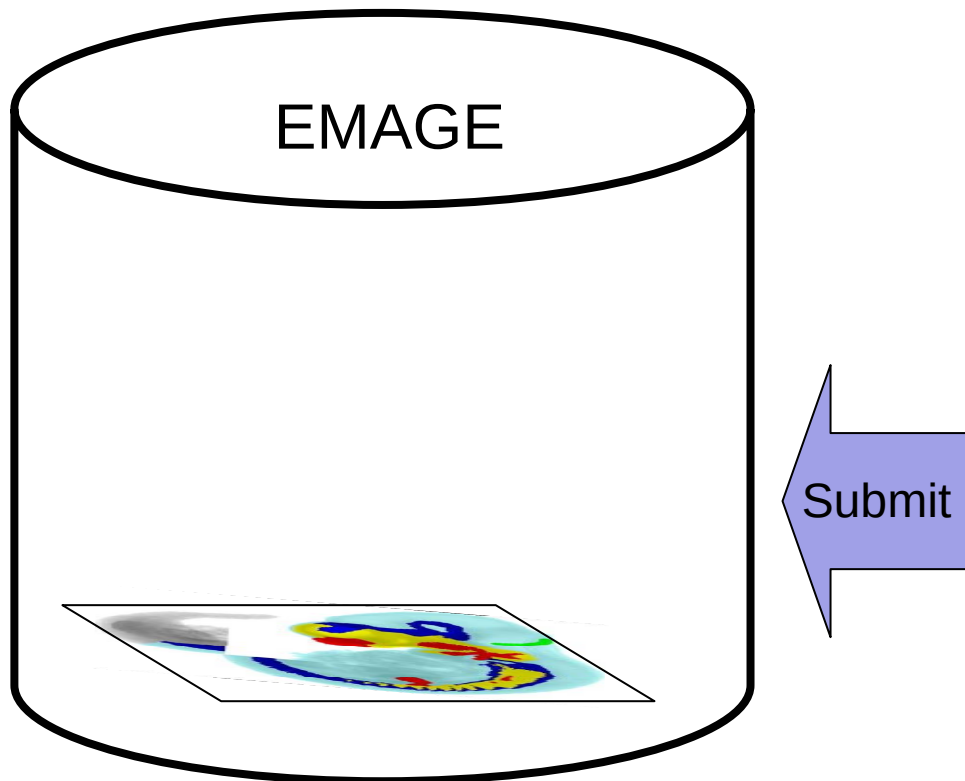


Data Query and Analysis

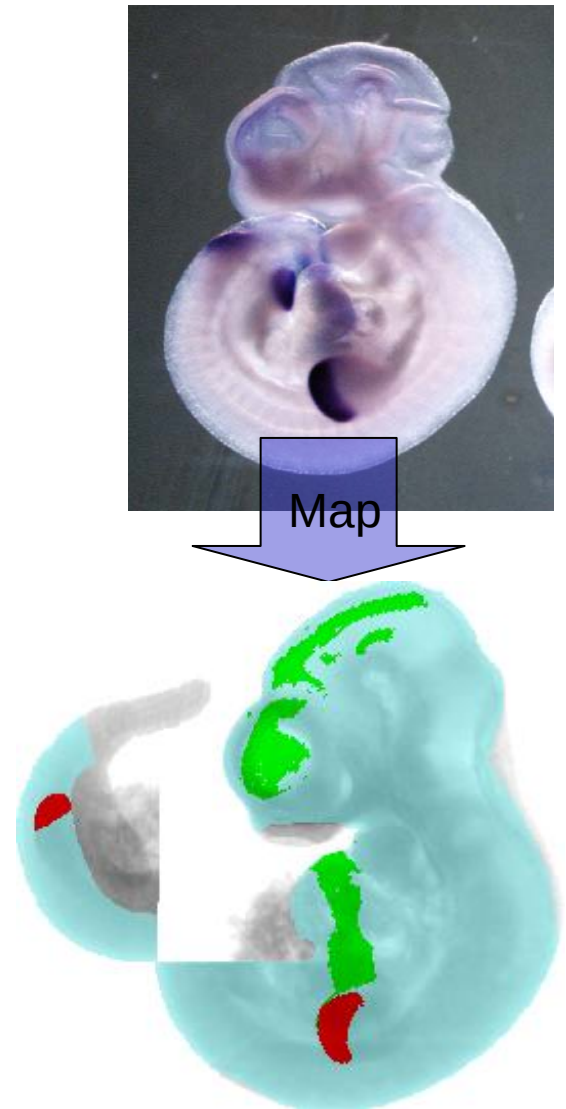
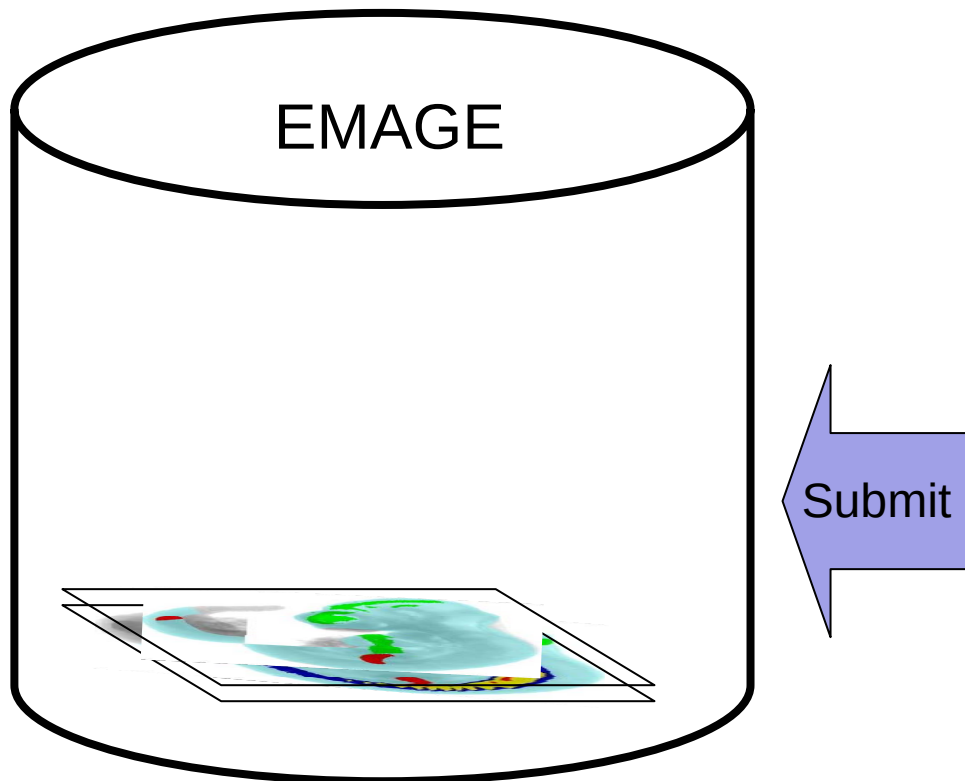
Statistics &
Clustering



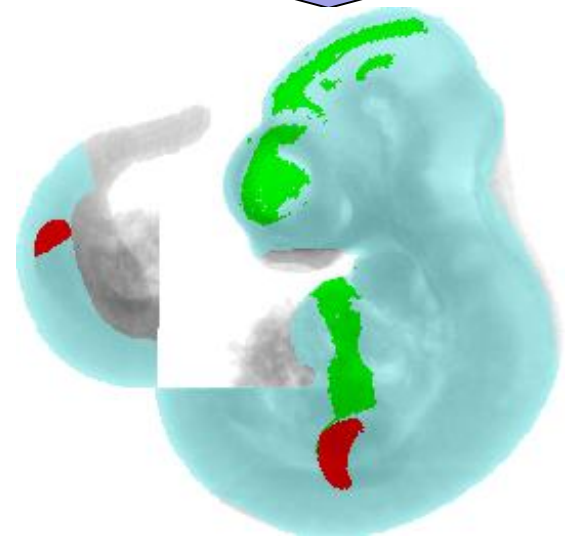
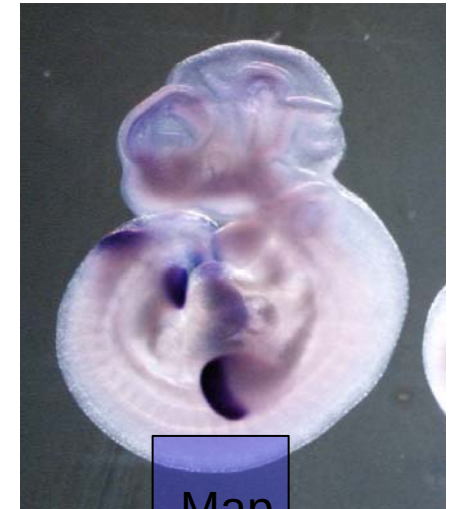
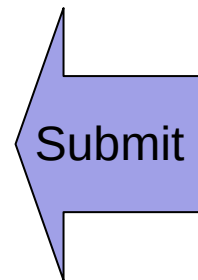
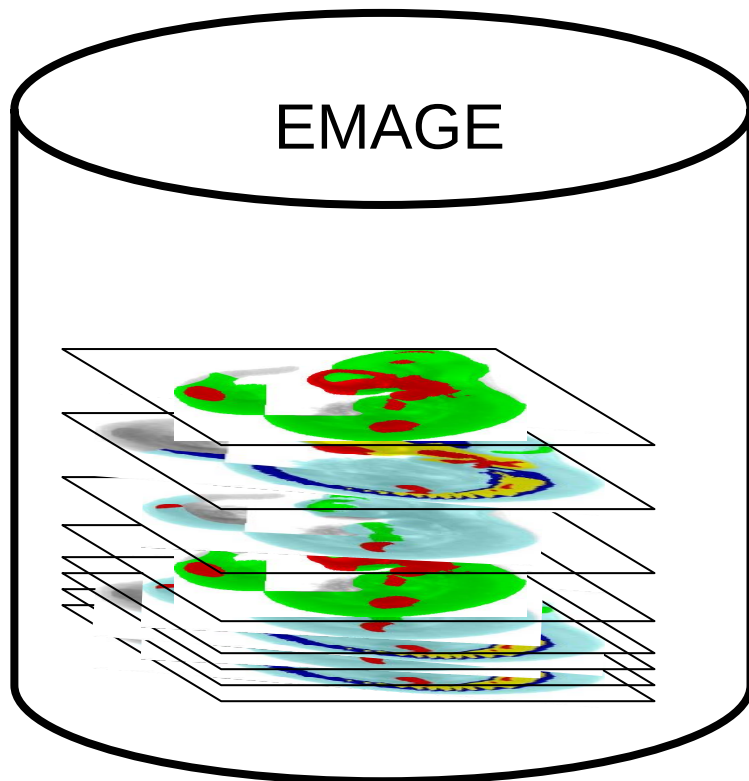
Data Submission



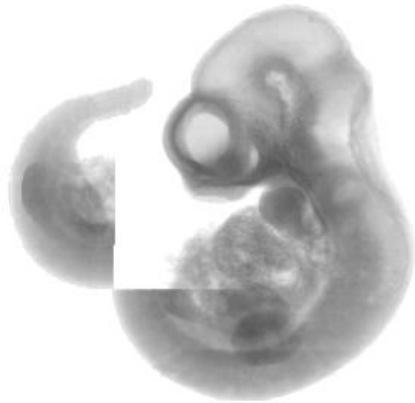
Data Submission



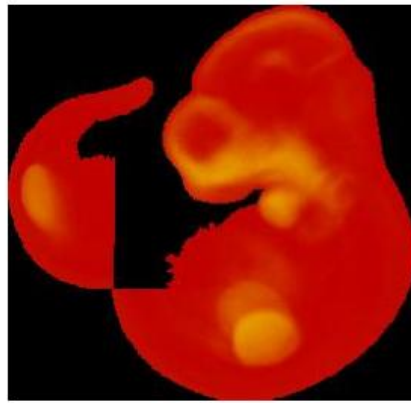
Data Submission



Summary Gene-Expression Activity



TS17_2_WM_left.wlz



strong



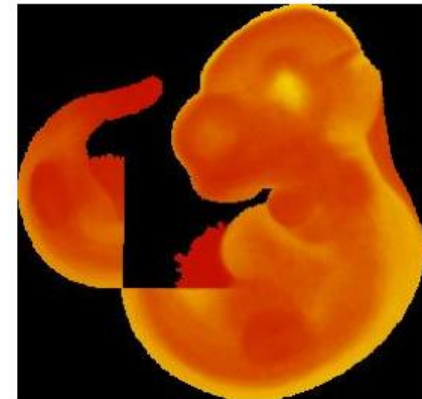
moderate



weak



possible

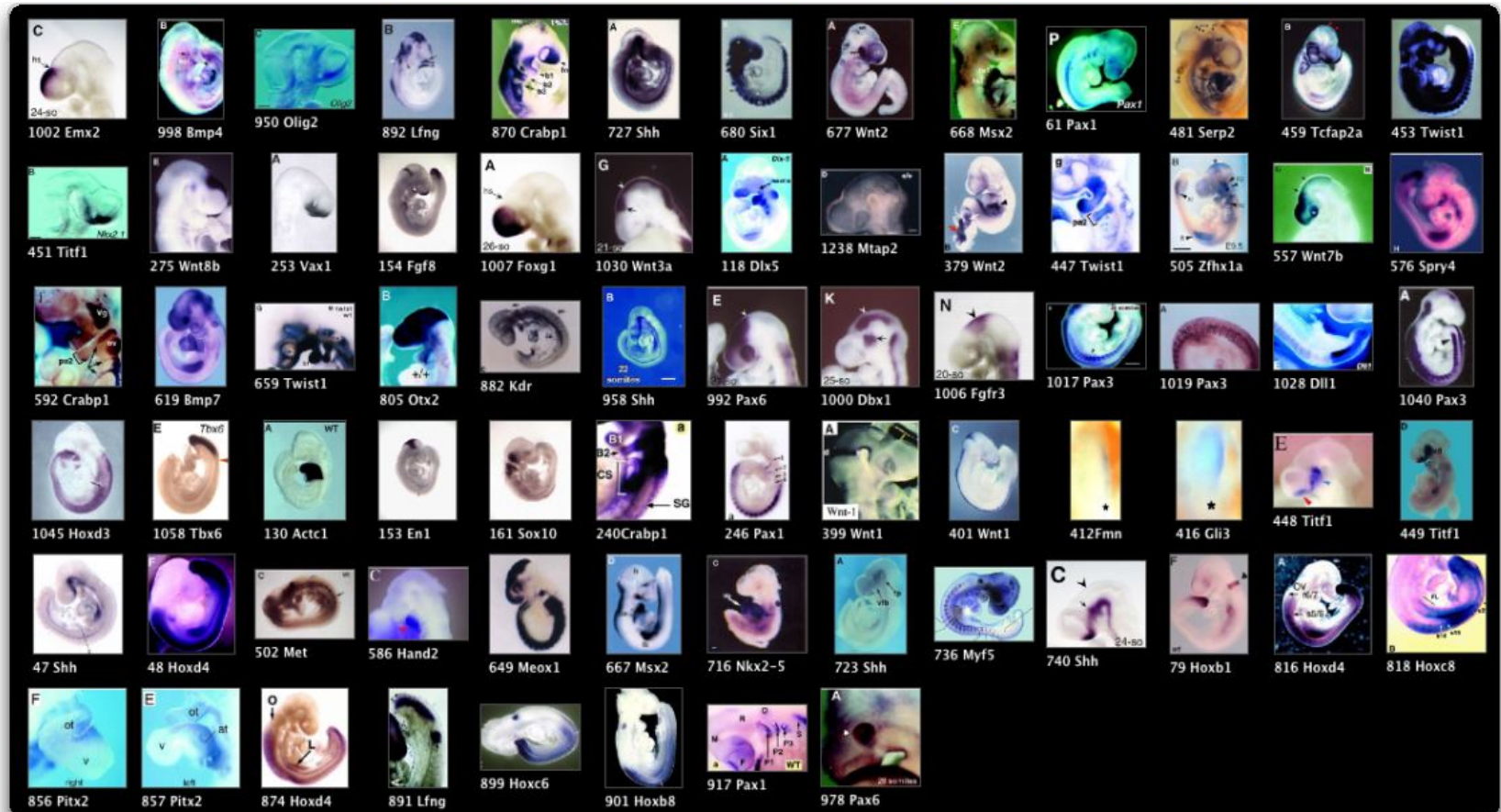


notDetected

Data Query and Analysis

Image Comparison

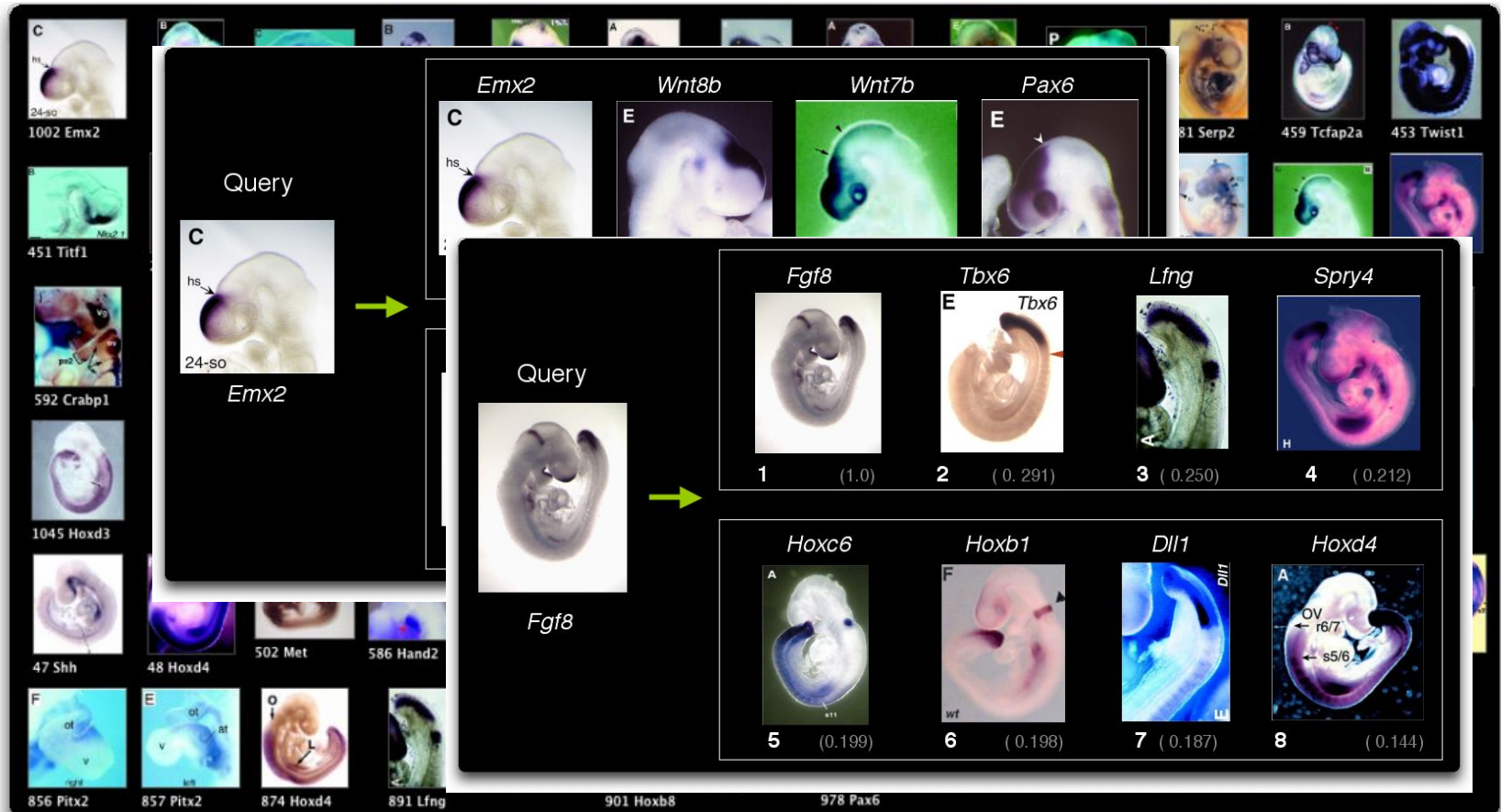
Non-linear mapping and spatial pattern comparison



Data Query and Analysis

Image Comparison

Non-linear mapping and spatial pattern comparison



Similarity Measures

- Type 1 (strong):

$$V_1 = \frac{S(d_1 \wedge d_2)}{S(d_1 \vee d_2)}$$

- Type 3 (strong):

$$V_3 = \frac{S(d_1 \wedge d_2)}{S(d_1)}$$

- Type 5:

$$V_5 = \begin{cases} 1.0 & : S(d_2) = 0 \quad \text{or} \quad S(d_3) = 0, \\ 1/\delta & : S(d_2) = 0 \quad \text{and} \quad S(d_1 \wedge d_3) = 0, \\ \delta & : S(d_3) = 0 \quad \text{and} \quad S(d_1 \wedge d_2) = 0, \\ \frac{S(d_1 \wedge d_2)}{S(d_2)} \times \frac{S(d_3)}{S(d_1 \wedge d_3)} & : \text{otherwise.} \end{cases}$$

Similarity Measures

- Type 6:

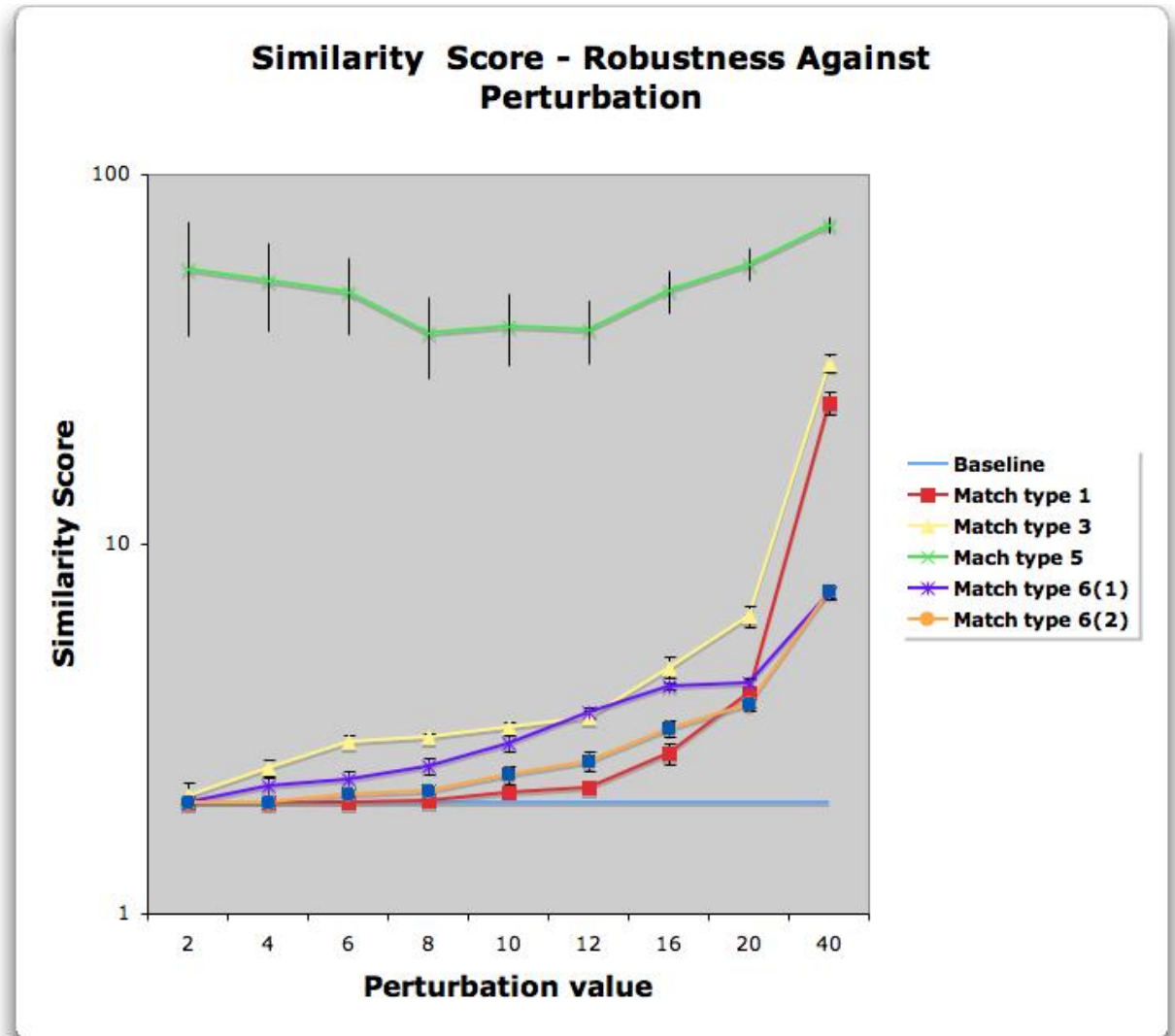
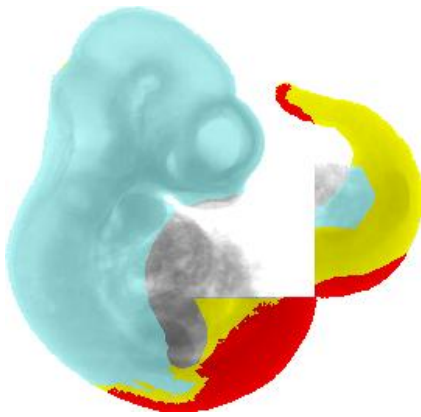
$$V_6 = \frac{\sum_{Pixels} M_{ll'}}{A_{contrib}} \quad \text{where}$$

$$A_{contrib} = \sum_{Pixels} \begin{cases} 1 & \text{if } C_{ll'} \neq 0, \\ 0 & \text{if } C_{ll'} = 0, \end{cases}$$

$$l = \begin{cases} 1 & \Rightarrow \text{strong} \\ 2 & \Rightarrow \text{moderate} \\ 3 & \Rightarrow \text{weak} \\ 4 & \Rightarrow \text{possible} \\ 5 & \Rightarrow \text{notDetected} \\ 6 & \Rightarrow \text{notExamined} \end{cases}$$

$$M = \begin{pmatrix} 10 & 5 & 0 & -2 & -10 & 0 \\ 5 & 10 & 5 & 0 & -8 & 0 \\ 0 & 5 & 10 & 5 & -5 & 0 \\ -2 & 0 & 5 & 10 & 0 & 0 \\ -10 & -8 & -5 & 0 & 10 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}, \quad \text{and} \quad C = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix},$$

Robustness

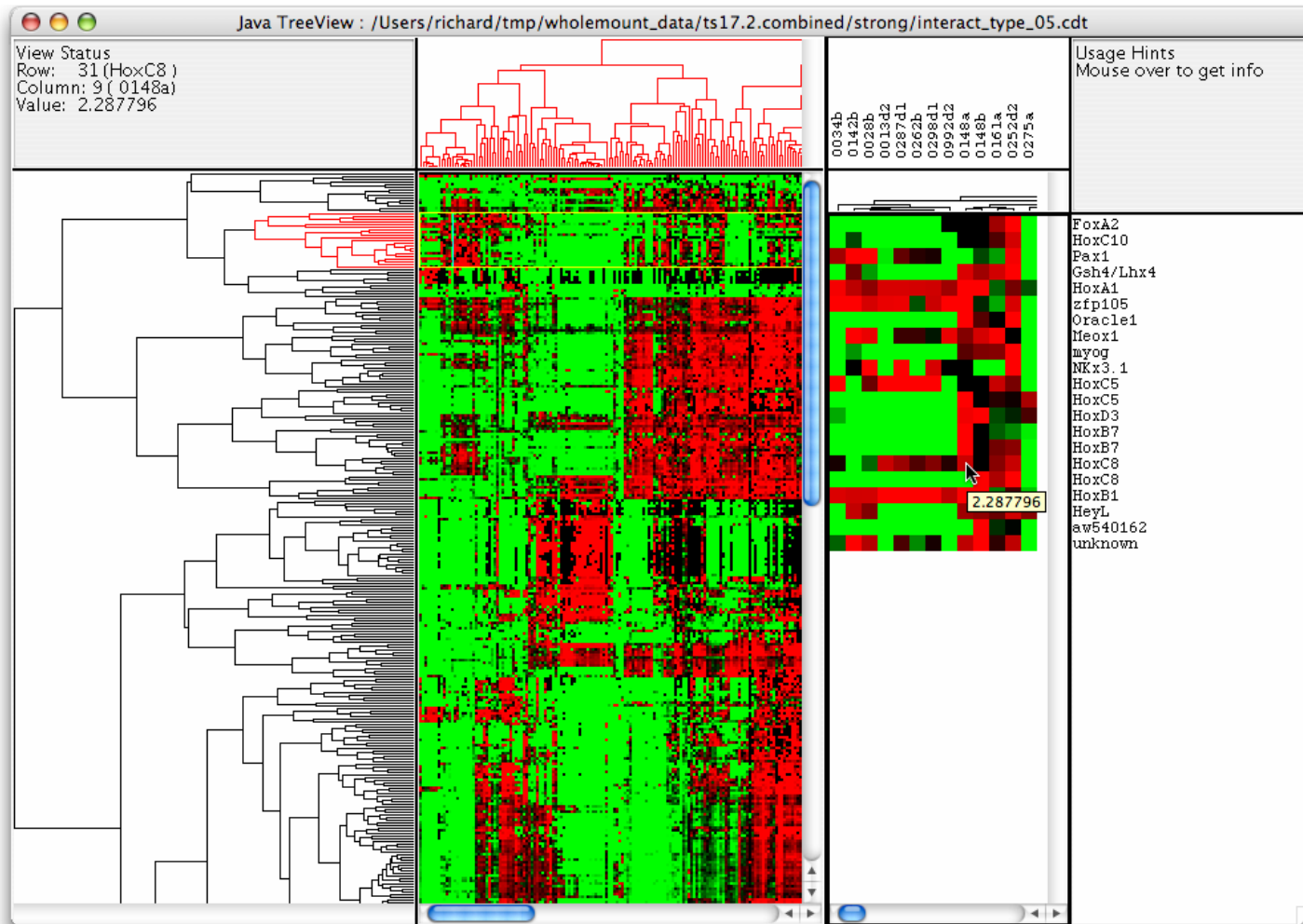


Data Analysis - Clustering

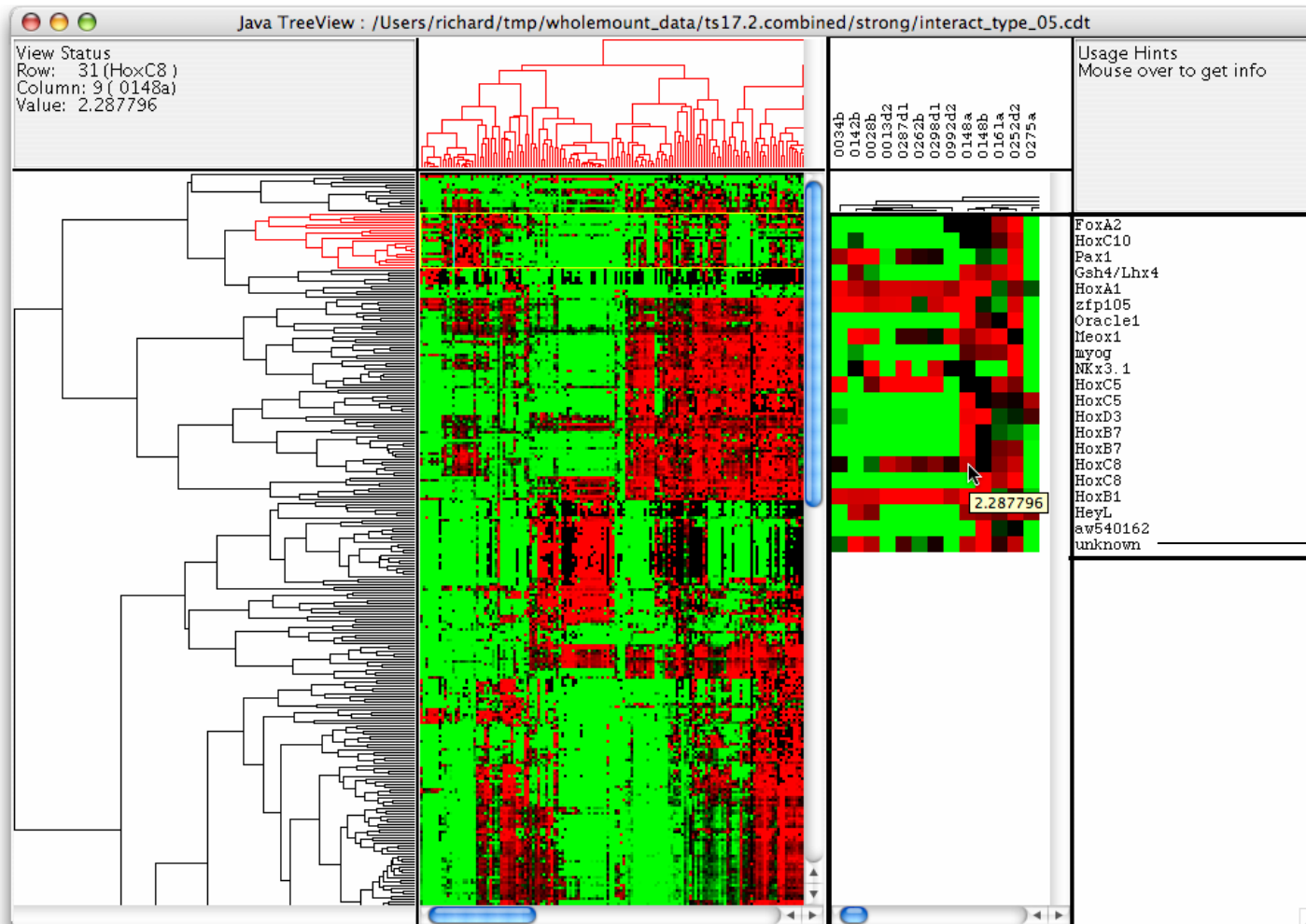
- Compare each pattern with each other
- Use standard genomic style clustering

UNIQID	NAME	GWEIGHT	GORDER	0001d2	0004d2	0005d1	0006a	0011d1	0013d2	0015b
EWEIGHT				1	1	1	1	1	1	1
0001d2	NKx			1	0.01	0.01	5.345728	0.01	0.01	0.01
0004d2	NKx			0.01	1	9.313241	1.964581	37.587019	0.01	0.01
0005d1	NKx			0.01	9.184143	1	5.520206	0.01	0.01	0.01
0006a	Hmx1			7.299398	2.014282	5.435595	1	0.01	0.01	0.15469
0011d1	FoxA2			0.01	26.366263	0.01	0.01	1	0.01	0.01
0013d2	FoxB1			1	0.01	0.01	0.01	1	1	0.01
0015b	FoxC1			0.01	0.01	0.01	0.114347	0.01	0.01	1
0016d2	FoxC2			0.01	3.93355	0.633846	23.100338	1	0.01	13.584363
0018d2	FoxD2			0.01	0.954655	0.090103	2.275649	0.01	0.01	8.376957
0020d1	FoxD4			0.01	4.220602	1.676885	3.514618	1	0.01	15.17175
0023d1	FoxF2			0.01	2.700665	0.35672	2.895248	1	0.01	100
0026a	FoxJ2			0.01	1.999041	1.608848	1.500608	15.808047	5.942074	15.480723
0028b	FoxL1			0.01	0.01	2.825315	0.01	0.01	32.375944	0.01
0034b	Mlt7			0.01	0.01	0.01	0.01	0.01	100	1
0037a	FoxP2			0.01	5.804941	2.114197	9.748518	1	0.01	12.085173
0040b	unknown			0.01	1.364949	0.319905	0.589841	64.508614	0.01	85.576549
0041a	CHES1			0.01	0.01	0.01	0.01	0.01	0.01	30.625037
0042a	Nr0b1/Dax1			0.01	0.737887	4.134882	0.01	0.01	0.01	0.766799

Data Analysis - Clustering

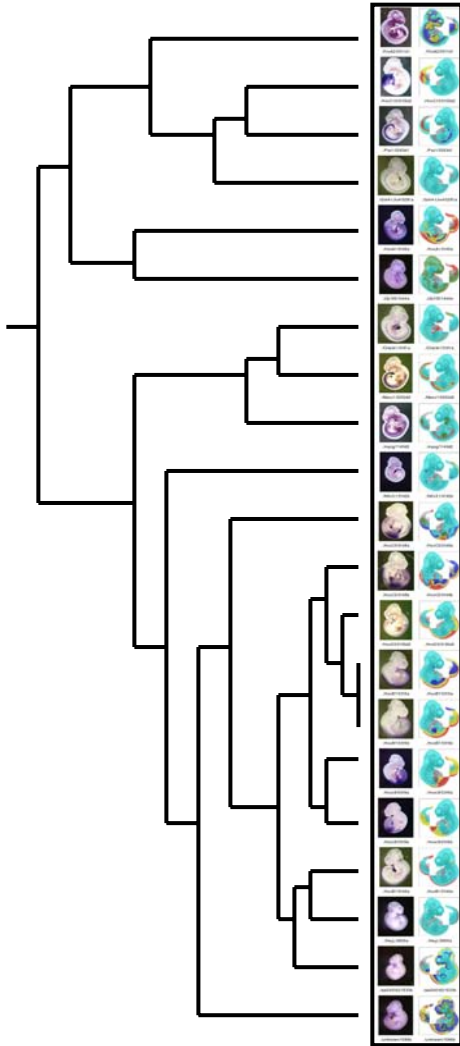


Data Analysis - Clustering



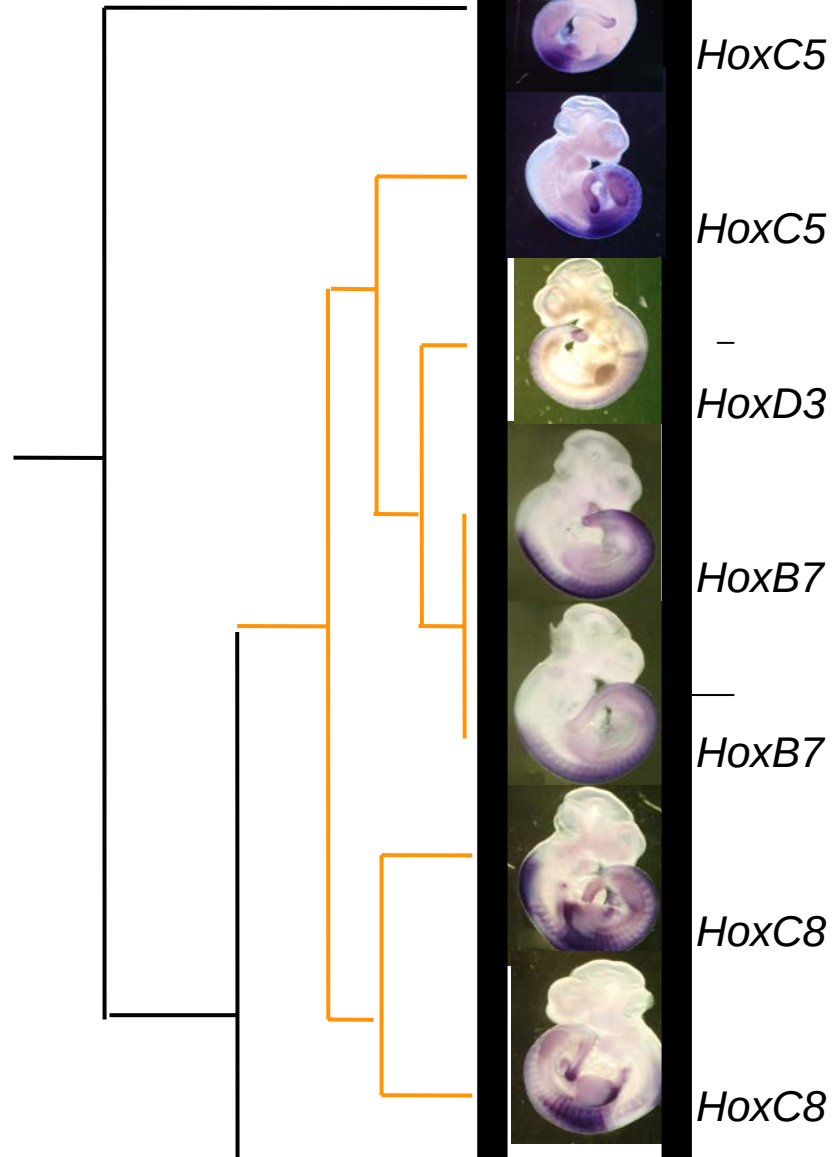
Data Analysis - Clustering

'Gray' Data



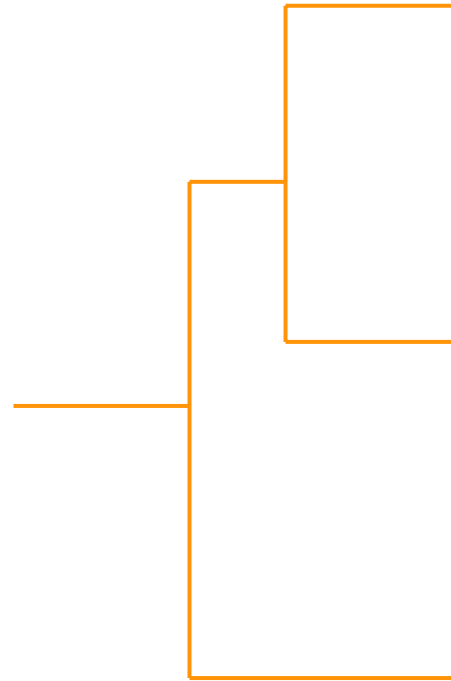
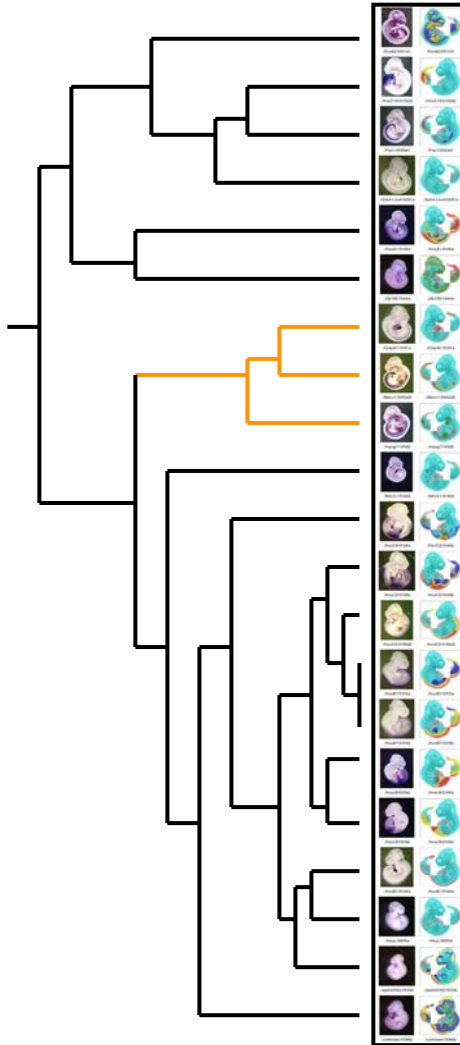
Data Analysis - Clustering

Gray' Data



Data Analysis - Clustering

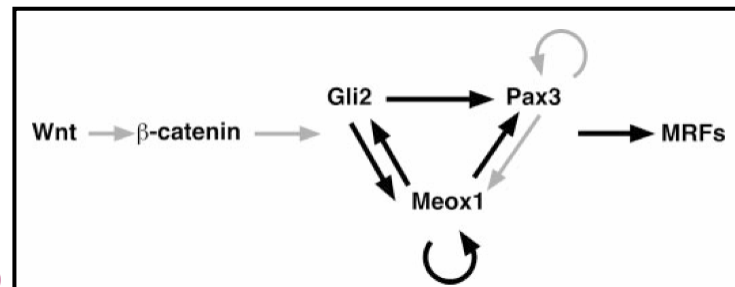
'Gray' Data



Oracle1/Ldb3/Cypher

Meox1

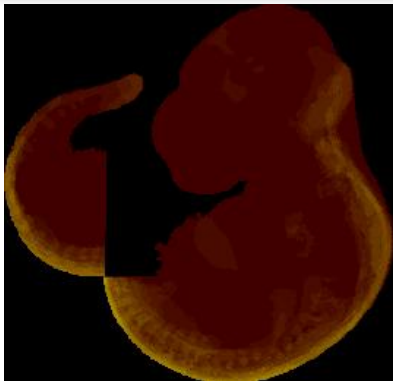
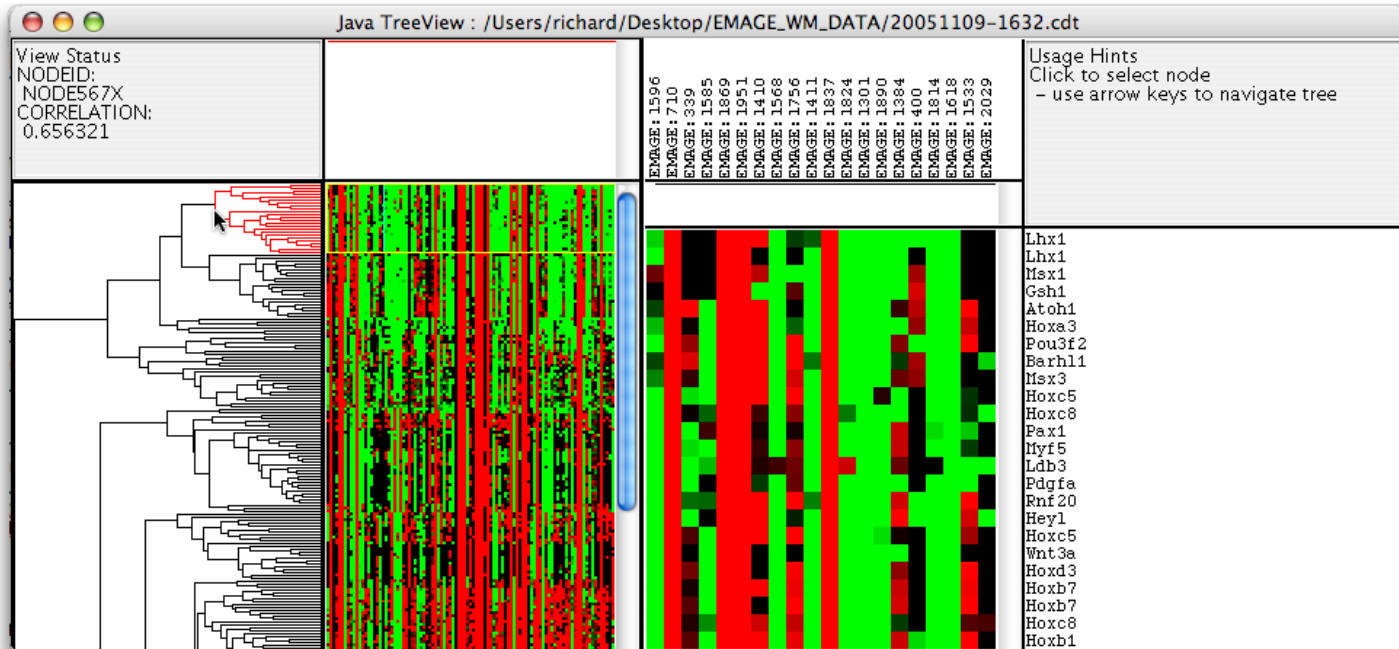
myogenin



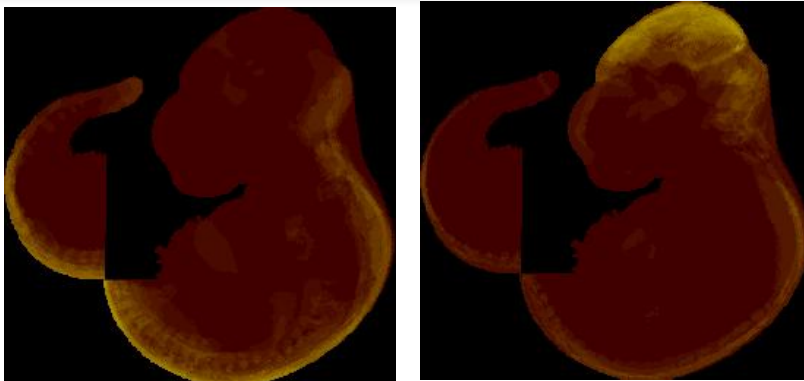
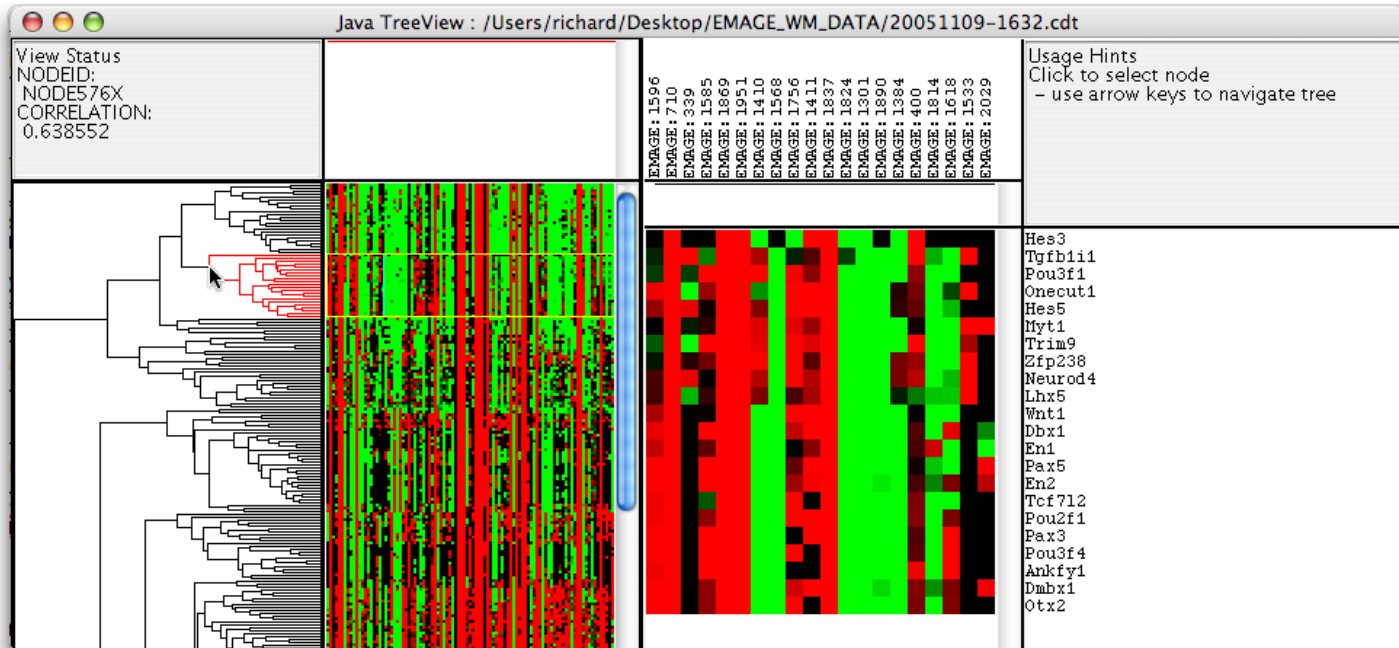
(myogenic regulatory factors)
eg. **myogenin**

maintenance of Z-band
cypher

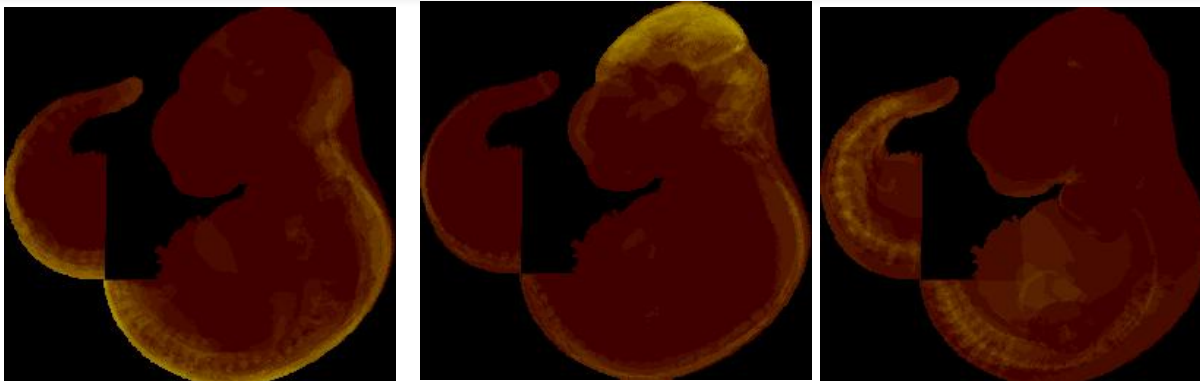
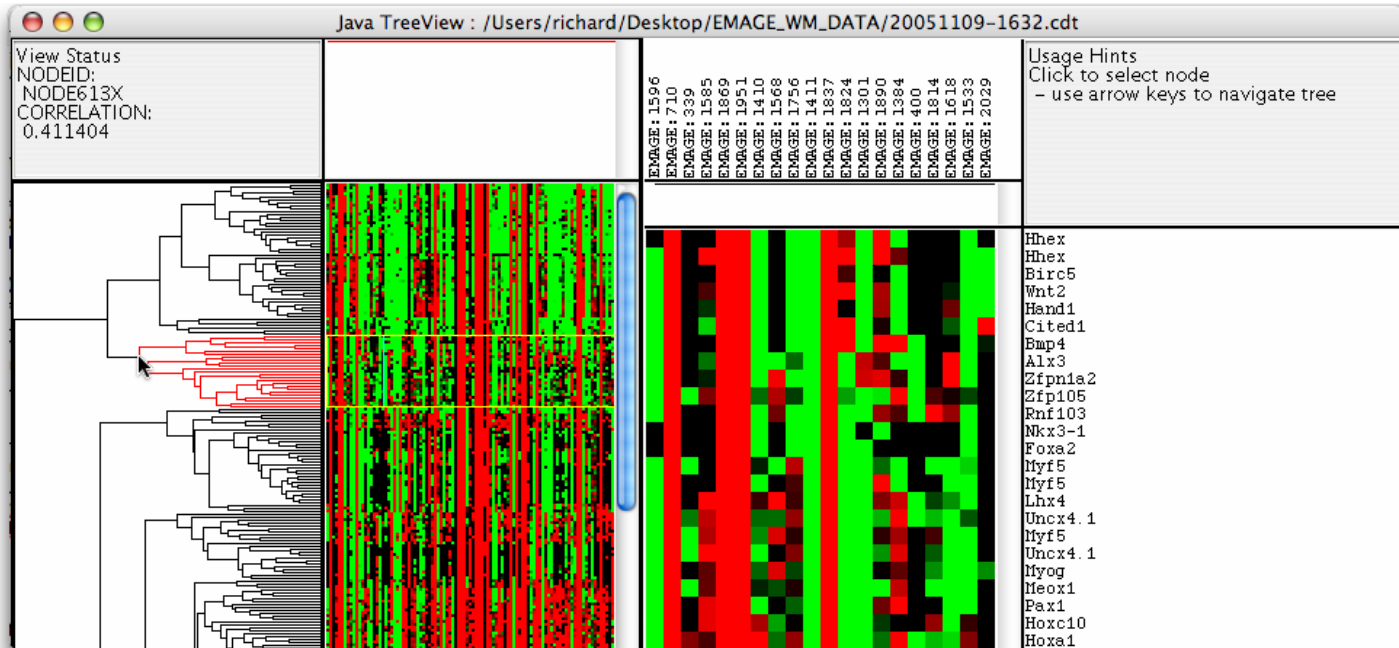
Spatial Clusters



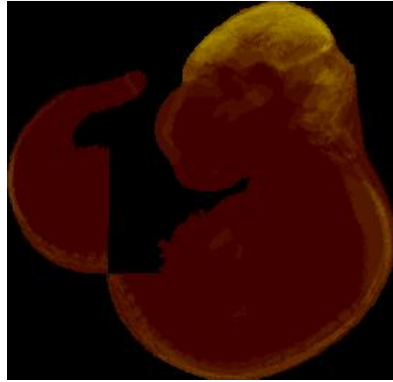
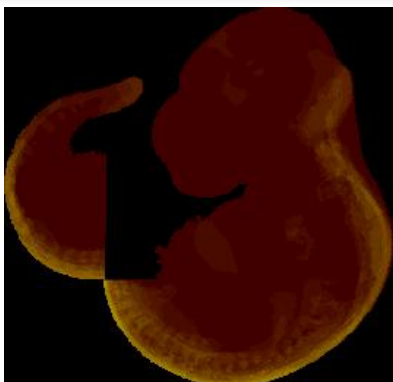
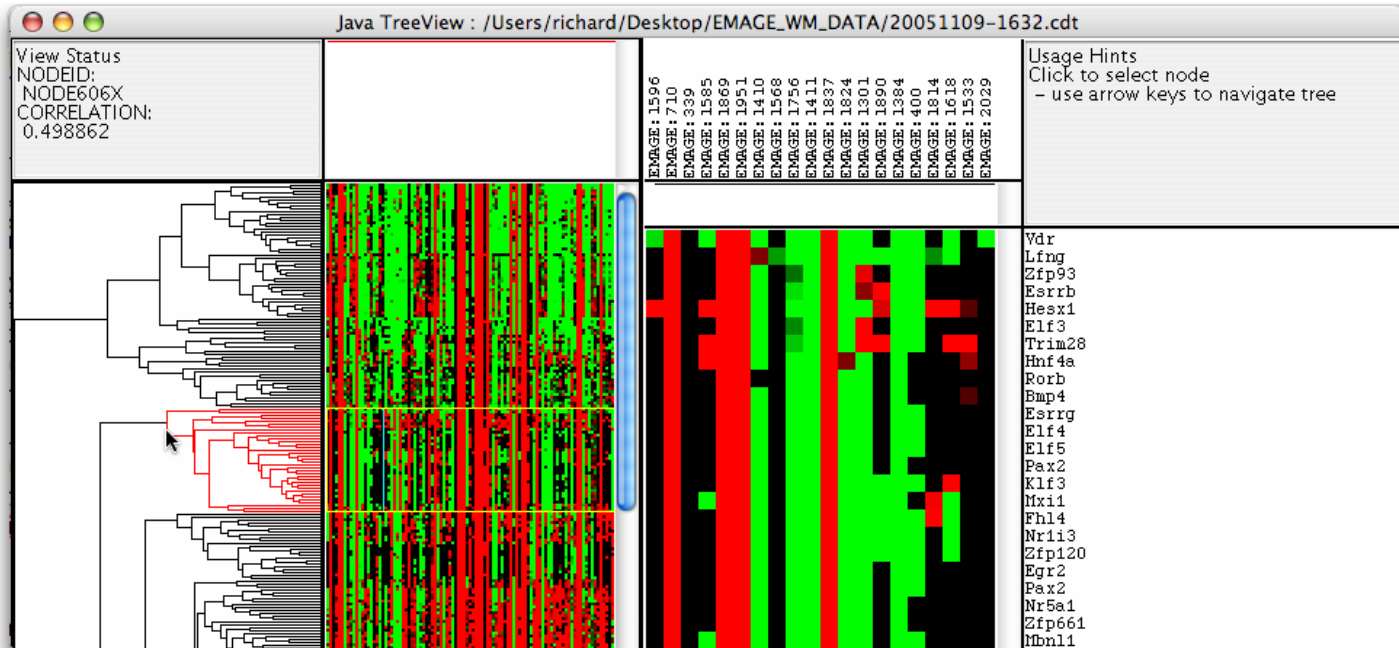
Spatial Clusters



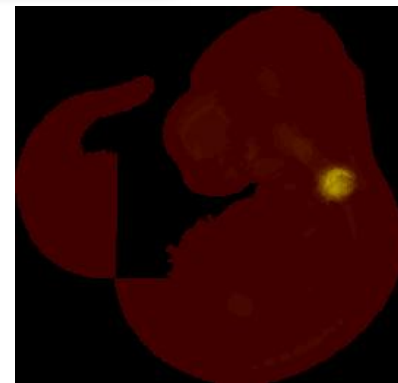
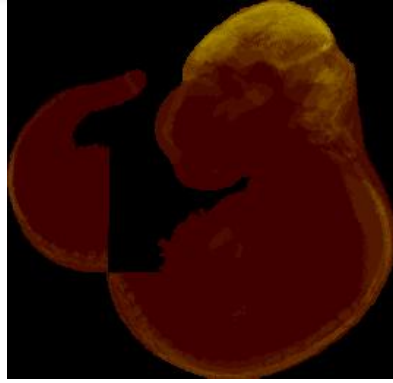
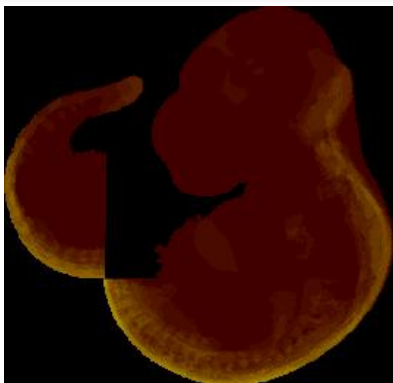
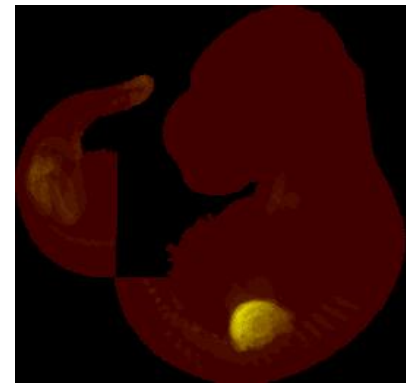
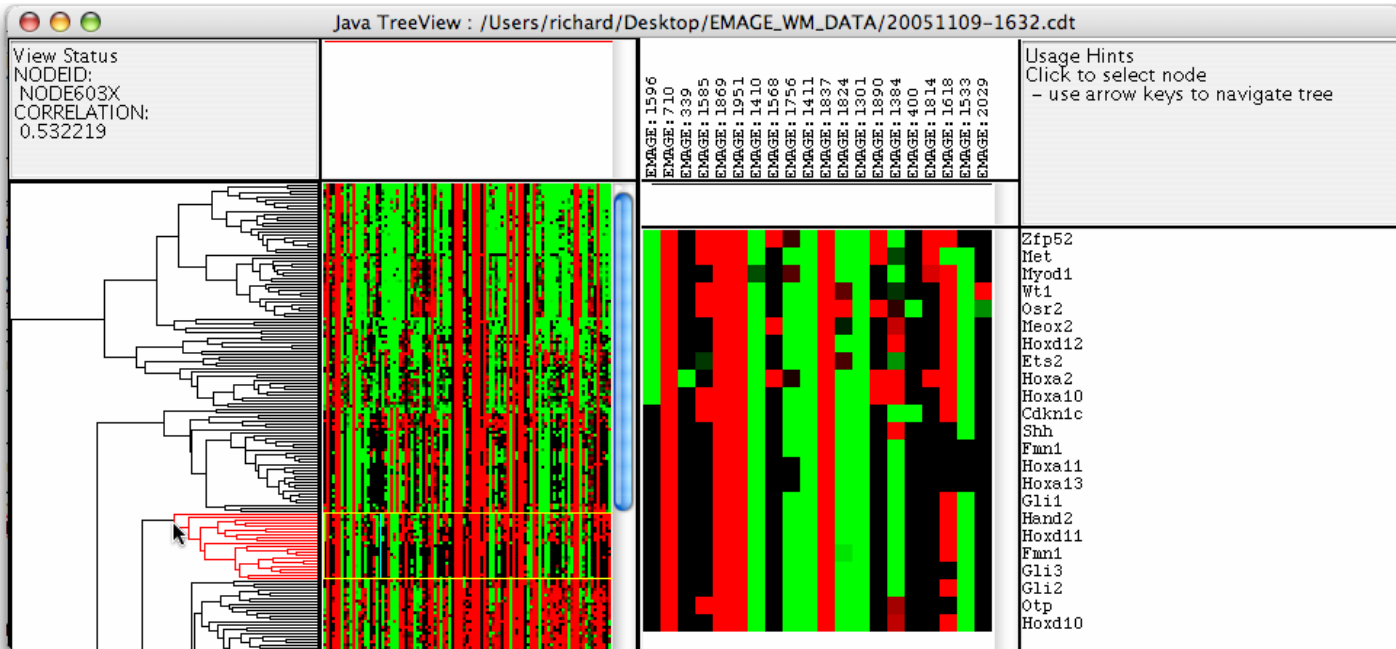
Spatial Clusters



Spatial Clusters



Spatial Clusters





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End