北京大學 PEKING UNIVERSITY

生命科学学院 School of Life Sciences

Decoding Regeneration: Unveiling The Hidden Mechanisms in Diverse Organisms

UHPB Journal Club

Jiaxi Liu (刘家希)

School of Life Sciences

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UHPB Supervisor

Yan Song（宋艳）

- Vice Dean & Principal Investigator, School of Life Sciences, Peking University
- Principal Investigator, PKU-THU Joint Center for Life Sciences (CLS)

Research Interests:

- Inheritance of neuronal cell fate memory
- Brain-specific gene expression programs
- Decoding temporal regulation in neural development

Distinguished Guests

Wei Wang （王伟）

- Principal Investigator & Assistant Professor, National Institute of Biological Sciences, Beijing (NIBS)
- Assistant Professor, Tsinghua Institute of Multidisciplinary Biomedical Research(TIMBR).

Research Interests:

- Molecular basis of regeneration
- Evolution of regenerative capacities in vertebrates
- Regeneration and rejuvenation

Distinguished Guests

Cheng-Ran Xu（徐成冉）

- Principal Investigator, School of Basic Medical Sciences Peking University
- Principal Investigator, Peking-Tsinghua Center for Life Sciences (CLS)

Research Interests:

- Directed differentiation of embryonic stem cells & Tissue and organ regeneration
- Mechanisms of mammalian liver and pancreas development
- Regulation of gene networks by cell signaling and epigenetic mechanisms during development and regeneration

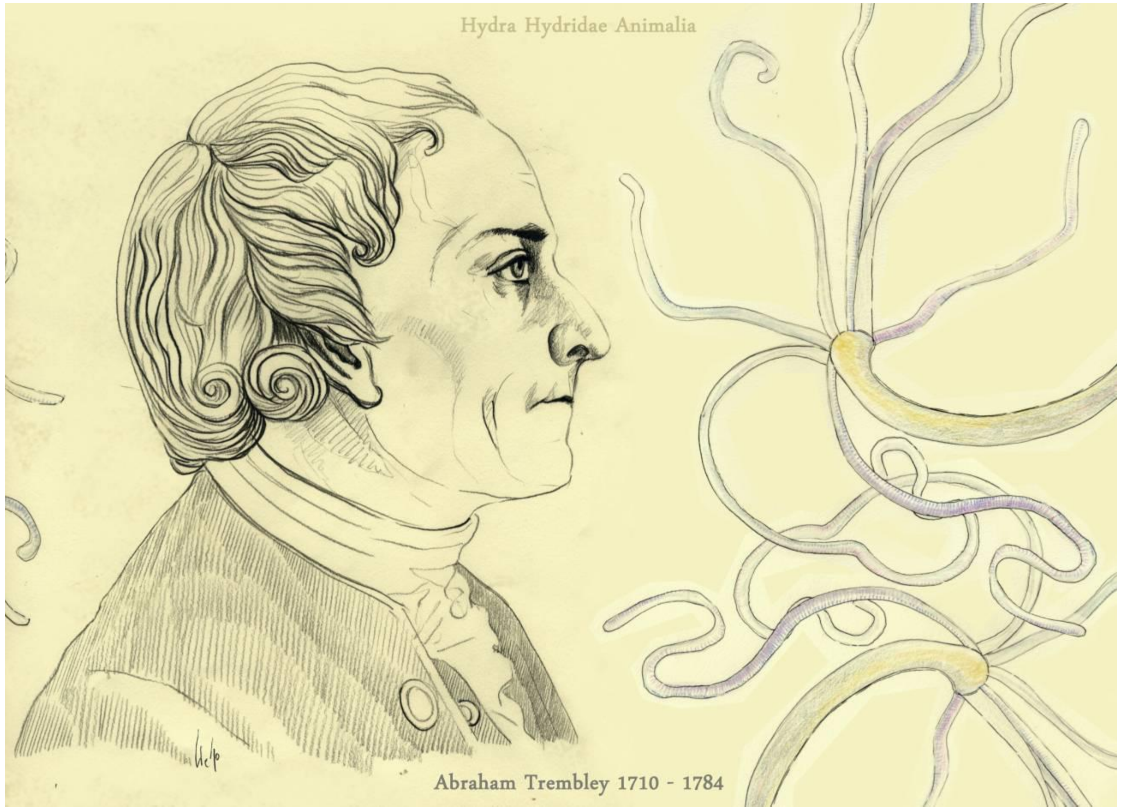
Regeneration in our life

Doctor Who

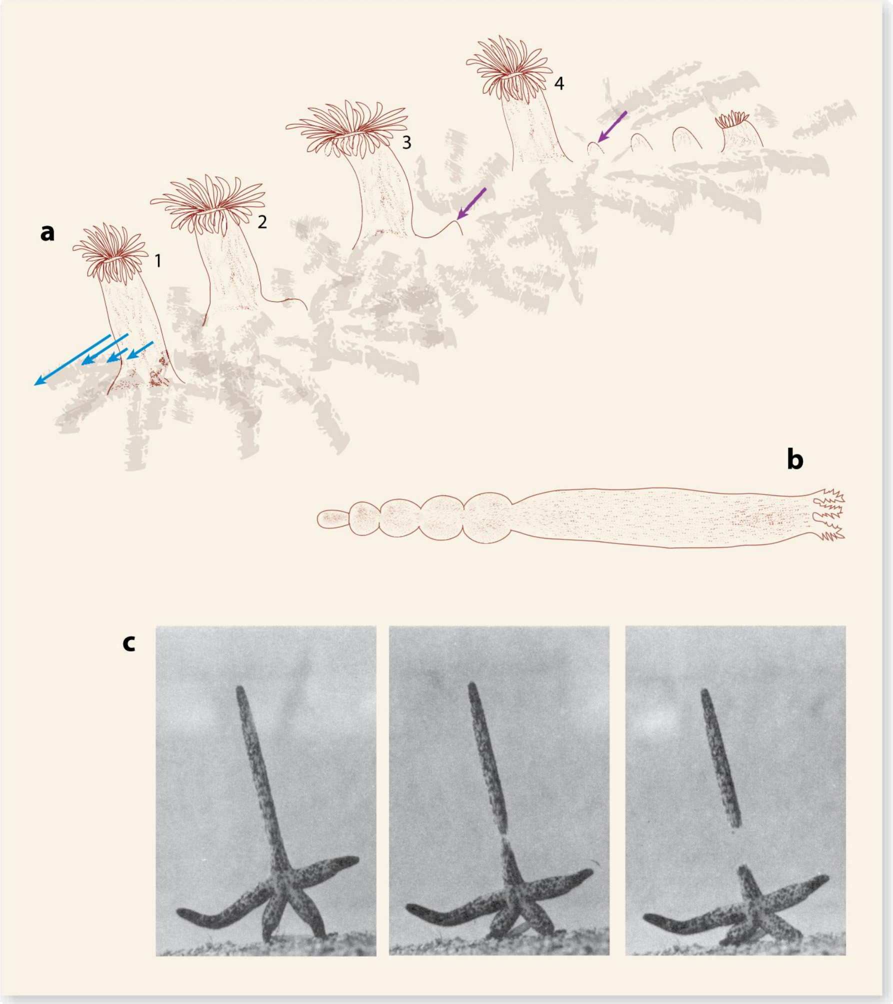
Gecko (Credit: Feast or Famine)

Maine Lobster

Historical Foundations of Regeneration

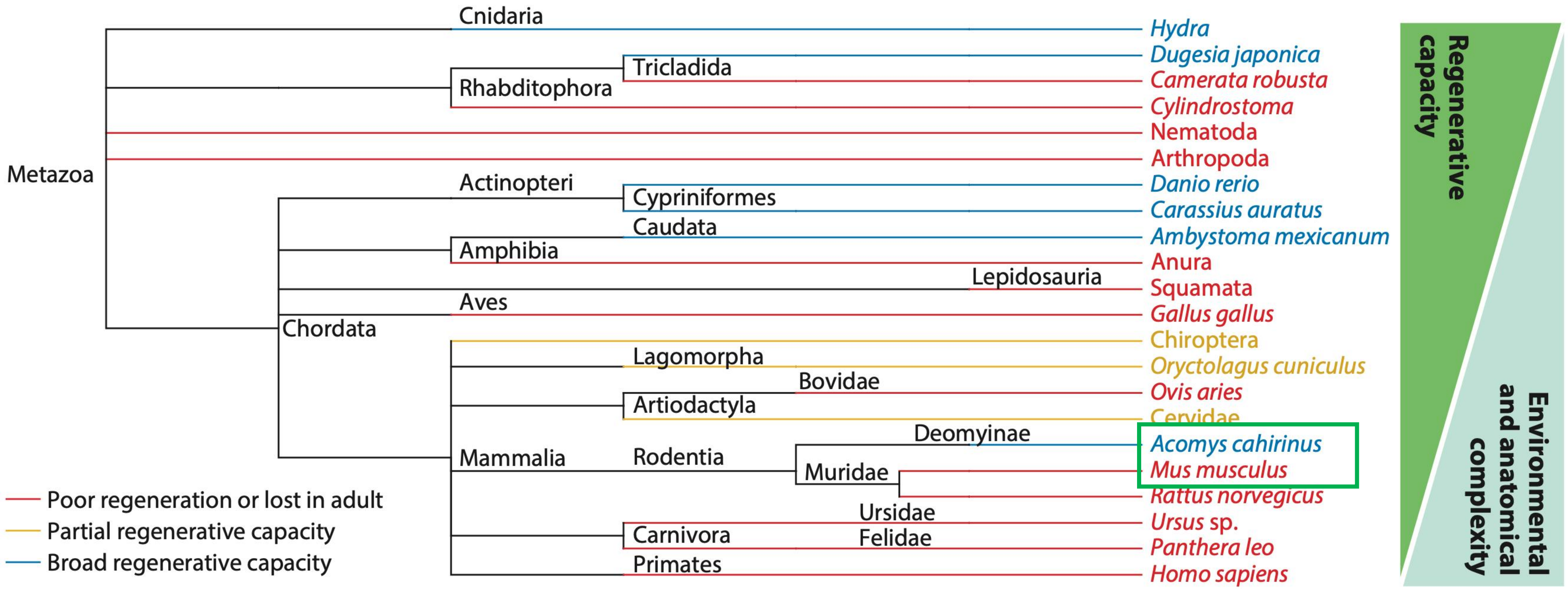


Abraham Trembley (1710-1784)



Brockes JP, Kumar A. 2008.
Annu. Rev. Cell Dev. Biol. 24:525–49

Regeneration Across the Animal Kingdom



The ability to regenerate is widespread in the animal kingdom

Liao K et.al, *Annu Rev Anim Biosci*. 2025

Key Questions in Regeneration

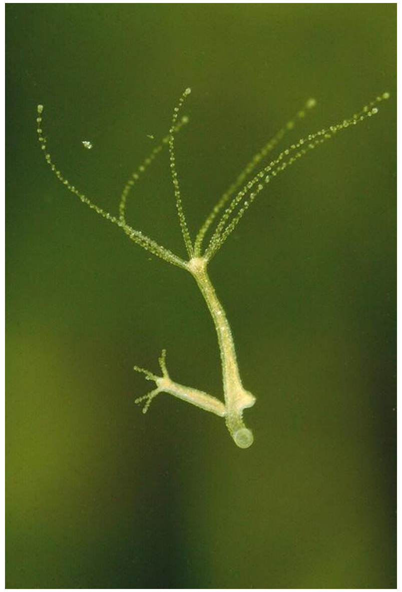
Biologists have long been captivated by questions such as:

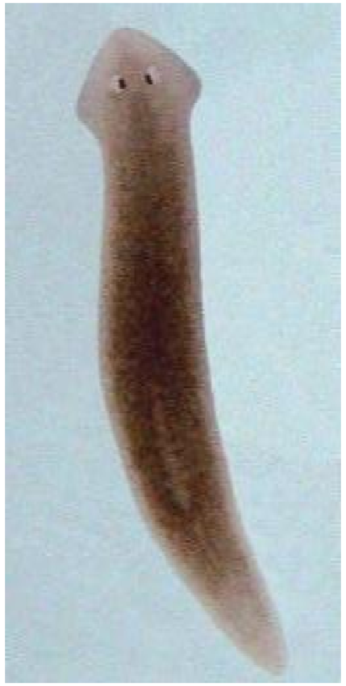
- Where do the new cells come from? ——**cell sources**
- Why do some animals/organs regenerate while most mammals do not? ——**evolution**
- How does the process start? /How do wounded tissues "know" what to remake? ——**signal control**

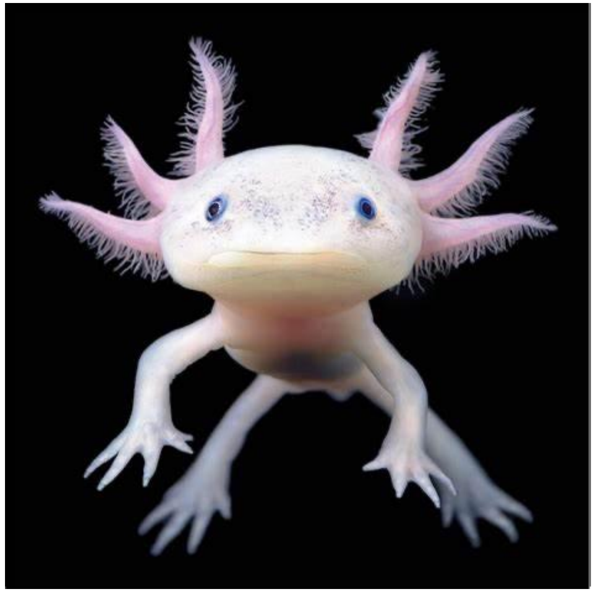
Classical Model Organisms

invertebrate | **vertebrate**

Hydra planarians zebrafish *Axolotl* AcoMys







adult pluripotent stem cells

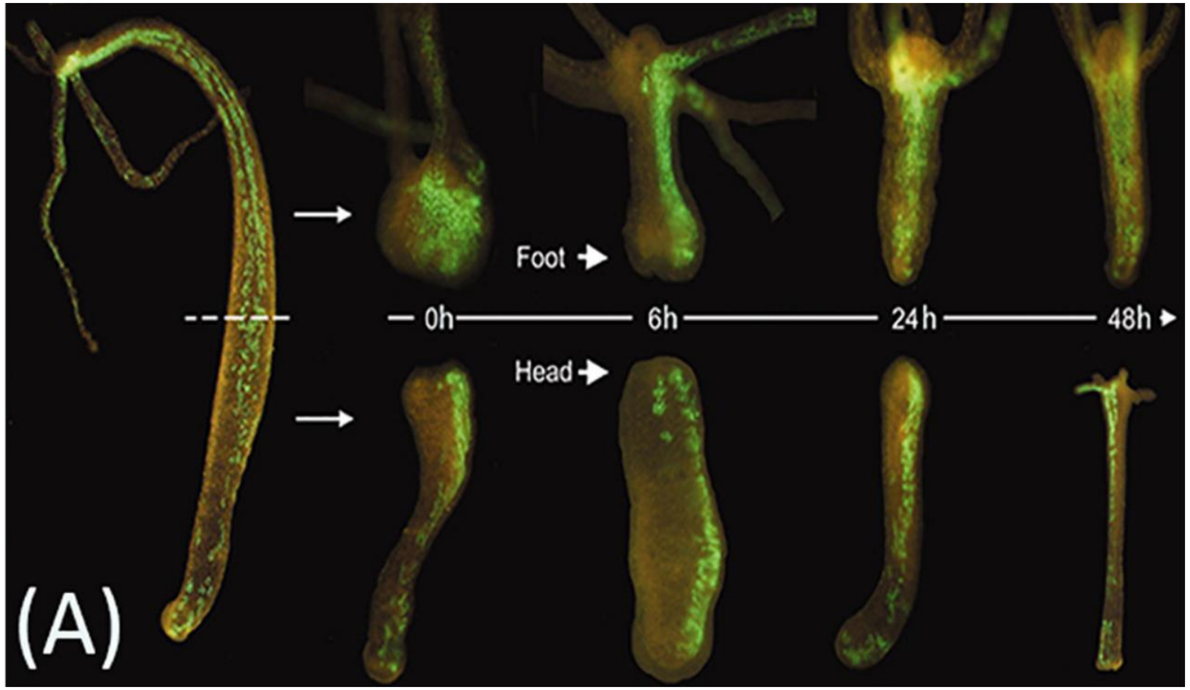
lineage-restricted progenitors from different tissues

from wikipedia and other website

Model Organisms – invertebrates

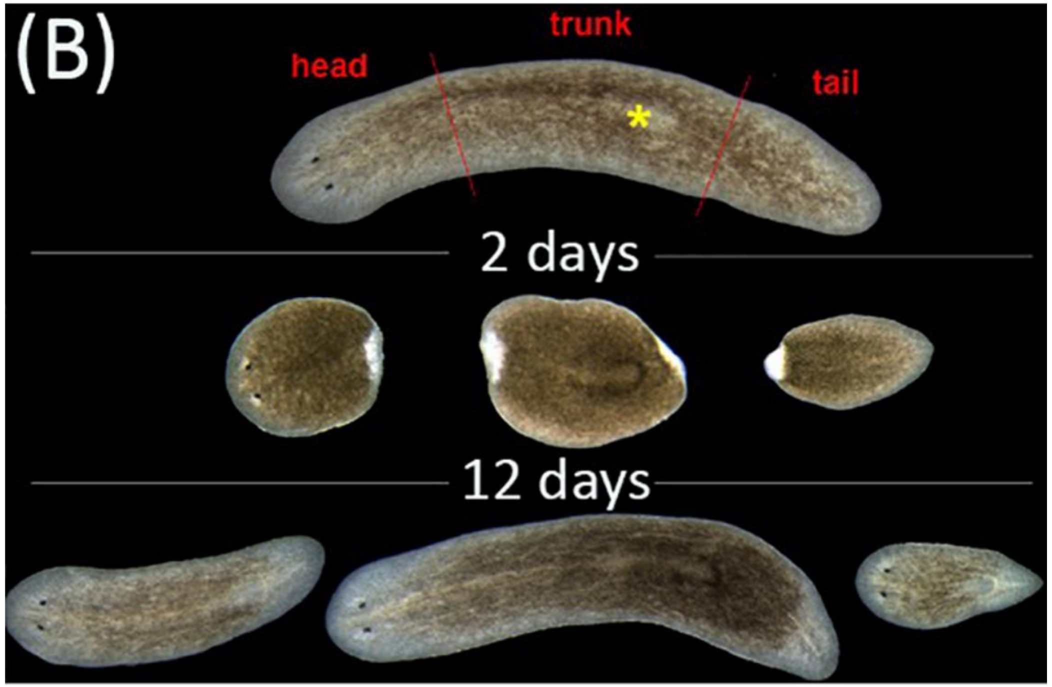
Small fragments of Hydra or planarians tissue can regenerate a complete organism

Hydra



Wittlieb, J. et.al. *Proc. Natl. Acad. Sci*. 2006

planarians



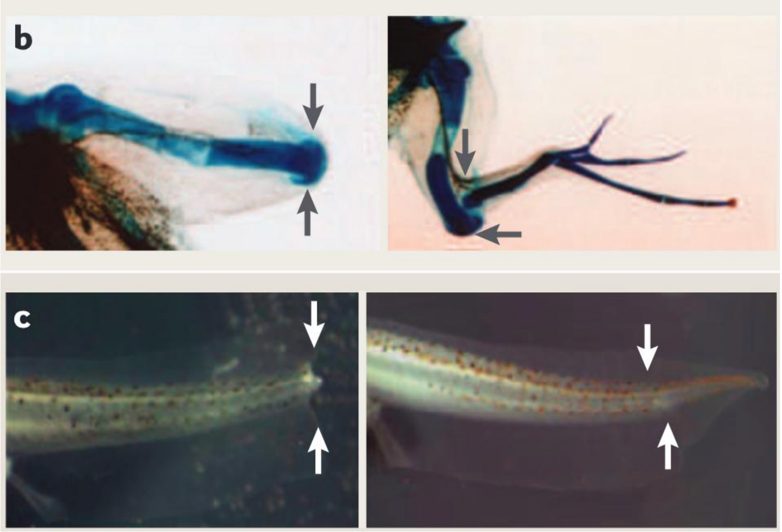
Adell, T. *Biomed Res.* 2014

Model Organisms – vertebrates (no mammals)

Salamanders
- limbs
- tail
- lower jaw
- the lens of the eyes
- the heart
- brain **(main1)**

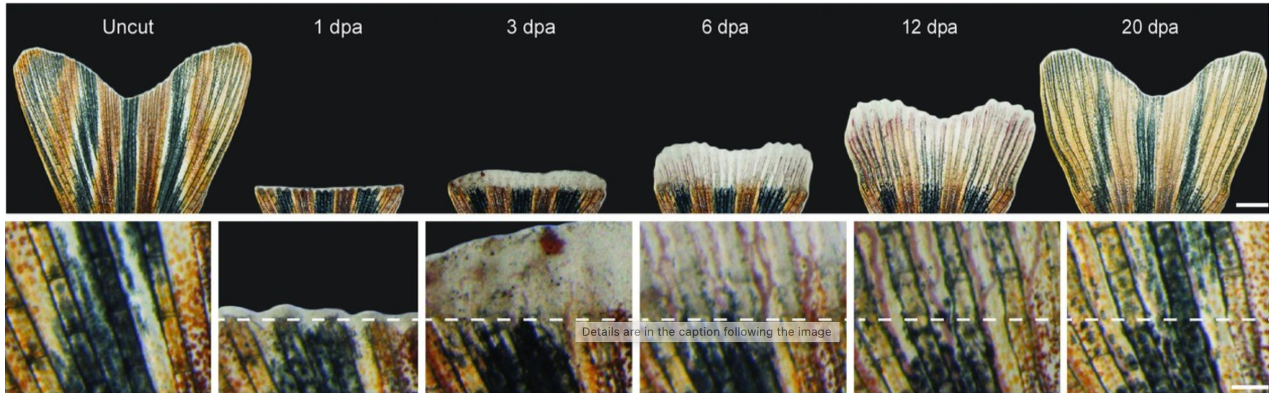
Monaghan et.al. *Regeneration*. 2014

Zebrafish
- Myocardium
- fin ray
- spinal cord



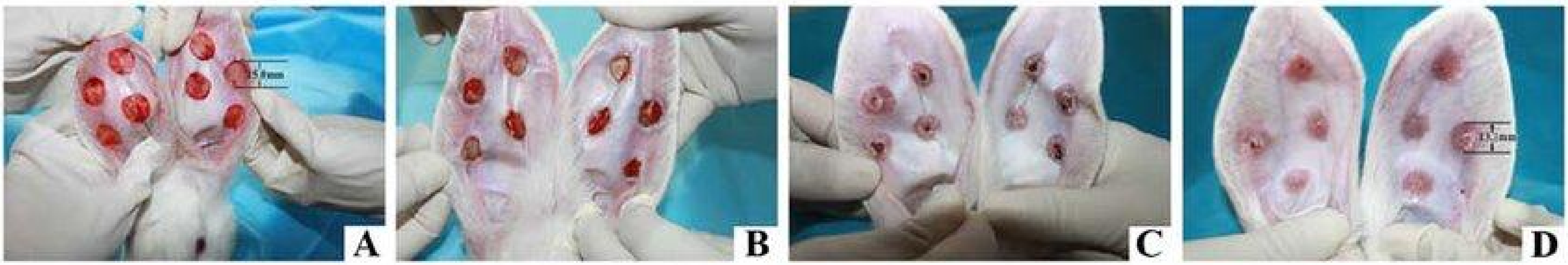
Xenopus
- limb
- tail

Sánchez Alvarado A. *Nat Rev Genet*. 2006

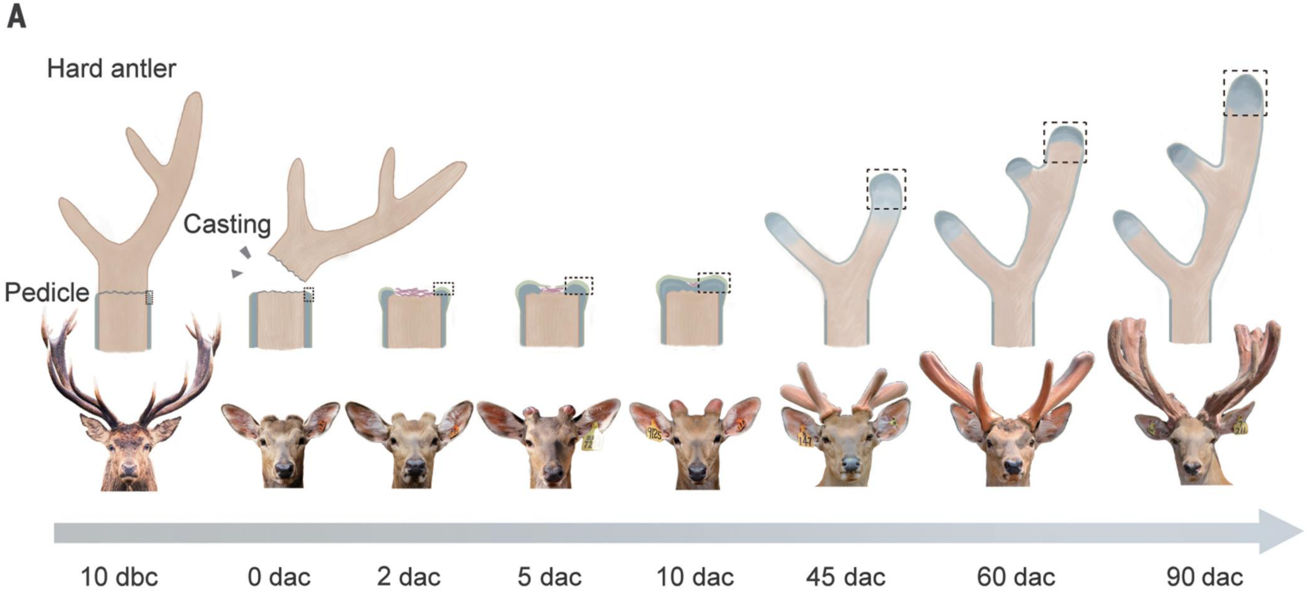


Pfefferli C et.al *Regeneration (Oxf)*. 2015

Regeneration in Mammals



Zhao JC et.al. *Exp Ther Med*. 2018

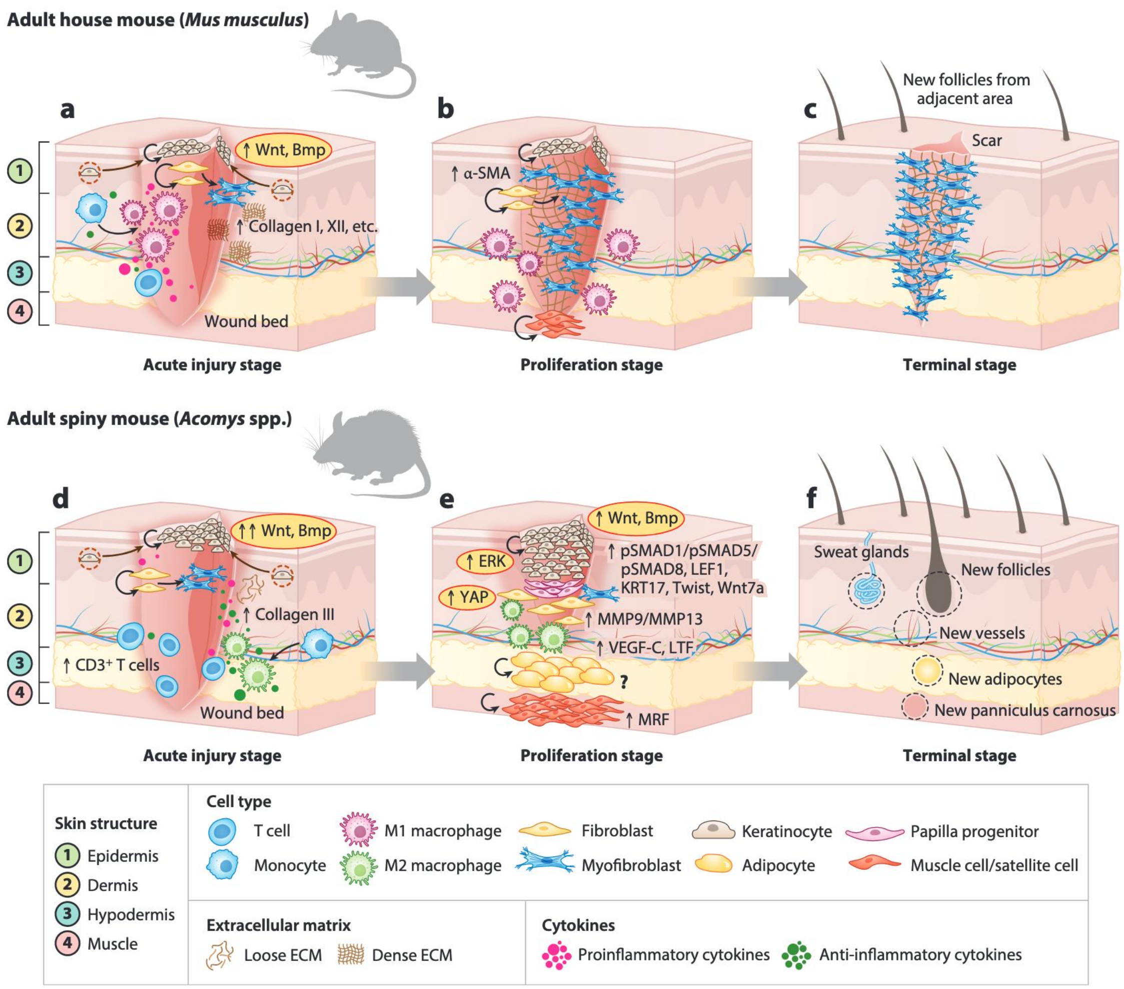


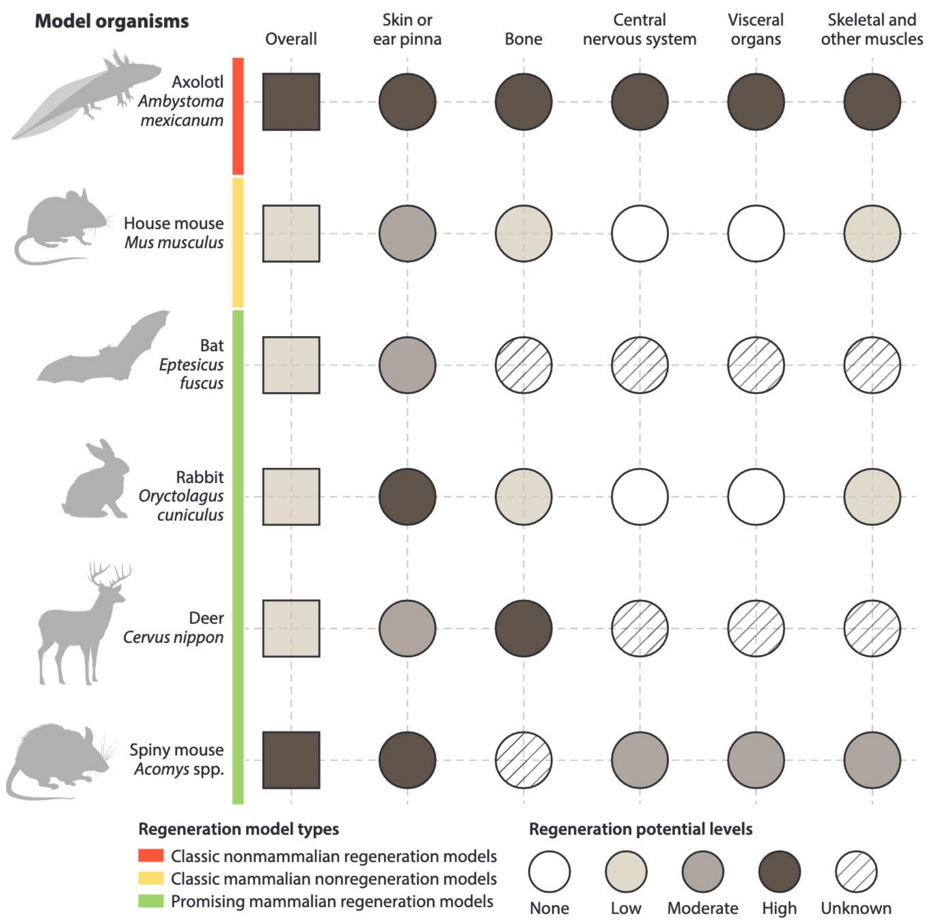
Qin T et.al. *Science*. 2023

from rika.com

Regeneration in Mammals – Limitations

Differences in ear pinna healing between house mice and rabbits **(main2)**





Liao K et.al. *Annu Rev Anim Biosci.* 2025

Regeneration in Mammals – Limitations

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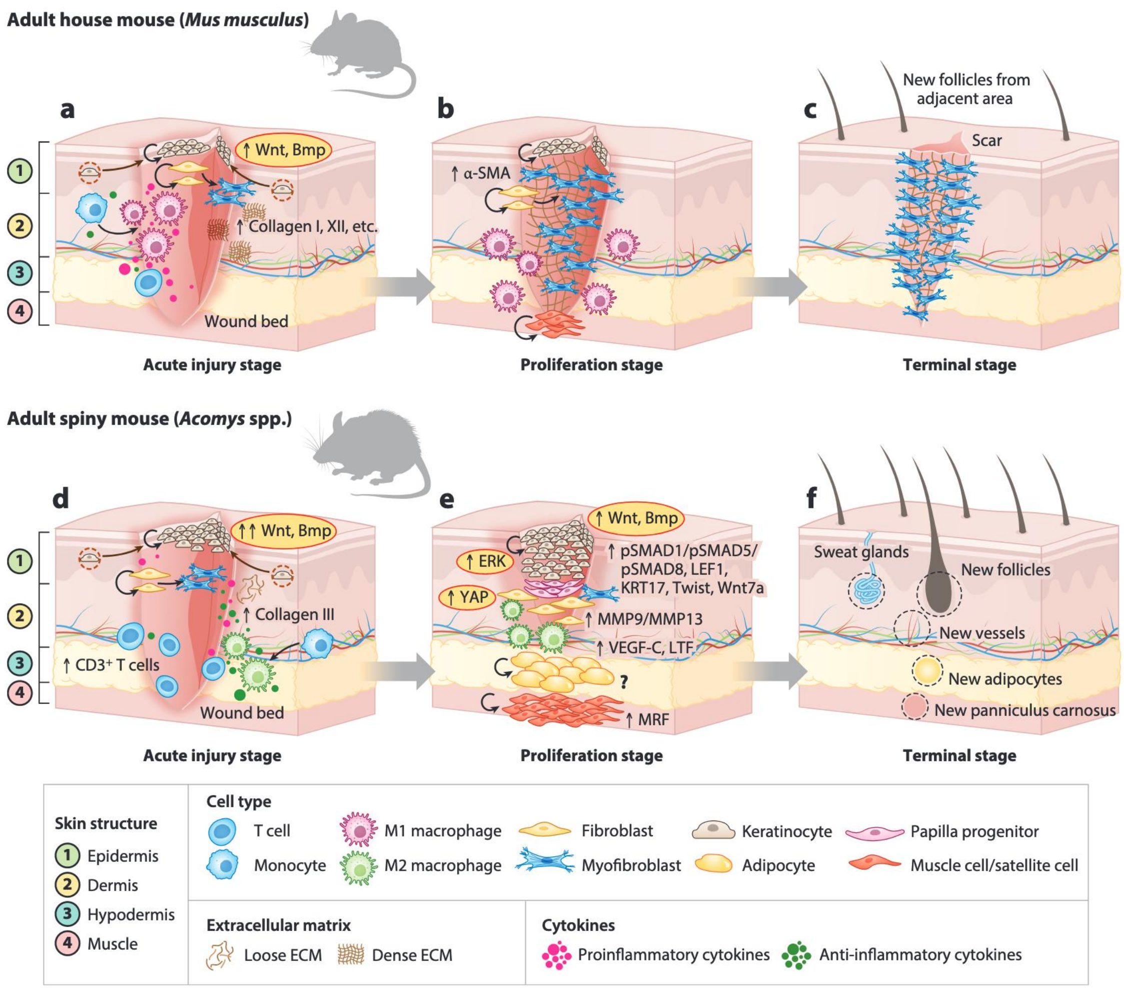
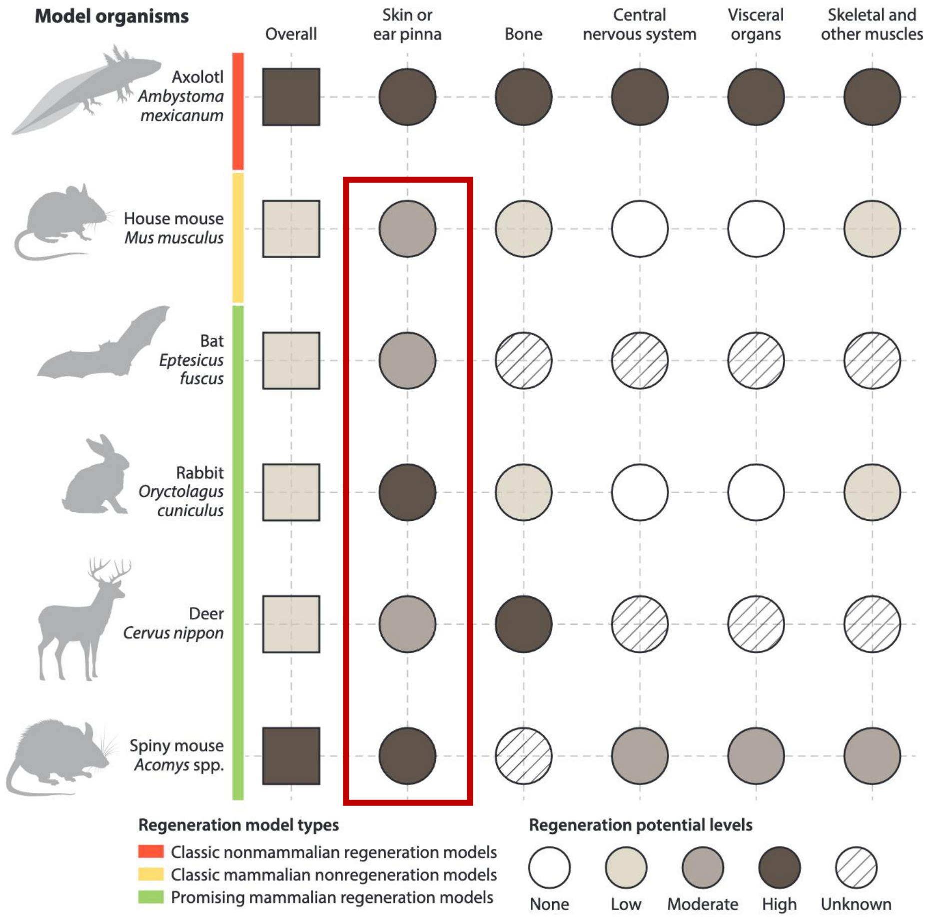
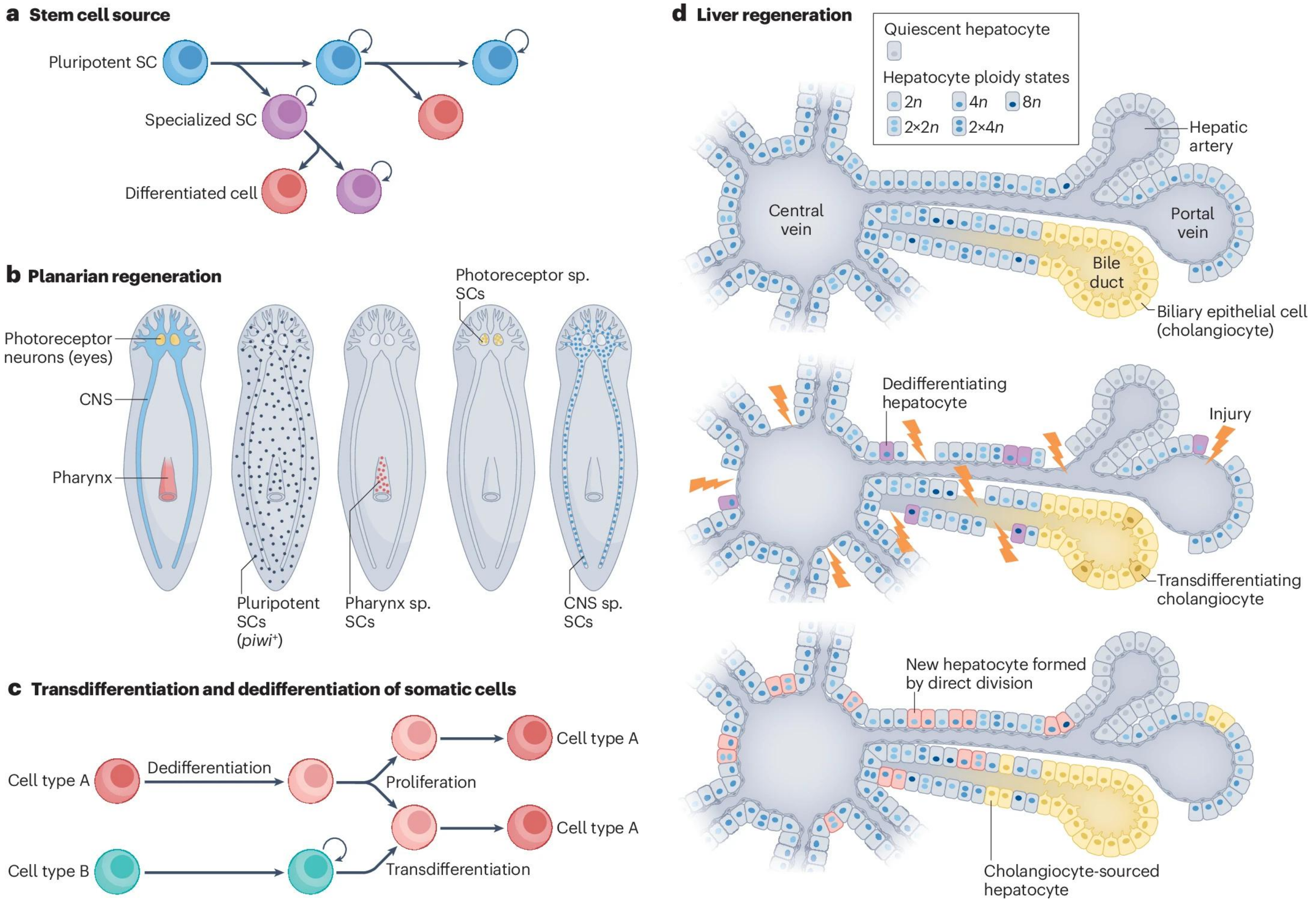




Liao K et.al. *Annu Rev Anim Biosci.* 2025

Cellular Sources for Regeneration

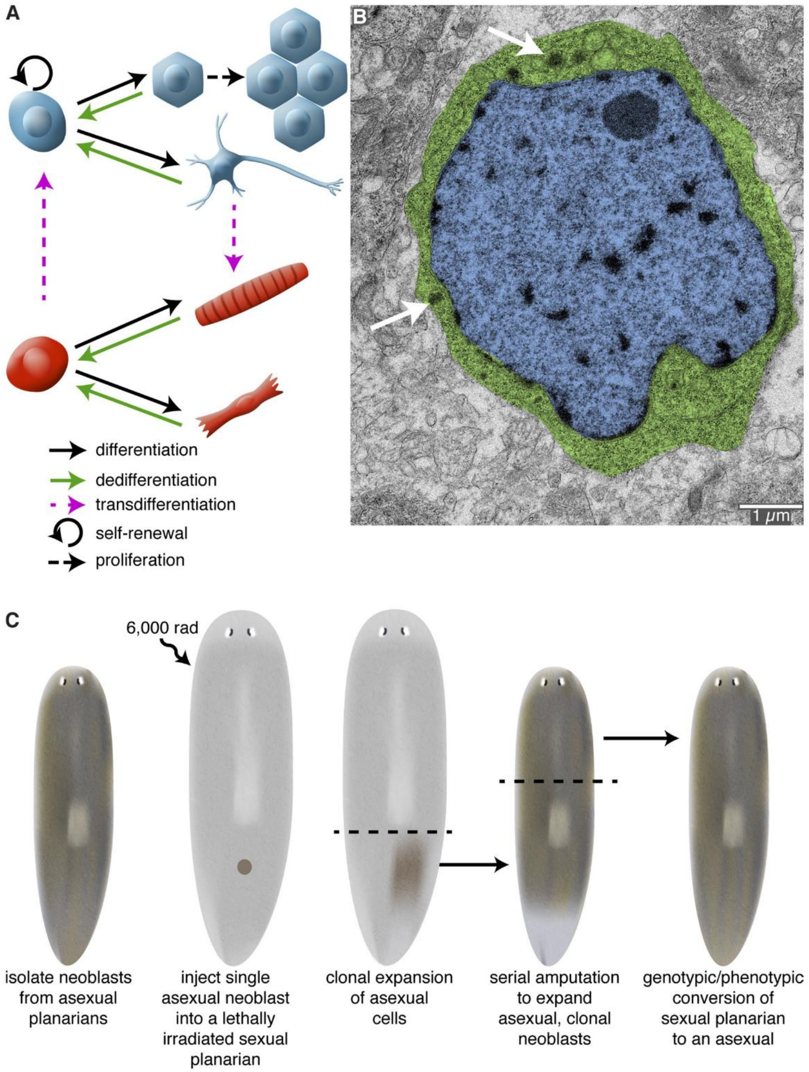
- stem cell
- dedifferentiation
- transdifferentiation
- other: self-duplication



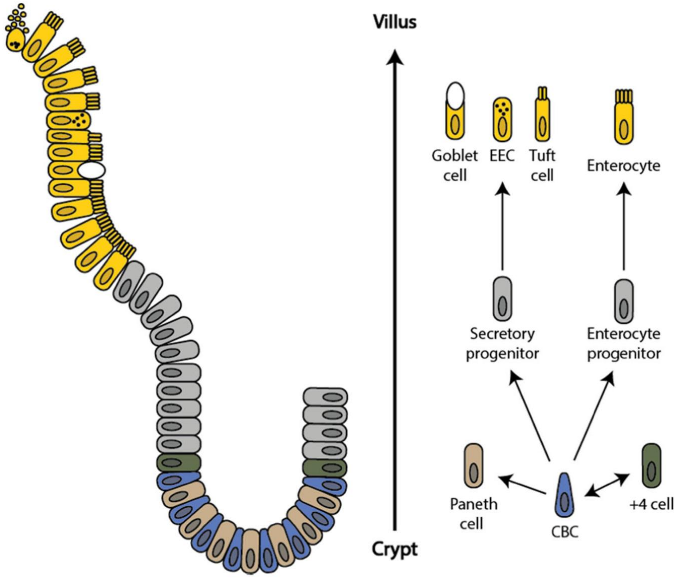
Sushant Bangru et.al, *Nat Rev Mol Cell Biol*, 2025

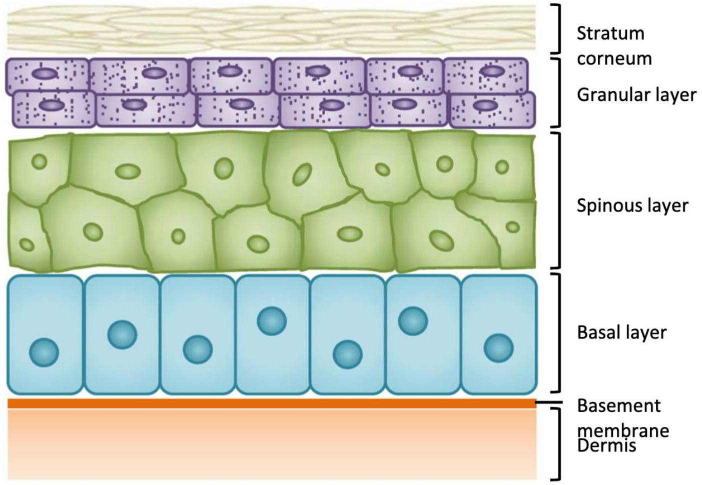
Stem Cell–Driven Regeneration

- Planarians accomplish regeneration with use of adult pluripotent stem cells (**neoblasts**)
- several vertebrates utilize a collection of lineage-restricted progenitors



Ryan S. King et.al. *JCB*. 2012

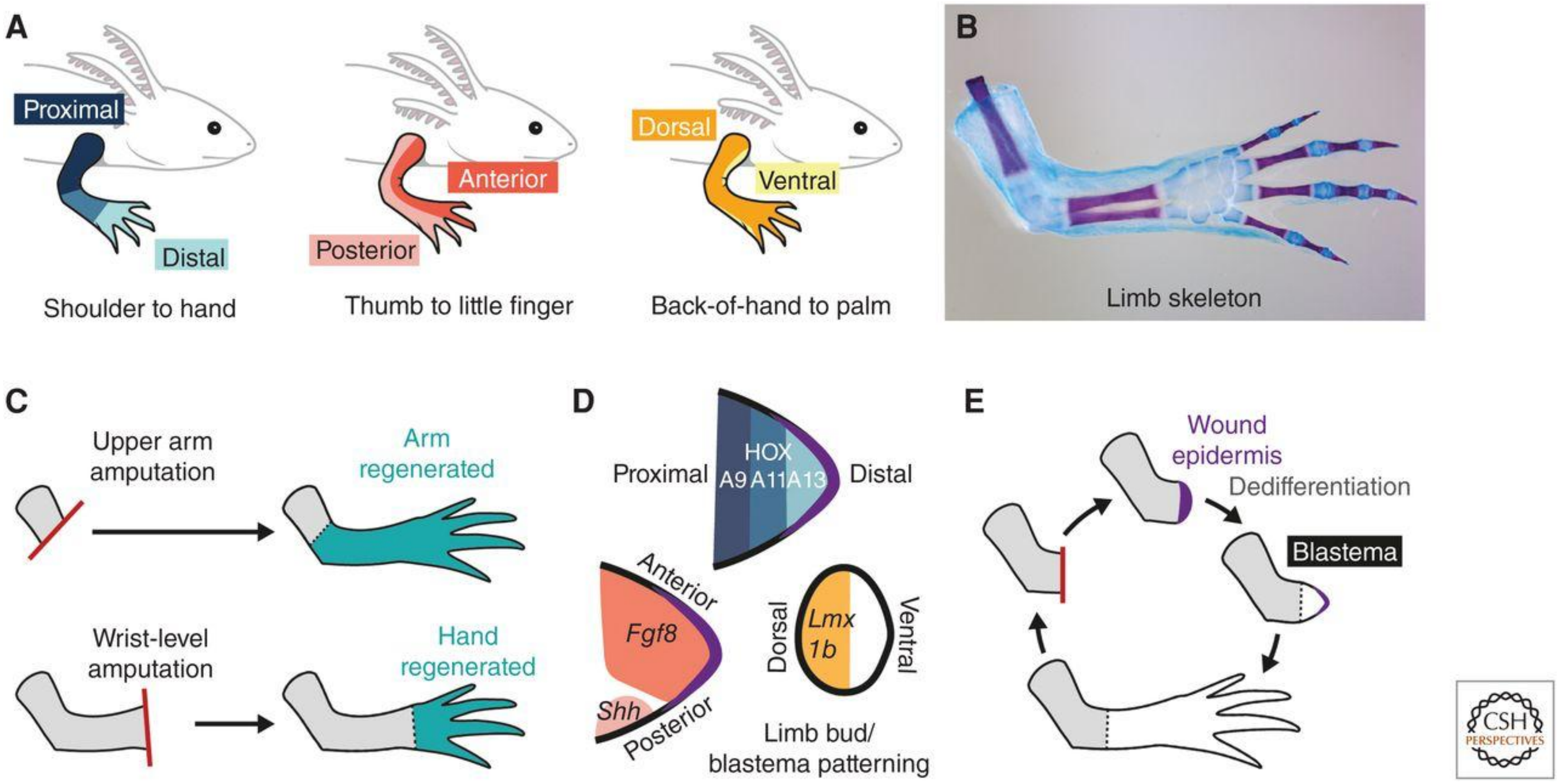




Iismaa SE et.al. *NPJ Regen Med.* 2018

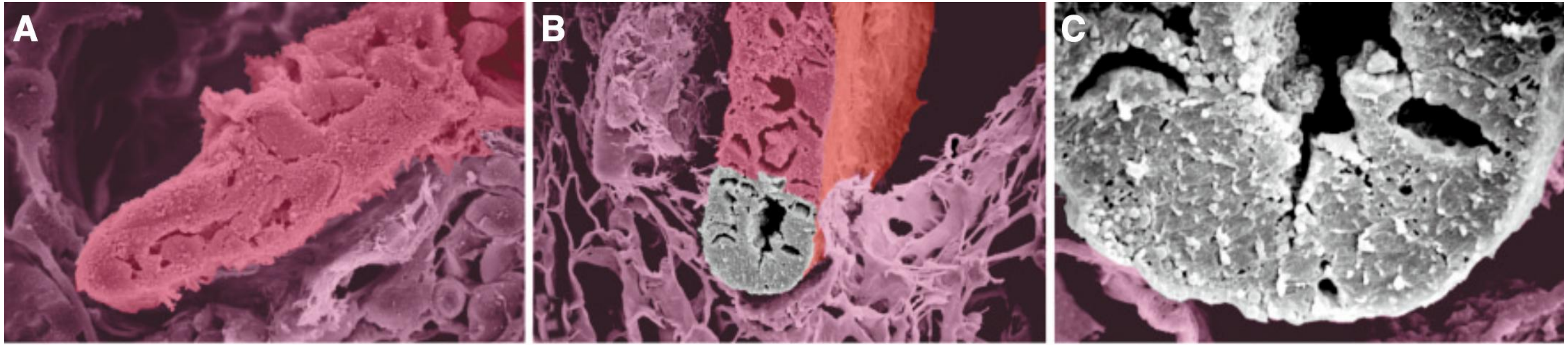
Dedifferentiation and Blastema (Salamanders)

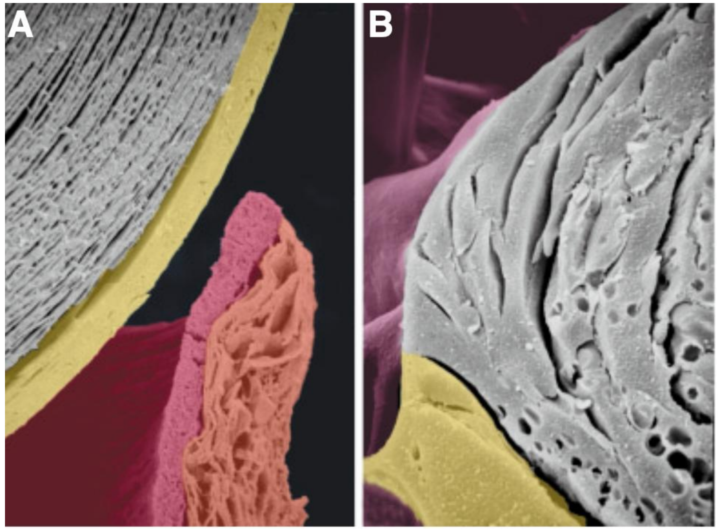
Regeneration generally involves formation of a wound epithelium after injury,followed by the generation of regenerative progenitor cells (a **blastema**)

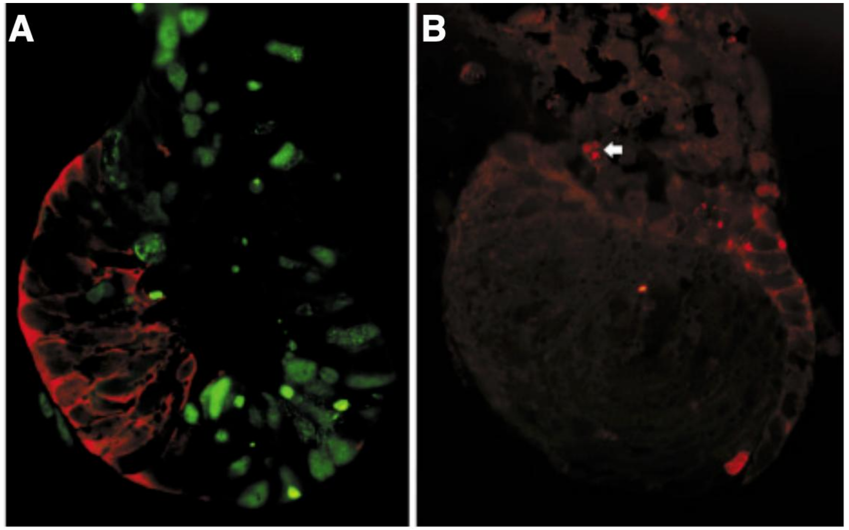


Otsuki L et.al. *Cold Spring Harb Perspect Biol.* 2022

Transdifferentiation and Cellular Plasticity

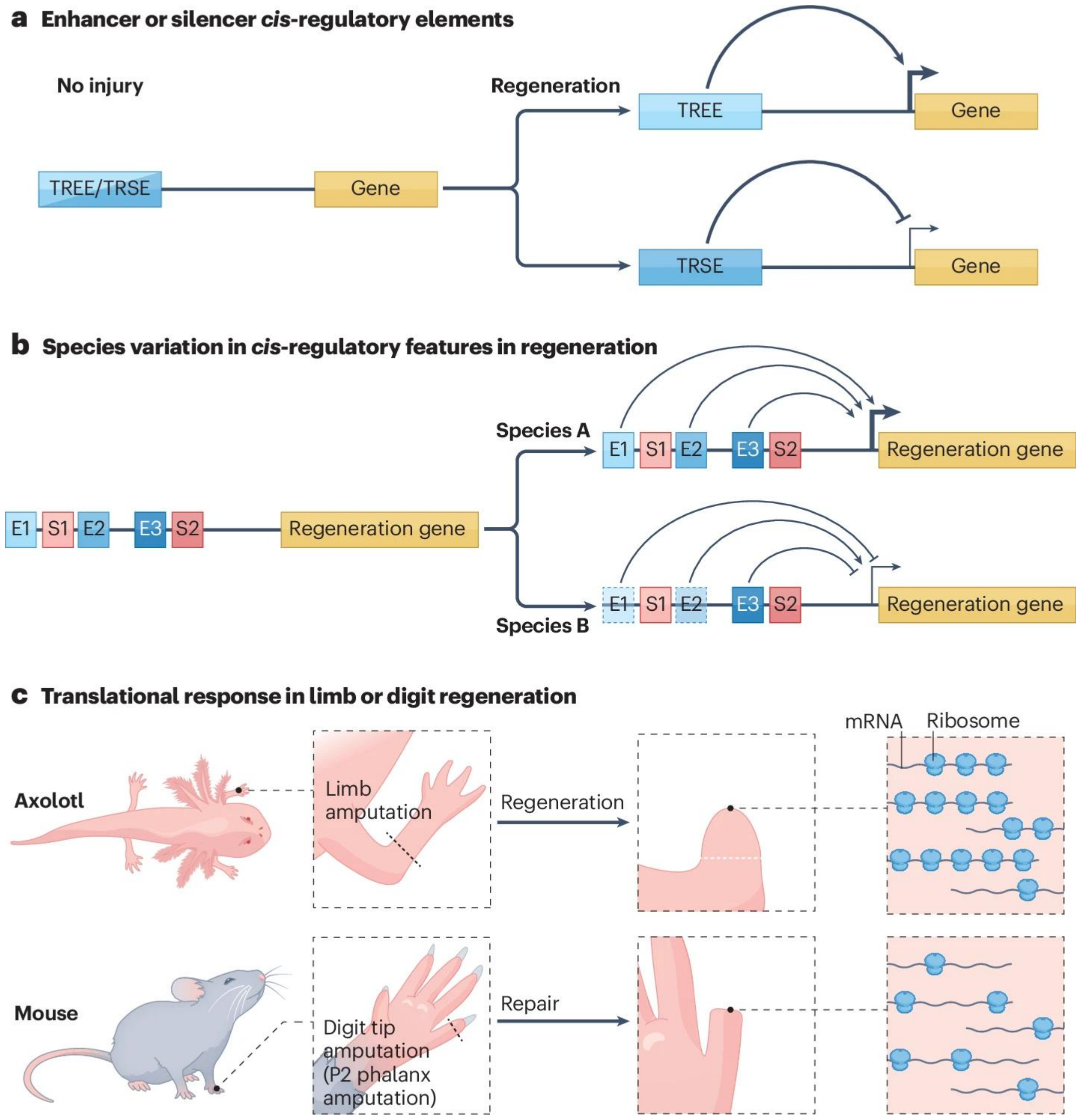




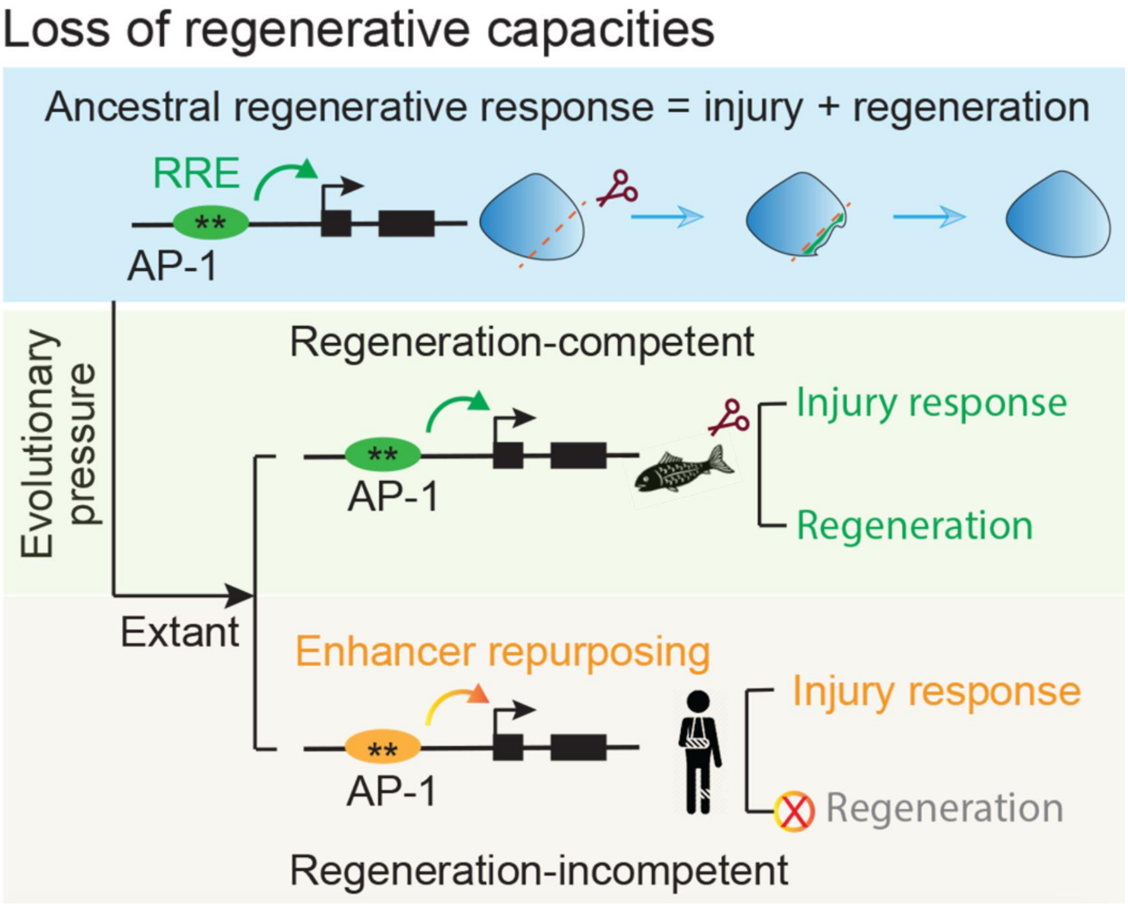


Tsonis PA et.al *Int J Dev Biol.* 2004

Gene regulation mechanisms



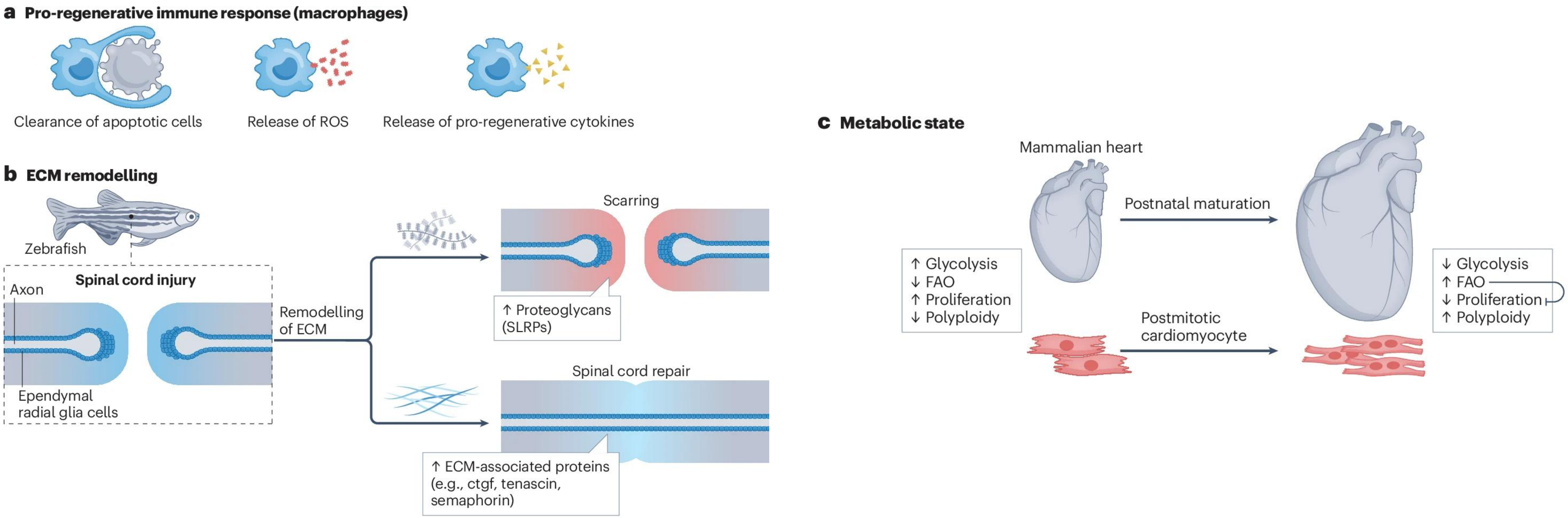
Sushant Bangru et.al, *Nat Rev Mol Cell Biol*, 2025



Wang W, *Science*. 2020

Microenvironment and metabolic state regulation

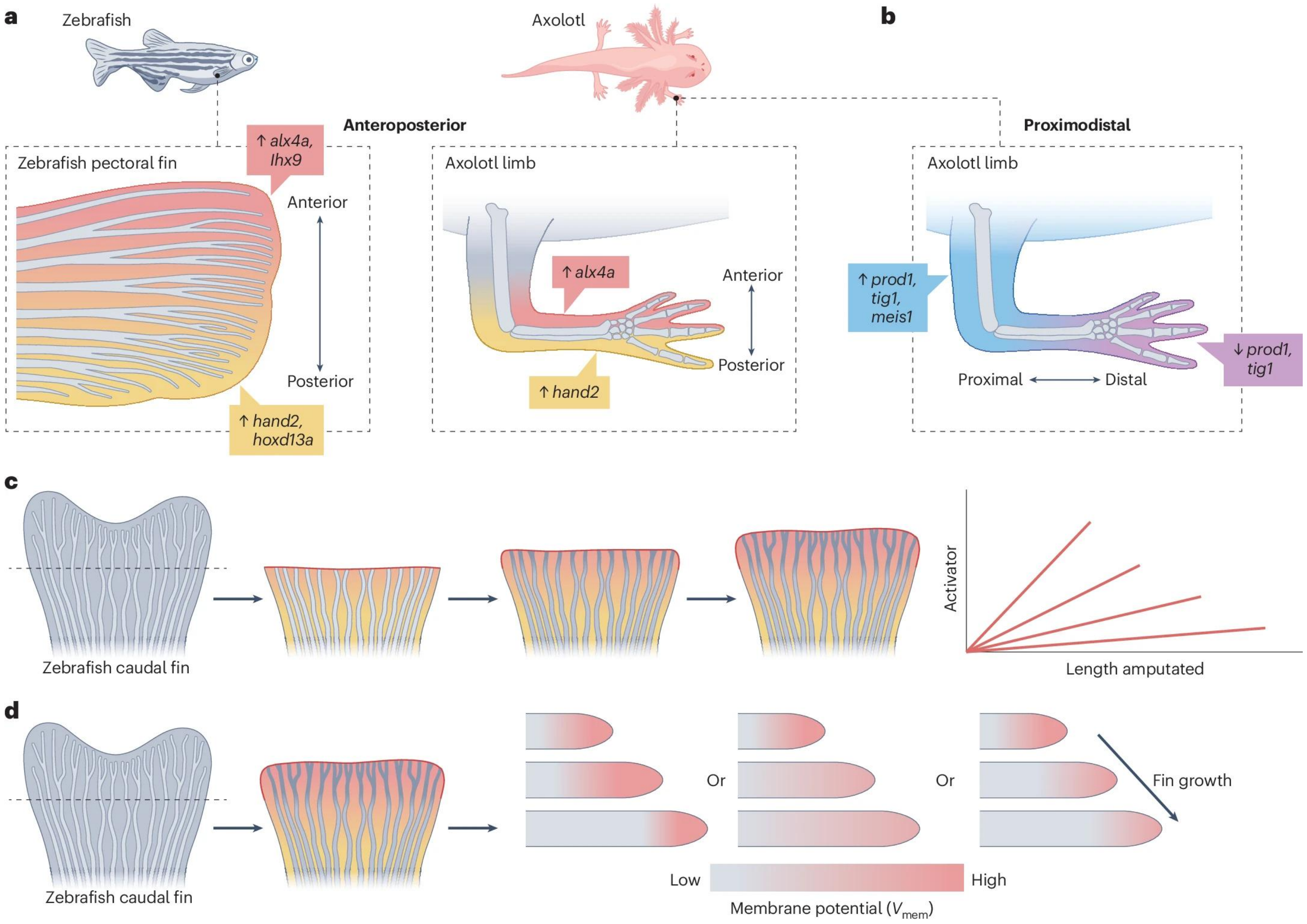
Immune activity, ECM remodeling, and metabolic state collectively shape whether tissue undergoes true regeneration or fibrotic repair.



Sushant Bangru et.al, *Nat Rev Mol Cell Biol*, 2025

Patterning and Scaling in Regeneration

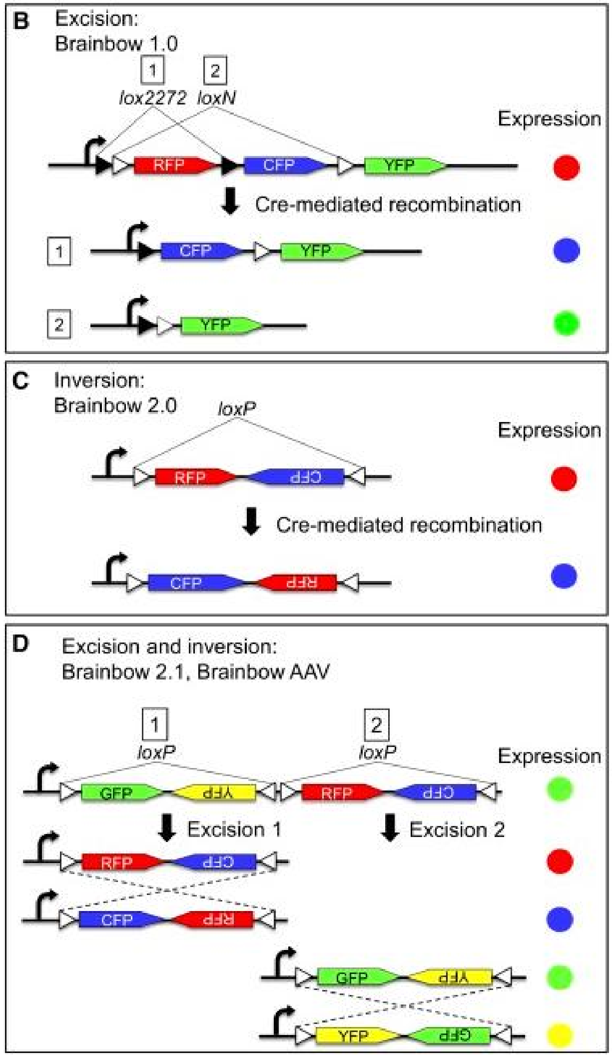
Positional identity and scaling mechanisms guide regenerating tissues to rebuild structures with correct orientation, shape, and size.



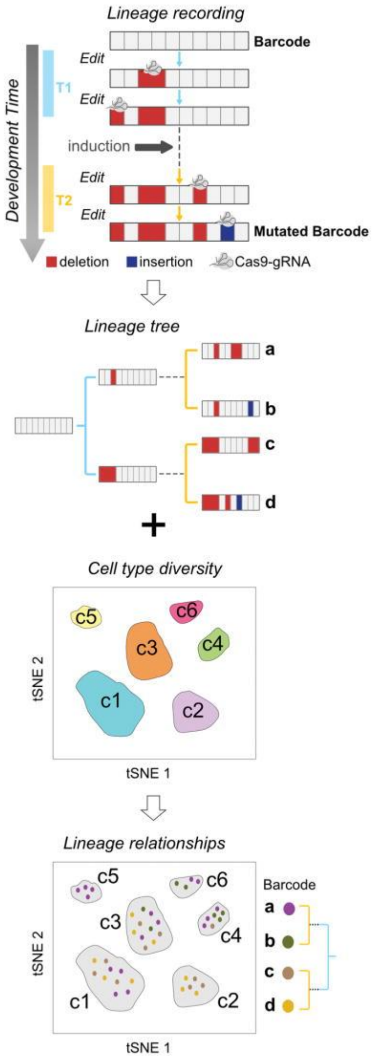
Sushant Bangru et.al, *Nat Rev Mol Cell Biol*, 2025

Tools: Single-cell omics to discover key events

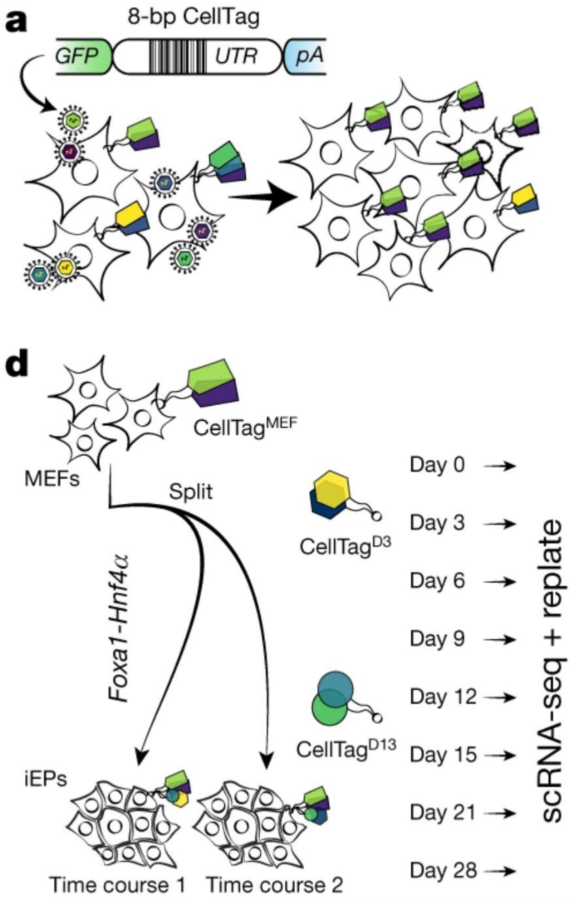
Brainbow



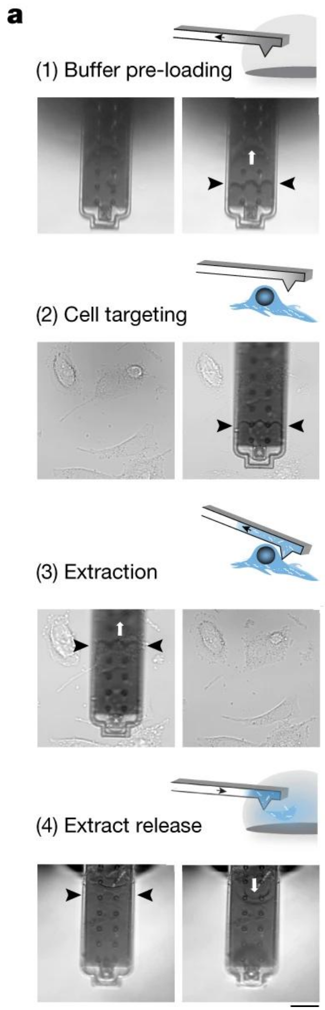
scGESTALT



CellTagging



Live-seq



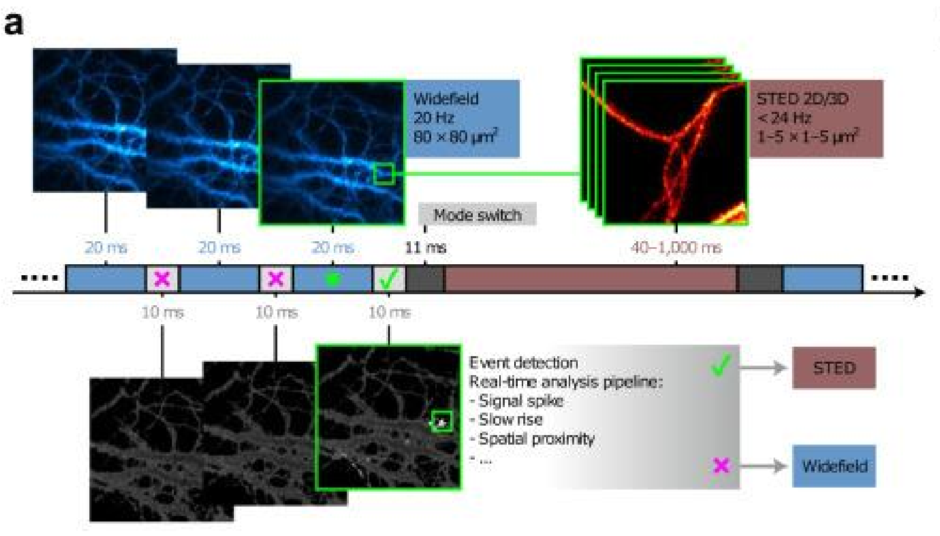
Weissman TA et.al. *Genetics*. 2015

Raj B et.al. *Nat Biotech.* 2018

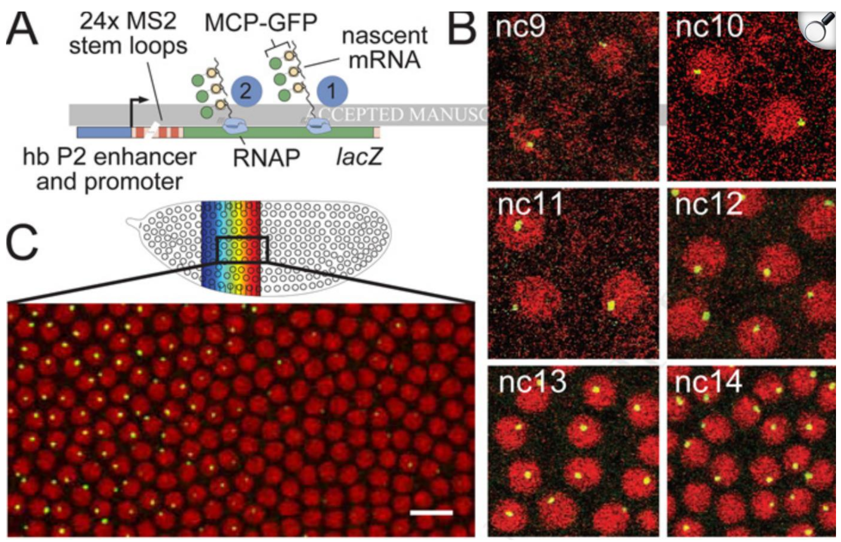
Biddy BA et.al. *Nature*. 2018

Chen W et.al. *Nature*. 2022

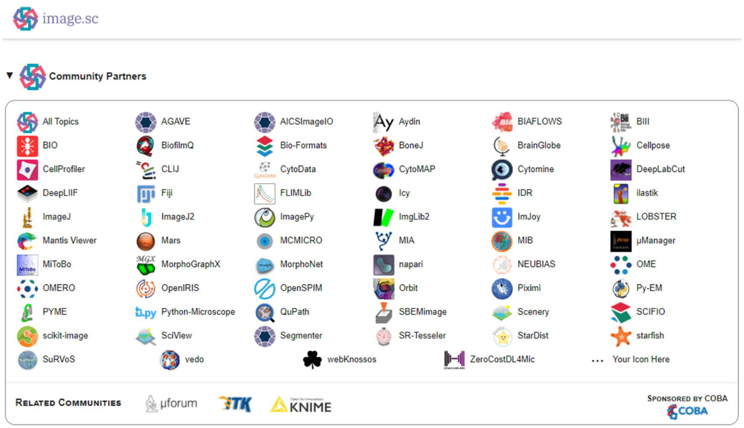
Tools for analysing dynamic cell behaviours



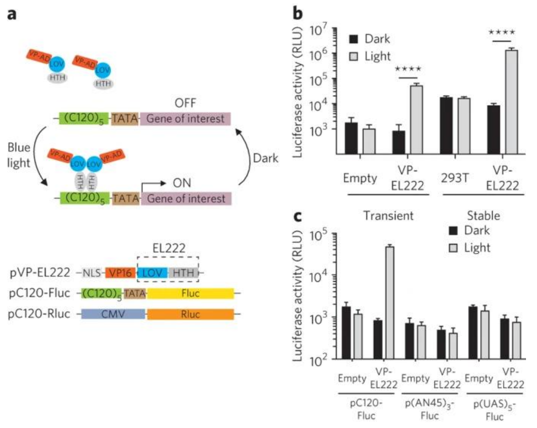
Balasubramanian H et.al. *Commun Biol.* 2023



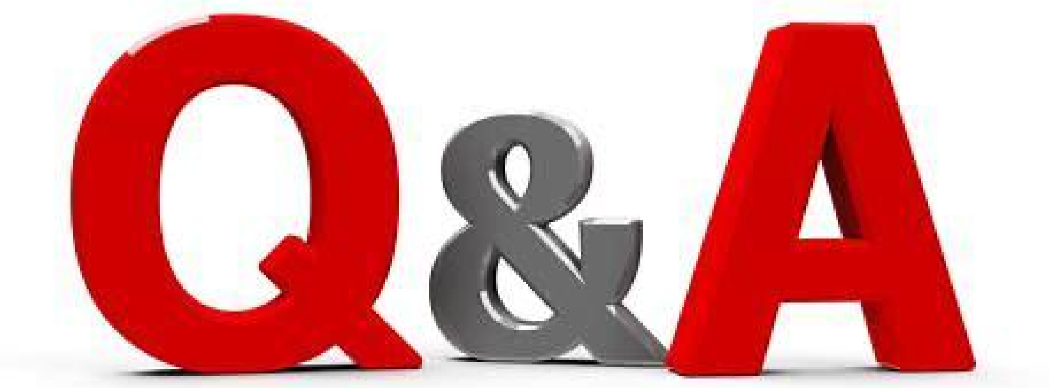
Garcia HG *Curr Biol.* 2013



Haase et.al. FEBS Lett. 2022



Motta-Mena LB et.al. *Nat Chem Biol.* 2014


Q&A

Thanks
For your Listening!

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