Axolotl Limb Regeneration

By: Elliot Bangerter, Brian Huntley, Kelly Phalen

Outline

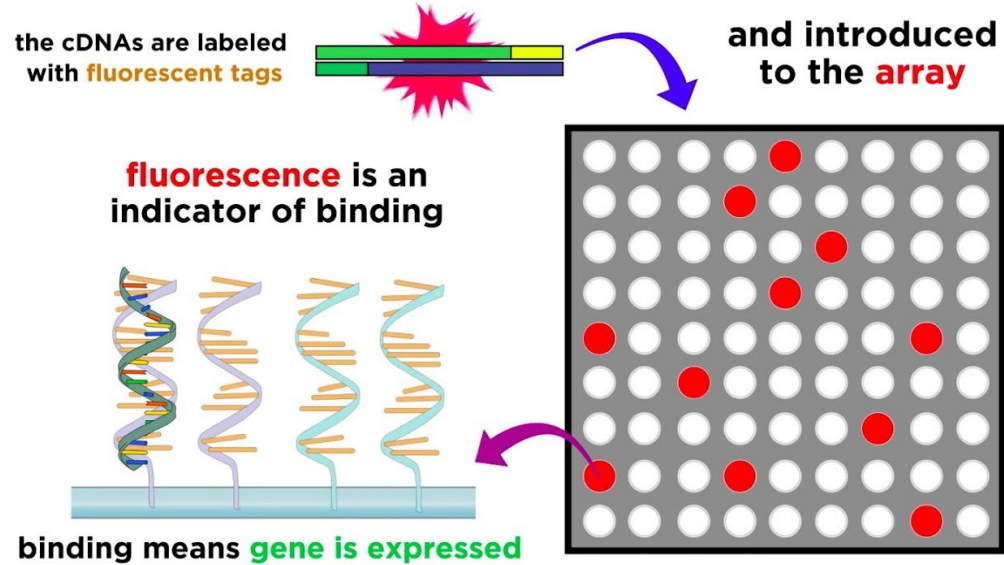Background

Motivation for visualizations

Impact and conclusion

1

3

5

2

4

6

Partner and research

Visualization implementation

Questions
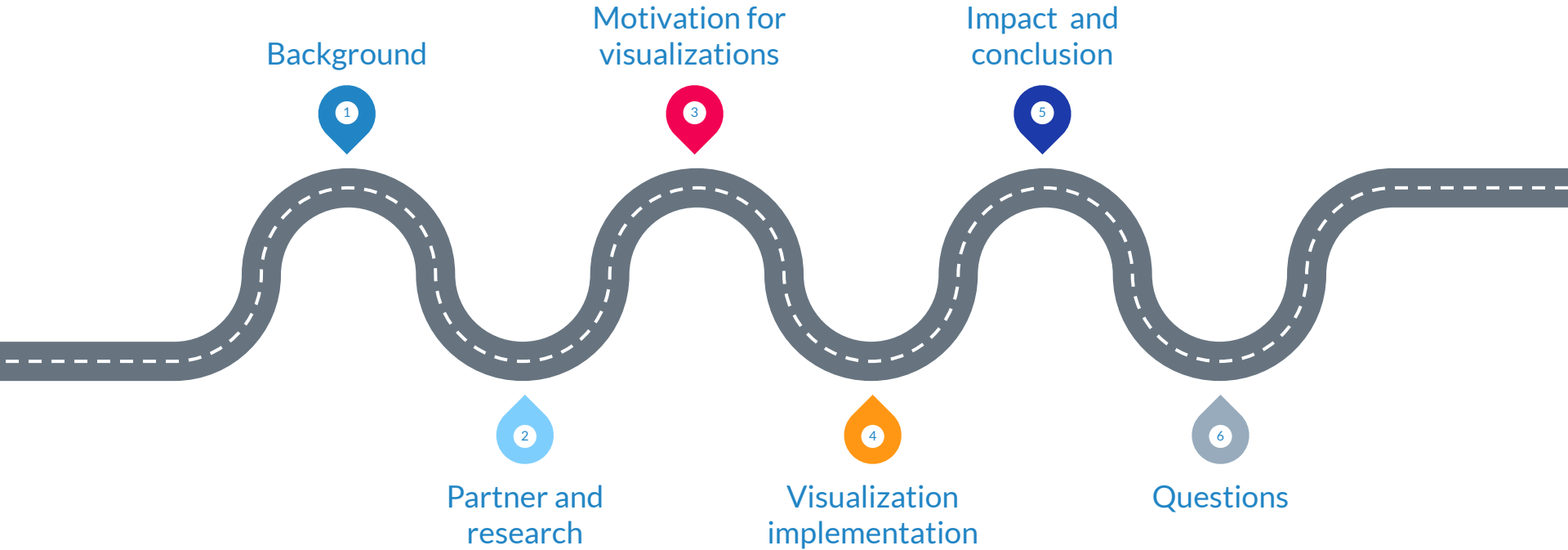
Background

Axolotls

▷ Type of salamander

▷ Remain in juvenile phase

▷ Known for their regeneration abilities
  ○ Limbs
  ○ Heart
  ○ Spinal cord

▷ No scarring of tissues

Gene Expression

▷ Genes have "on" and "off" switches

- ○ Determines if proteins are being made
- ○ Regulates the amount of proteins produced

▷ Fluorescent intensity shows the level at which the gene is expressed

- ○ Microarrays
- ○ Brighter the signal = more fluorescent intensity

the cDNAs are labeled with **fluorescent tags**

and introduced to the **array**

fluorescence is an indicator of binding

binding means **gene is expressed**

5

Partner and Research

Partner

▷ Dr. James Monaghan
  ○ Ph.D., Biology

▷ Associate Professor at Northeastern

▷ Specialty lies in regeneration biology
  ○ Focus on complex tissue regeneration

▷ ~30 published papers

The Monaghan Lab

▷ Study regenerative properties of axolotls
  - ○ Complex tissue regeneration
  - ○ Molecular properties- gene expression

▷ Animal homeostasis and regenerative medicine

Study from 2017

"Transcriptional correlates of proximal-distal identify and regeneration timing in axolotl limbs"

- ▷ Limb amputations at upper arm

- ▷ Gene expression recorded from day 0 to day 28
  - ○ Fluorescent intensity

- ▷ 20,000 genes

axolotl_gene	human_gene	D0	D0.5	D1	D1.5	D2	D3	D4
axo30838-f_	18sRNA	3.4728091	3.4256446	3.421645	3.479558	3.4491456	3.5568671	3.4667837
axo31258-f_	18sRNA	9.1699097	9.1117678	8.7806228	8.7813891	8.7268298	8.8050763	8.871721
axo26998-f_	5srRNA	6.1651086	5.4985653	5.5901233	5.7988792	5.8937668	5.8876031	6.0449534
axo30420-f_	7SK	3.5943214	3.5024485	3.6305547	3.6886102	3.7728091	3.8986149	3.8243676
axo31716-f_	7SK	9.8724306	11.087544	11.096343	11.154088	10.9289201	10.6723238	10.6293461
axo17055-f_	A2BP1	4.778857	4.6748512	4.6065707	4.5878507	4.6029898	4.6050215	4.5285153
axo20288-f_	A2LD1	4.5178893	4.6477986	4.4856239	4.5231152	4.765029	4.7748796	4.7194684
axo00006-f_	A2M	12.279243	12.473944	12.442651	12.548459	12.940593	12.891853	12.505468
axo00001-f_	A2M	3.6944151	3.6573035	3.650757	3.7536188	3.6791872	3.6847033	3.6750446
axo00004-r_	A2M	4.6245487	4.2814737	4.6432049	4.2713247	4.3393745	4.3778664	4.4532504
axo00002-f_	A2M	9.3318147	9.8382911	9.8588698	9.8207864	9.9358056	9.6495662	9.4248461
axo00003-r_	A2M	4.3012124	4.081215	4.2409951	3.8523656	4.187634	3.9078929	3.9492902
axo01055-r_	A2ML1	4.7421674	4.1751933	4.5868717	4.1333119	4.2390104	4.3218629	4.2836311
axo01057-f_	A2ML1	7.0042379	5.7926852	6.7814936	5.6872441	5.7127232	5.8839136	6.3633846
axo15210-r_	AAAS	7.8149467	7.8092201	7.8308076	7.7048987	7.8999894	7.8686742	7.8910057
axo15211-r_	AAAS	5.956032	6.0273513	5.8643534	5.8962829	6.1715346	6.1402178	6.1029724
axo18653-f_	AACS	9.2821238	9.823007	9.7343423	9.8852741	9.6142018	9.351439	8.6635761
axo04823-f_	AADAC	9.0936581	9.3697129	9.4237166	9.2265613	9.3258773	9.4544882	9.4846747
axo04822-f_	AADAC	6.0871075	5.6368684	5.4672054	5.5778552	5.6234739	5.9844609	5.851457

Motivation

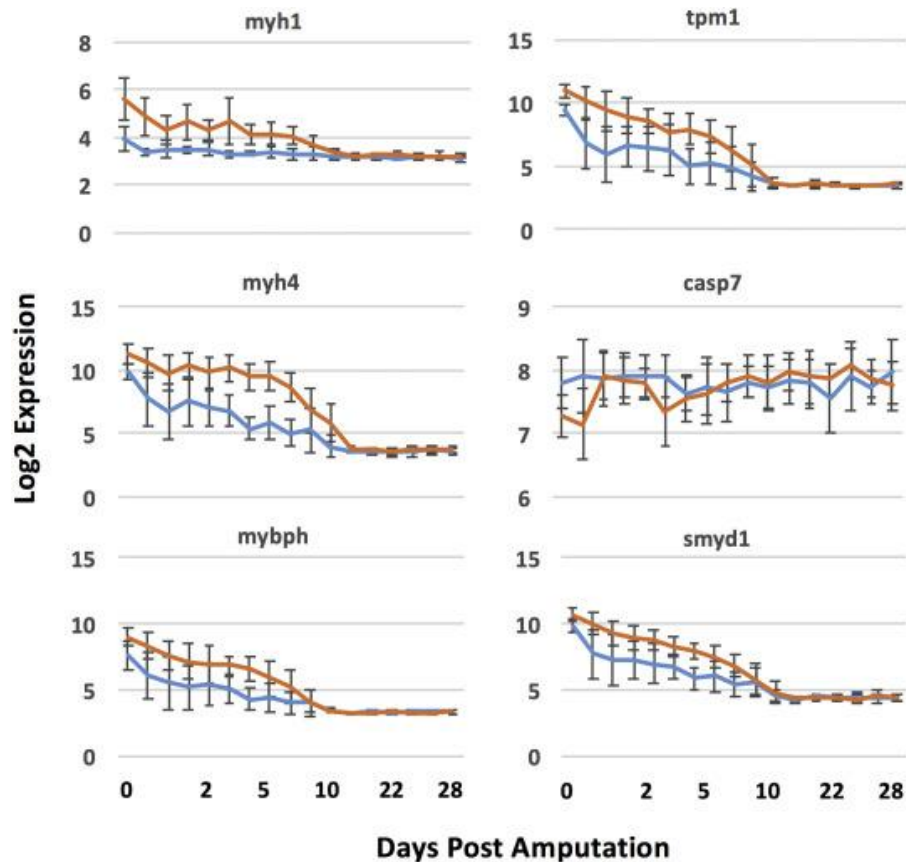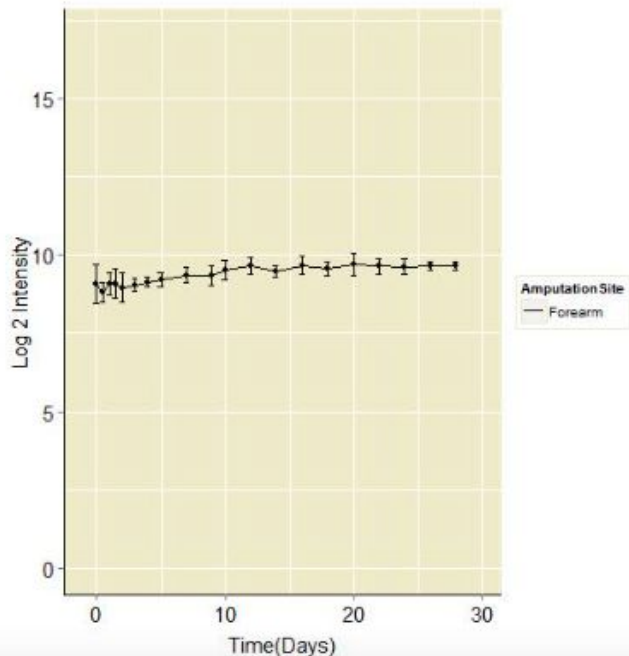# Standard Visualizations for Gene Expression

Comprehensive analysis of gene expression during axolotl limb regeneration

Probe Expression Information
Affy GeneChip Probe : axo06936
Source Sequence ID (Assembly V3.0): contig41114
**Gene Information :** ANXA7 annexin VII isoform 1 [Homo sapiens]

Problems

▷ Basic, show individual genes

▷ Unable to address relationships

▷ Lack of interactivity

▷ Trends are not easily digestible

Visualizations

Initial Ideas

▷ Consumable vis for the scientific community
- Make data more understandable
- Discover trends

▷ Exploratory visualizations
- Queryable
- Show change in gene expression
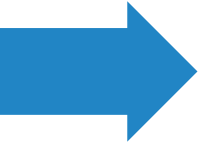
dot plot

line charts

heatmap
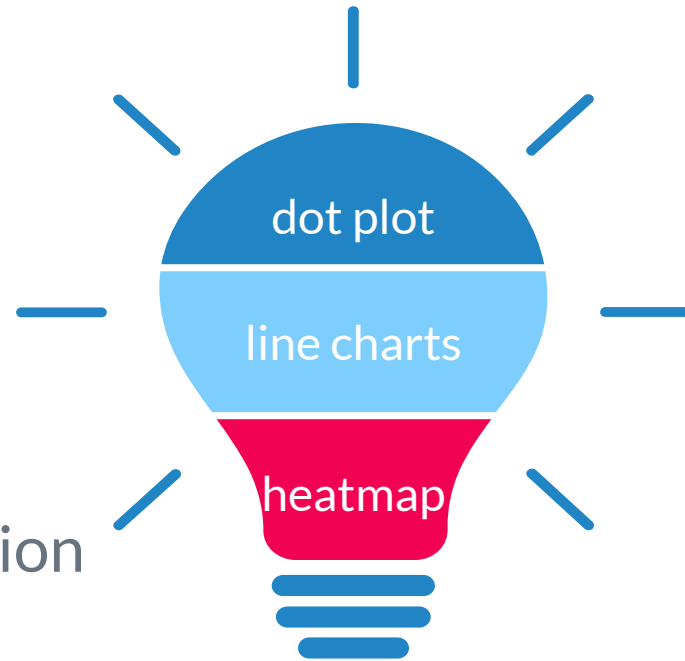
User tasks

▷ Use patterns to identify genes that change significantly over the regrowth period
  ○ Query task: identify
  ○ Search task: locate
  ○ Analyze task: discover

▷ Analyze genes and categories of genes
  ○ Query task: compare
  ○ Search task: browse
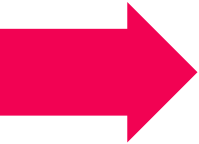 ○ Analyze task: discover

Next tasks
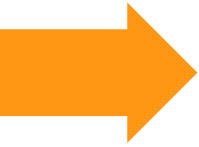
Grouping genes by trend
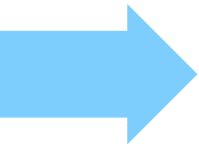Find trends among genes based on k means clustering

Transforming dot plot
Add mean intensity to the y-axis to create a volcano plot

Making the vis user friendly
Adding buttons, a search feature, zooming in on the dot plot

Heatmap interactivity
Button to clear heatmap, remove specific rows

Impact and Conclusion

Results

Dot plot

See trends among genes during regeneration period

Line charts

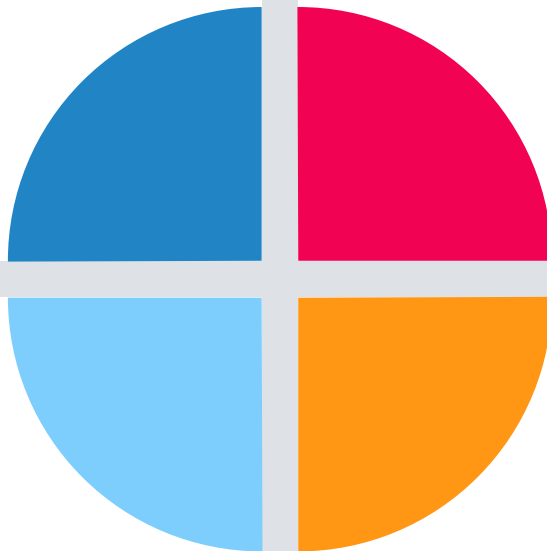Show individual gene expression changes over each point in time period

Heatmap

Discover further correlations between groups of genes

Effects

JAMES MONAGHAN

Not a visualization expert, used current standard visualization practices. Now, he can explore and present his data more easily and effectively.

ANALYSIS

View the change in gene expression in the context of many genes. Allows for more informed conclusions.

Discover important genes that are useful for future research.

FUTURE RESEARCH

Direct comparisons to human genes are helpful for the overall field.

REGENERATIVE MEDICINE COMMUNITY

20

Resources

▷ https://www.nationalgeographic.com/animals/amphibians/facts/axolotl

▷ https://web.northeastern.edu/monaghanlab/#_ga=2.246603140.1435557446.1649651530-1557804863.1639626050

▷ https://cos.northeastern.edu/people/james-monaghan/

▷ https://doi.org/10.1016/j.cbpc.2017.10.010

▷ https://ambystoma.uky.edu/quick-links/microarray-database

▷ https://www.yourgenome.org/facts/what-is-gene-expression

▷ https://www.youtube.com/watch?v=Hv5flUOsE0s

Thanks!

Any questions?