




基因分子生物學 (2)  
再生研究：斑馬魚的角度

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ICOB at Academia Sinica  
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Topics for today

1. 為什麼要研究再生?
2. 如何利用斑馬魚研究再生?
3. 人類有一天也可以斷肢再生嗎?

Some vertebrates are highly-regenerative




HHMI

Don't try this at home!



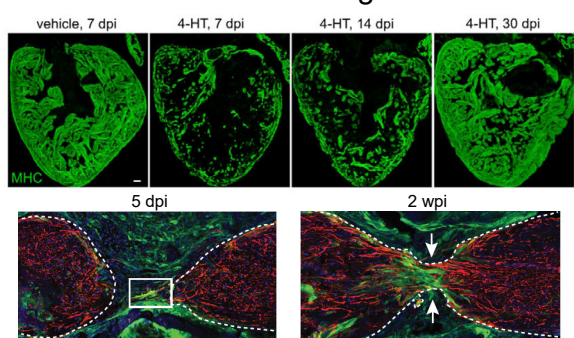
www.inquisitr.com

What if humans were highly-regenerative?



NEJM, 2012

Zebrafish are highly-regenerative to repair their internal organs



Wang et al, 2011; Mokalled et al, 2016

### Challenges in studying regeneration

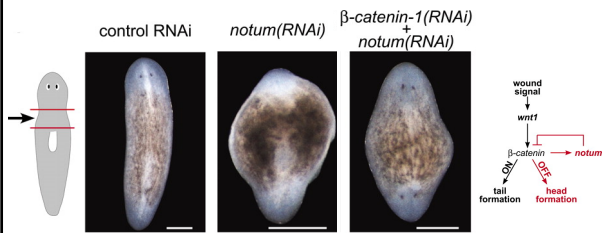


### Something about planarians



[http://pearsonlab.ca/?page\\_id=6](http://pearsonlab.ca/?page_id=6)

### Regeneration genes



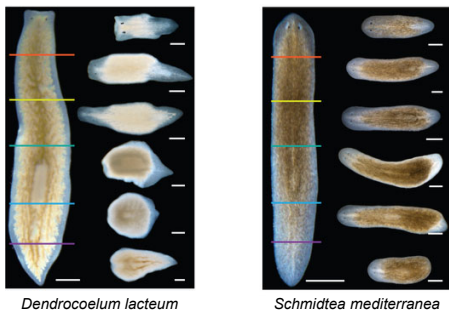
<http://scienceintheclassroom.org/research-papers/heads-or-tails/university>

### Regeneration and Immortality



<http://www.ub.edu/planaria/index.html>

### Some planarians can't regenerate

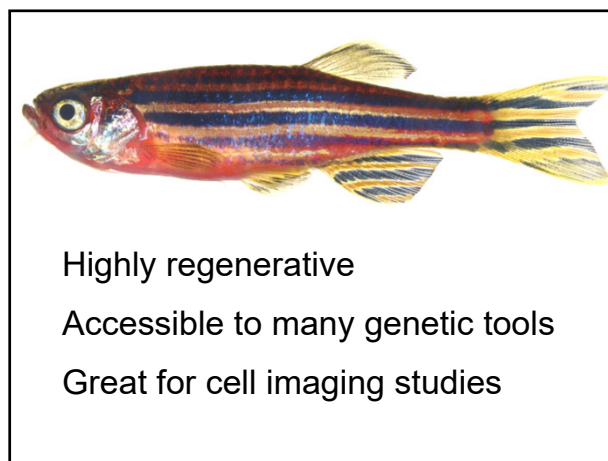
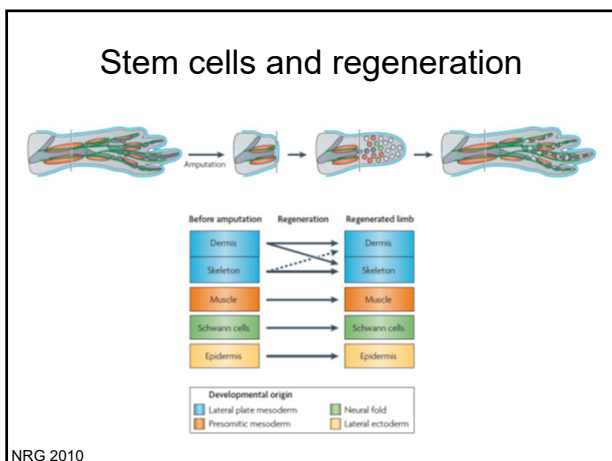
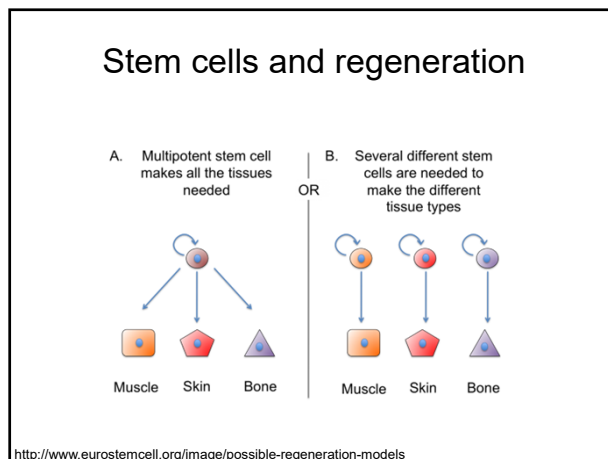
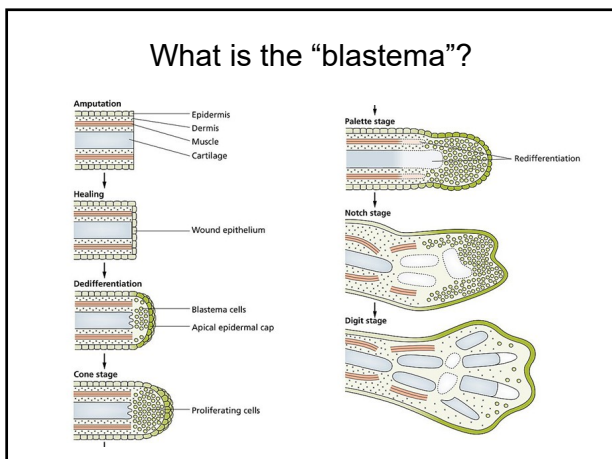


<http://www.nature.com/nature/journal/v500/n7460/full/nature12414.html>

### Models of highly-regenerative vertebrates



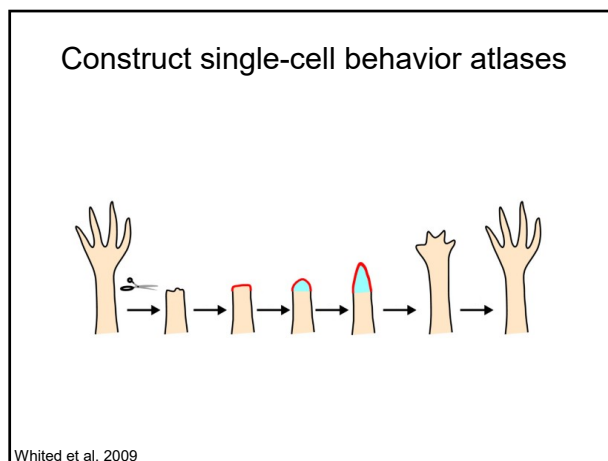
[mentalfloss.com](http://mentalfloss.com)



### My research program at ICOB

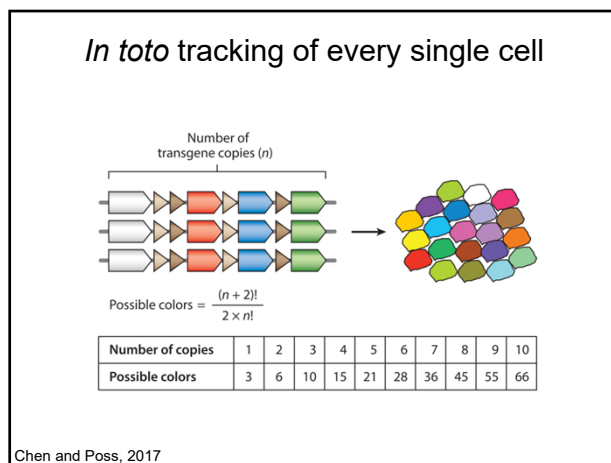
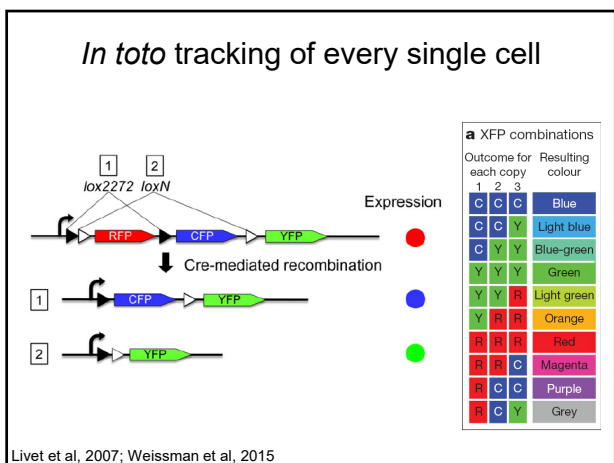
Direction#1: Collective cell behavior  
 Direction#2: Regeneration mutants

The left side shows a colorful microscopy image of a cell monolayer. The right side is a grid of 12 images showing various phenotypes of zebrafish fin regeneration mutants.

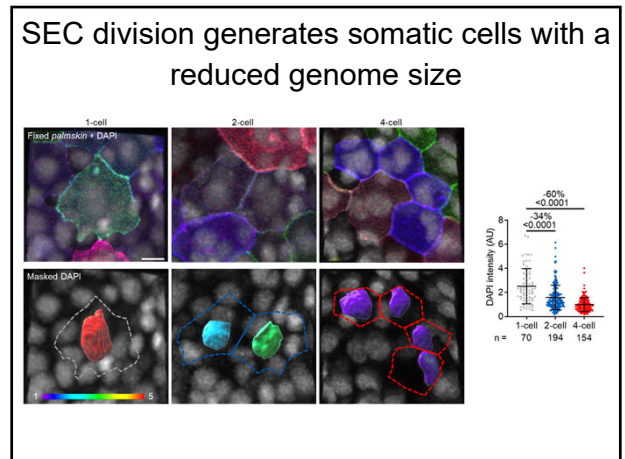
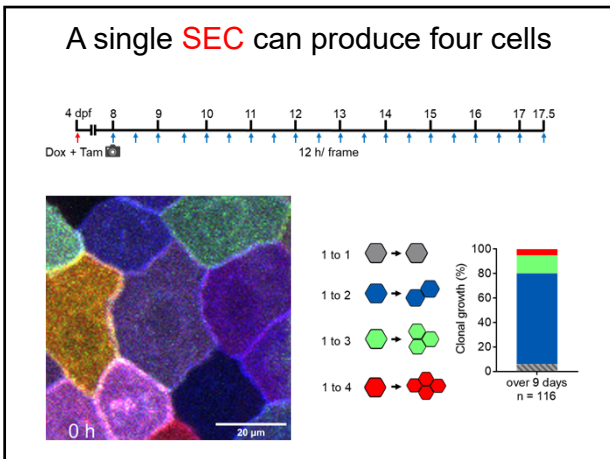
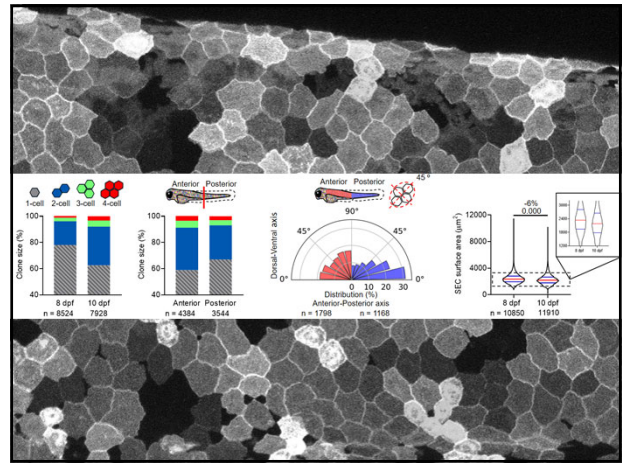
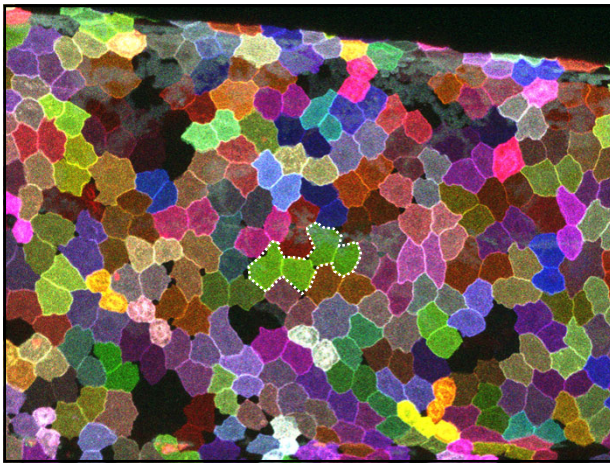
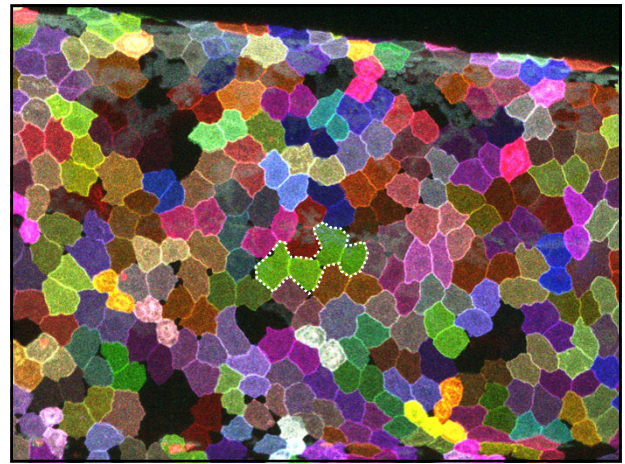
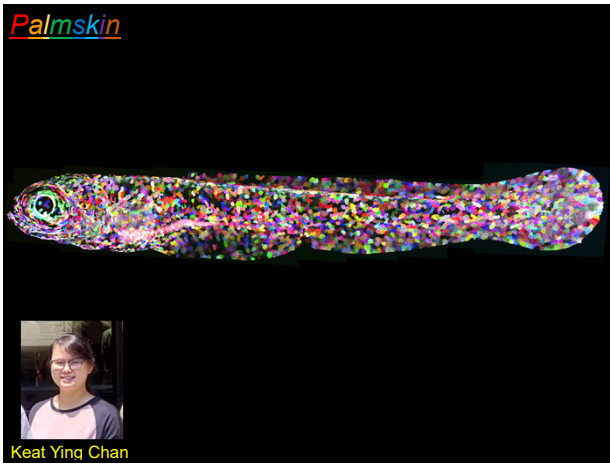




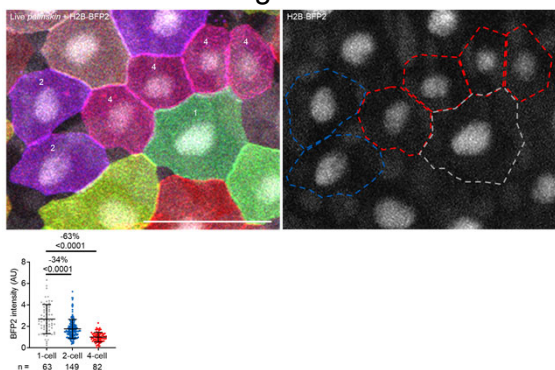
A single-cell behavior atlas  
= a high-resolution blueprint  
How can we generate such an atlas for thousands of cells?







SEC division generates somatic cells with a reduced genome size



How did we come up with the name?

Asynthetic Fission

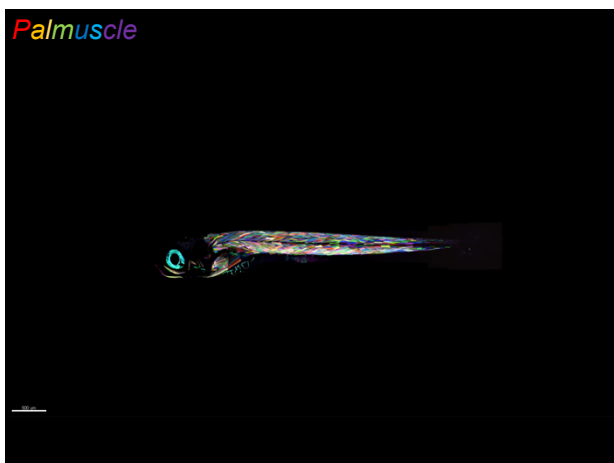
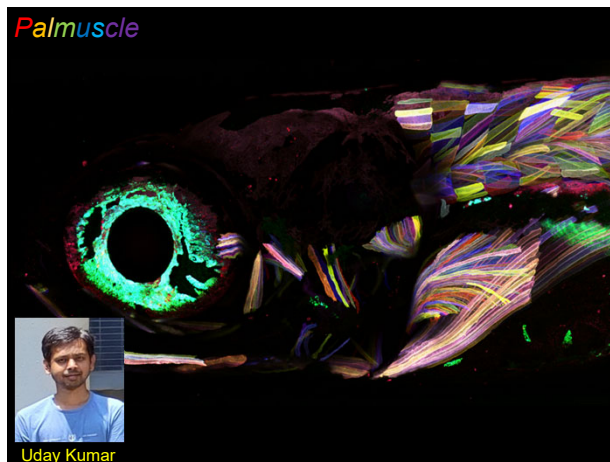
“a” as a prefix means “opposite”

“fission” means “splitting into two or more”

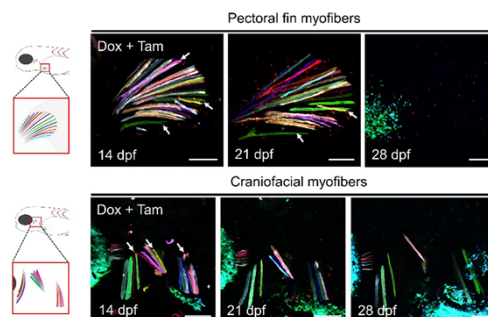
Chan et al., Nature (2022)

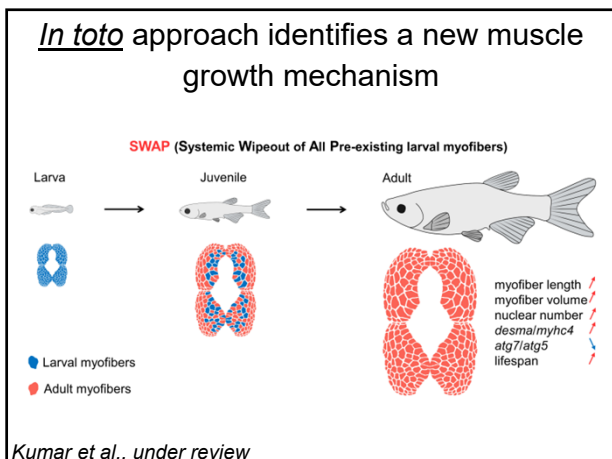
基礎研究

1. 正常細胞分裂- 發育 生長 繁殖 再生
2. 不正常細胞分裂- 癌症 疾病 老化
3. 明顯的例外- 基礎細胞分裂機制的研究
4. 斑馬魚是脊椎動物- 其它細胞或物種



Palmuscle enables long-term tracking of all myofibers in a growing individual





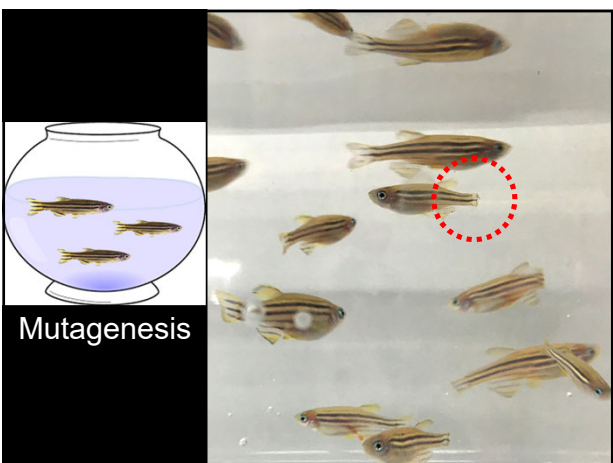
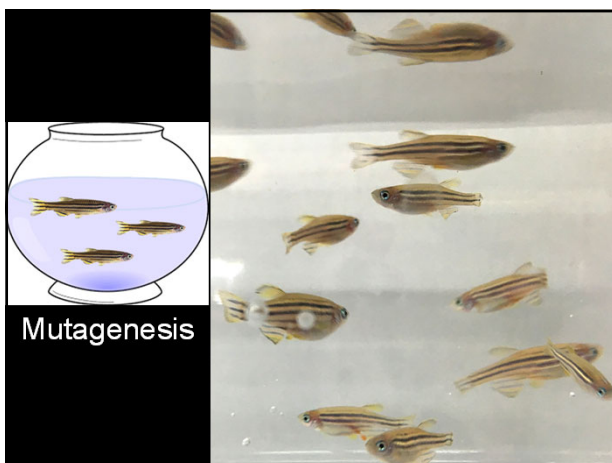
Any questions for the first part?

**My research program at ICOB**

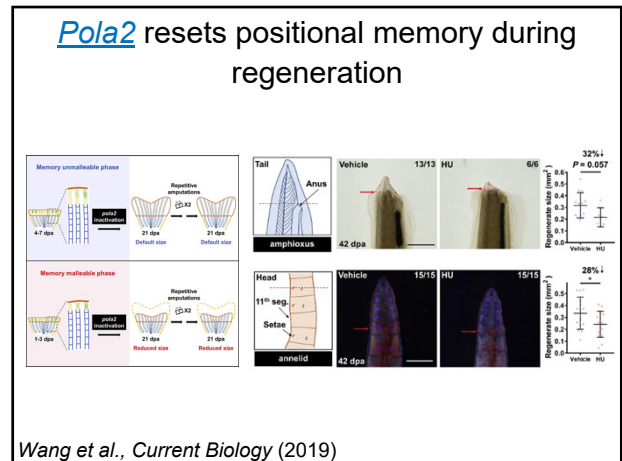
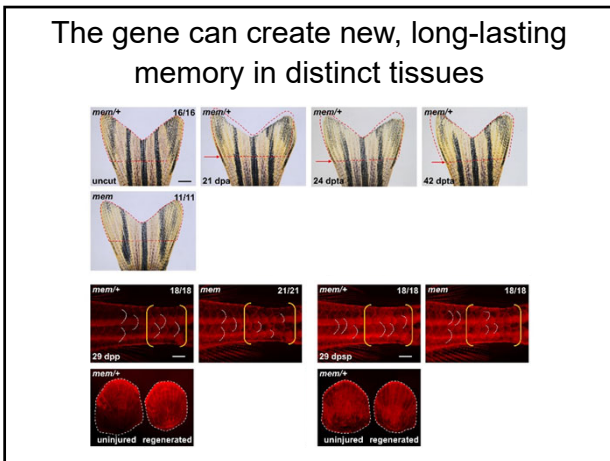
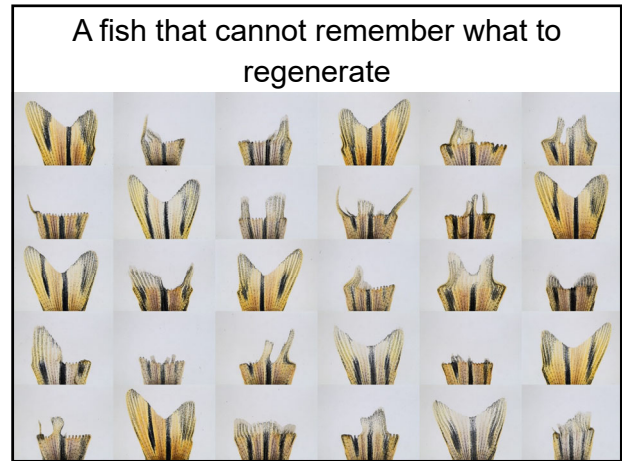
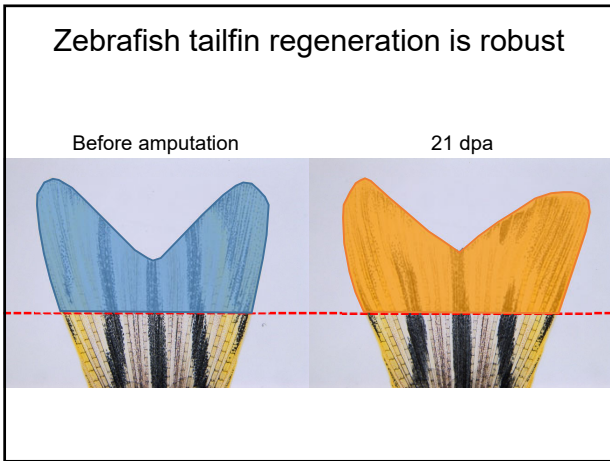
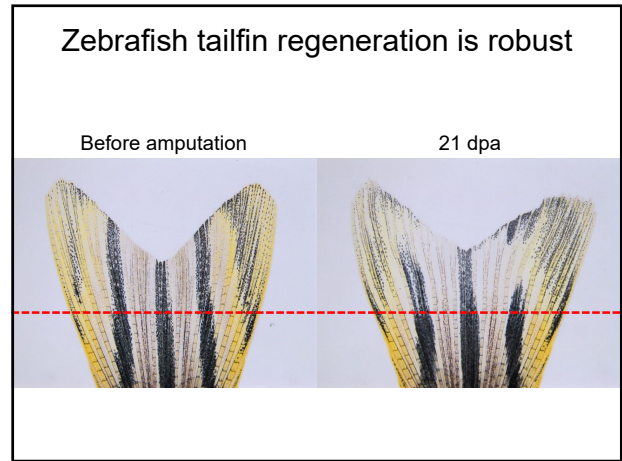
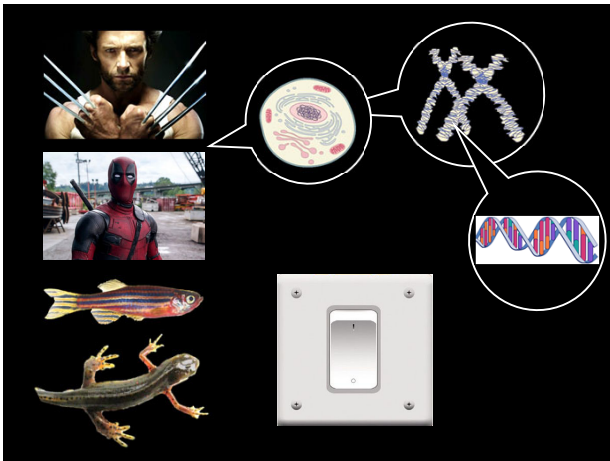
Direction#1  
Collective cell behavior

Direction#2  
Regeneration mutants

Find **Wolverines** or **Deadpools** that are unable to regenerate!









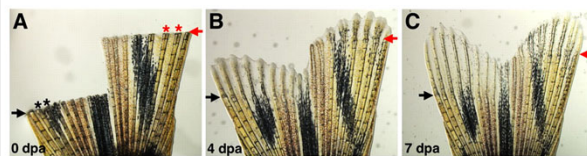
Regeneration speed vs. injury levels



Lazzaro Spallanzani  
(1729- 1799)

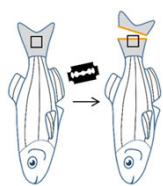


How do animals sense amputation levels and have different response?

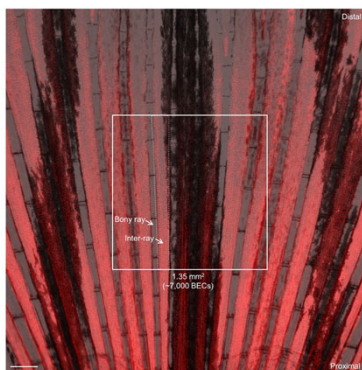


Lee et al., Dev (2005)

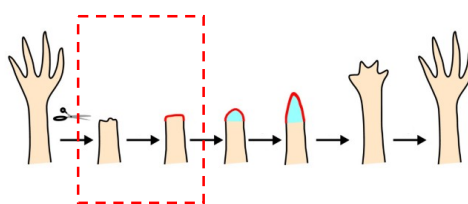
Rea-time monitoring of 7,000 cells in a live animal



Marco De Leon

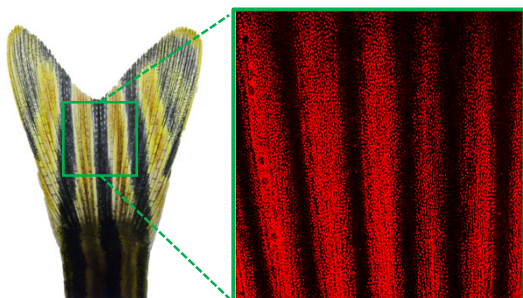


Wound healing is key to regeneration



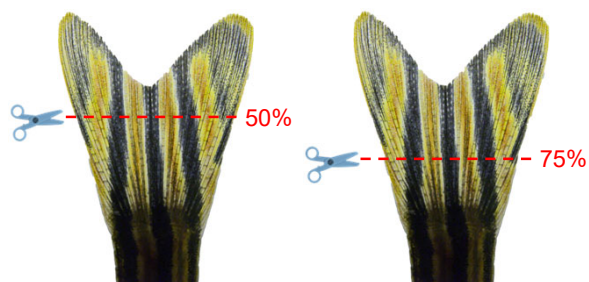
Whited et al, 2009

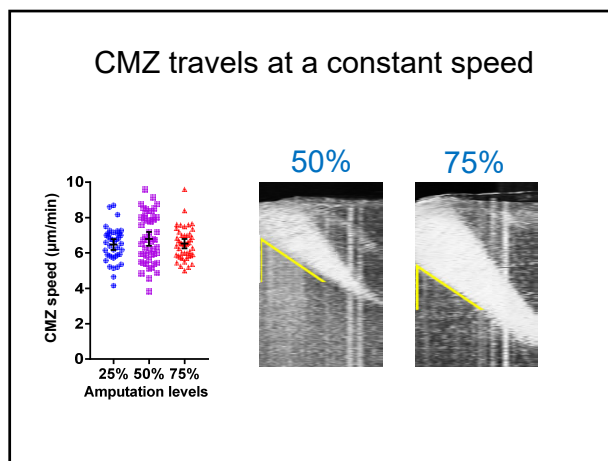
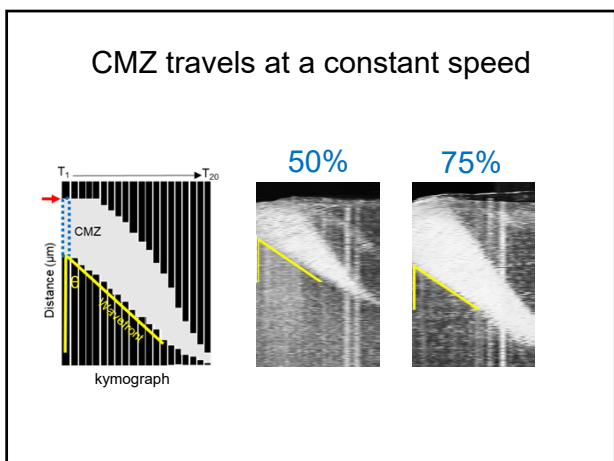
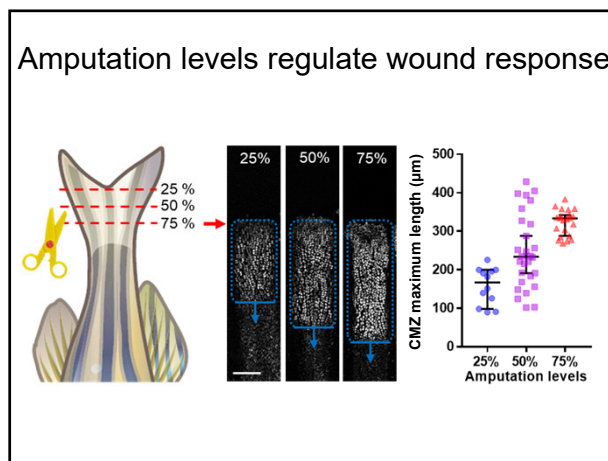
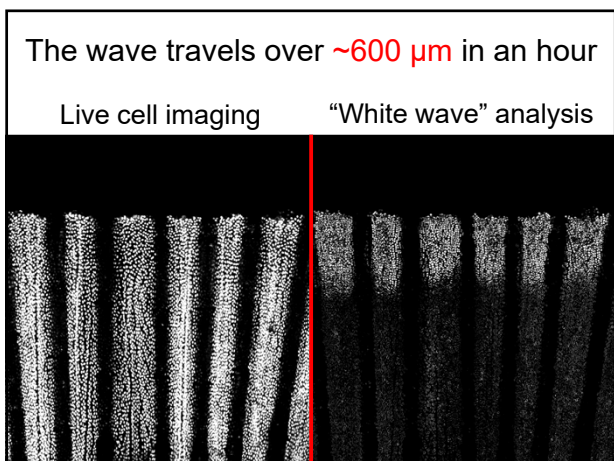
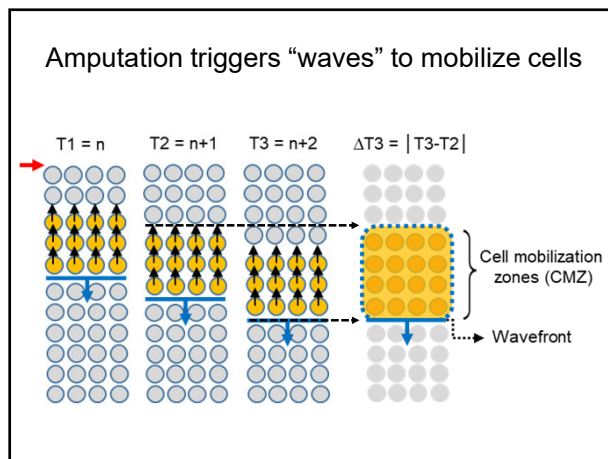
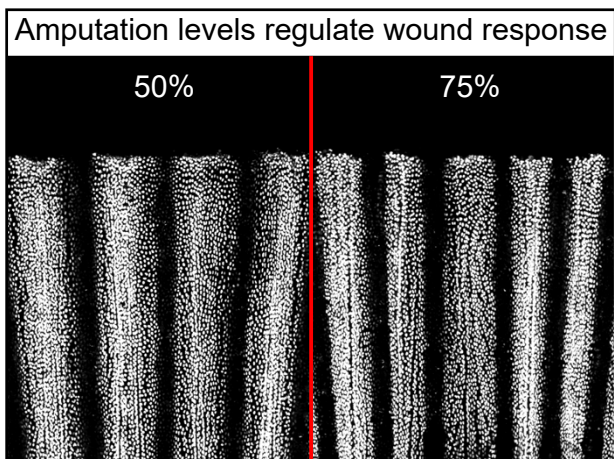
Live imaging of wound healing response



*Tg(krt19:H2A-mCherry)*

Distal amputation vs. Proximal amputation





Time to talk to a physicist!

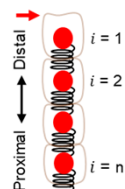


Dr. Lin, Keng-Hui  
A soft matter physicist at Academia Sinica

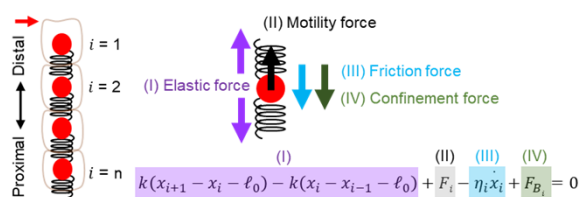


Dr. Wen, Fu-Lai  
A theoretical physicist at NCKU

One-Dimensional Active Spring (ODAS)

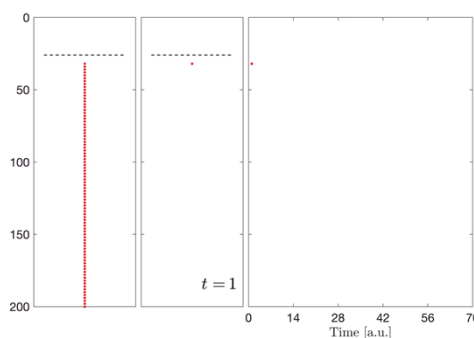


One-Dimensional Active Spring (ODAS)

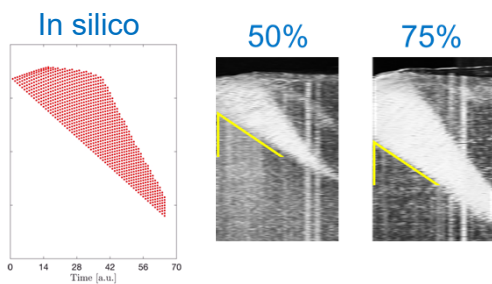


$$k(x_{i+1} - x_i - \ell_0) - k(x_i - x_{i-1} - \ell_0) + F_i - \eta_i \dot{x}_i + F_{B_i} = 0$$

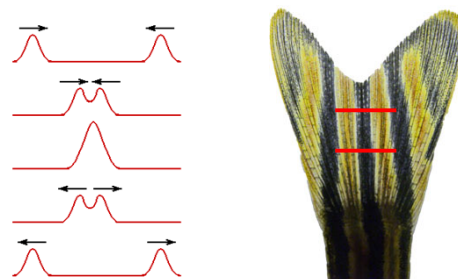
One-Dimensional Active Spring (ODAS)



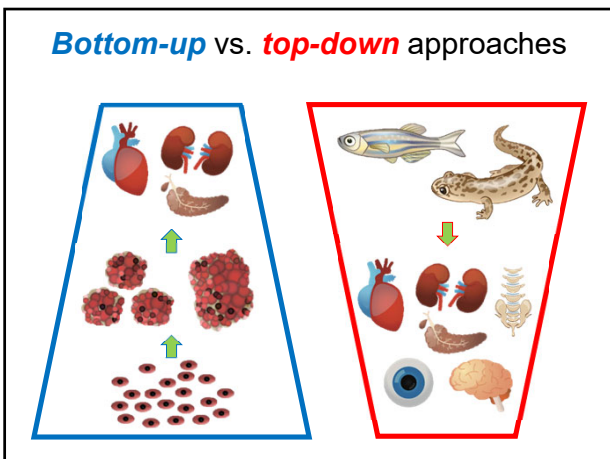
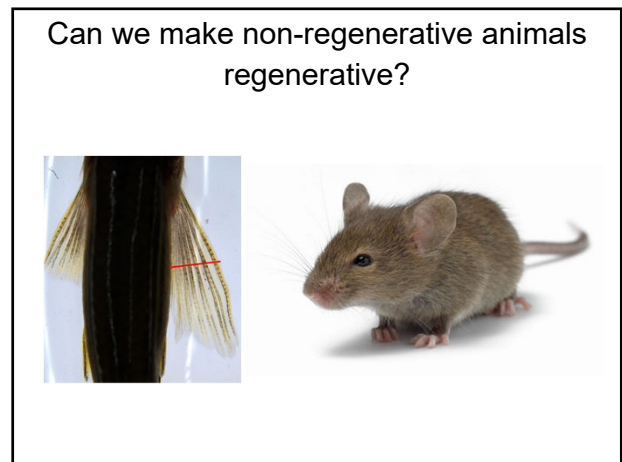
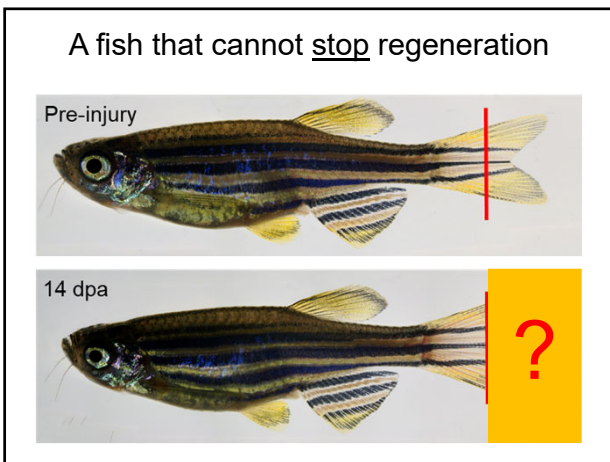
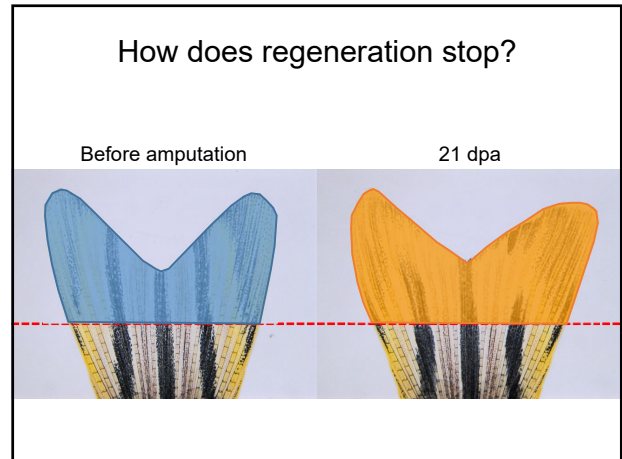
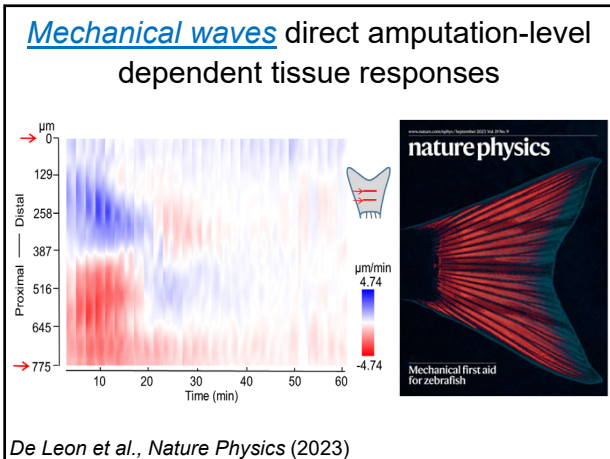
One-Dimensional Active Spring (ODAS)



Mechanical waves vs. Chemical waves







- Topics for today
1. 為什麼要研究再生?
  2. 如何利用斑馬魚研究再生?
  3. 人類有一天也可以斷肢再生嗎?

Topics for today

1. 為什麼要研究再生? 迷人&重要
2. 如何利用斑馬魚研究再生? 問對問題
3. 人類有一天也可以斷肢再生嗎? 可能

