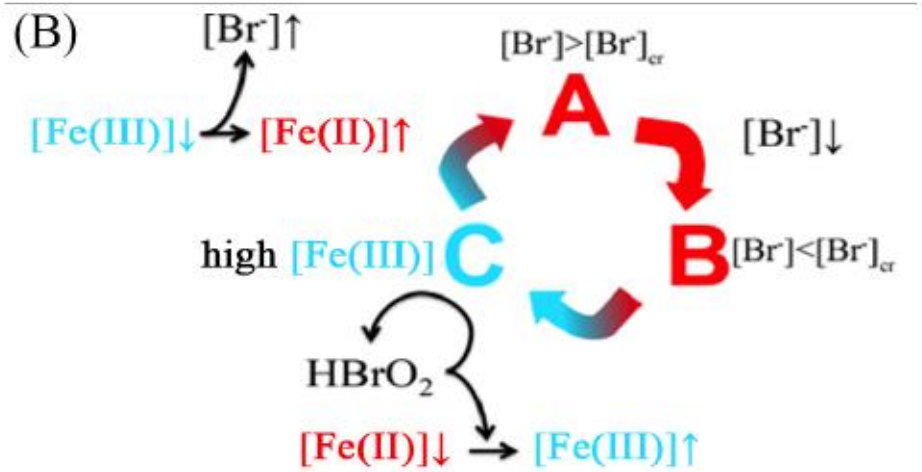
Master Chemistry PSL
ICI

December 2021, Philippe Nghe, ESPCI Paris

Self-organization in dissipative systems

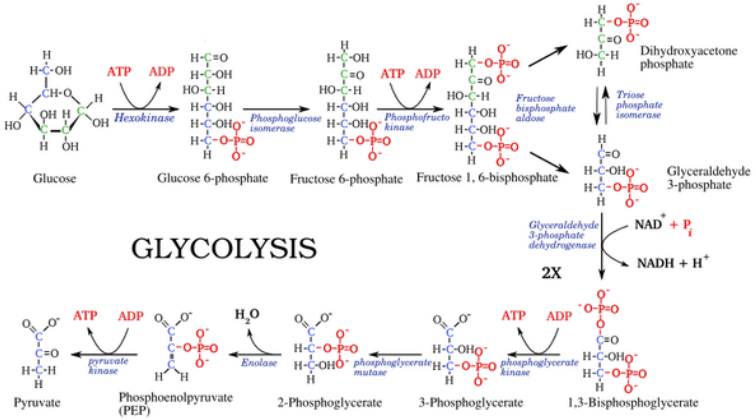
Self-organization in dissipative systems



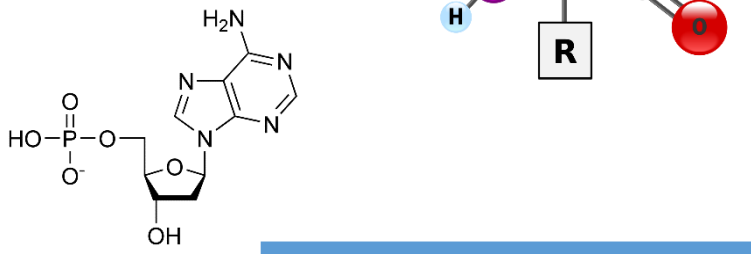

0 hrs

Volume growth, division

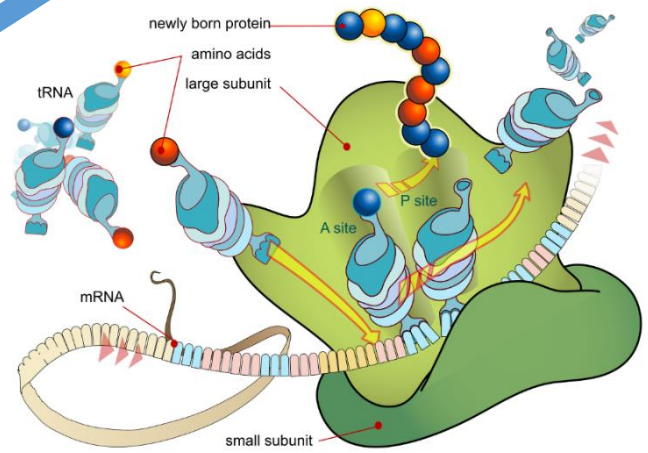
CATABOLISM



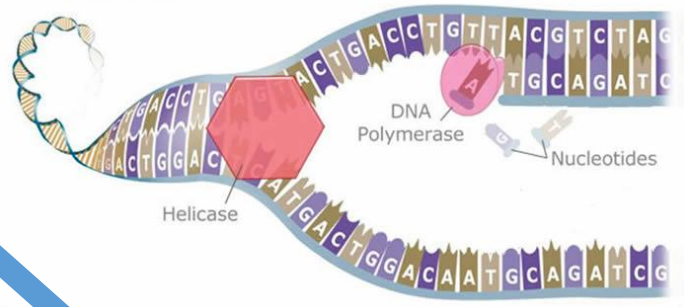
BUILDING BLOCKS



ANABOLISM



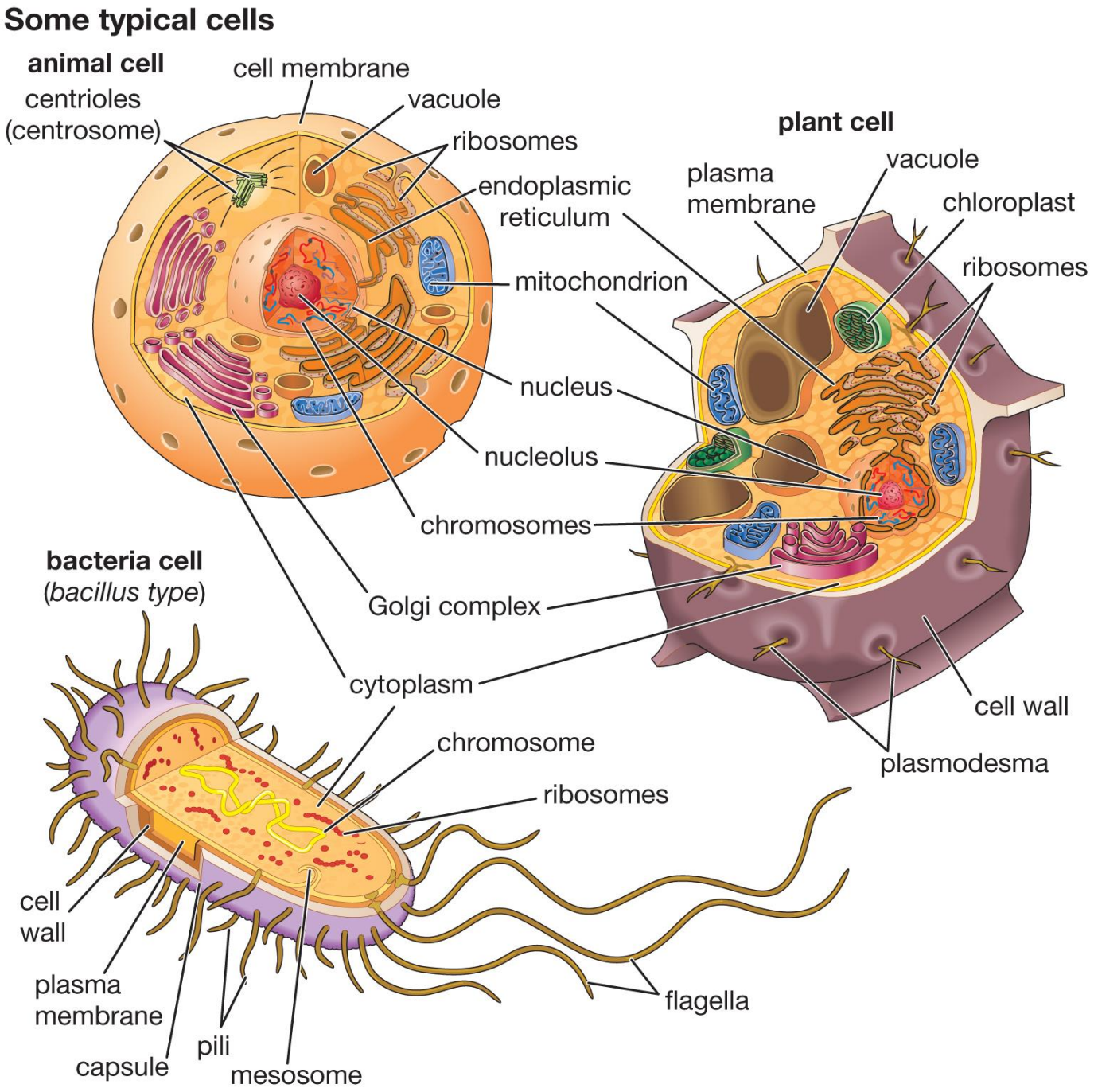
REPLICATION

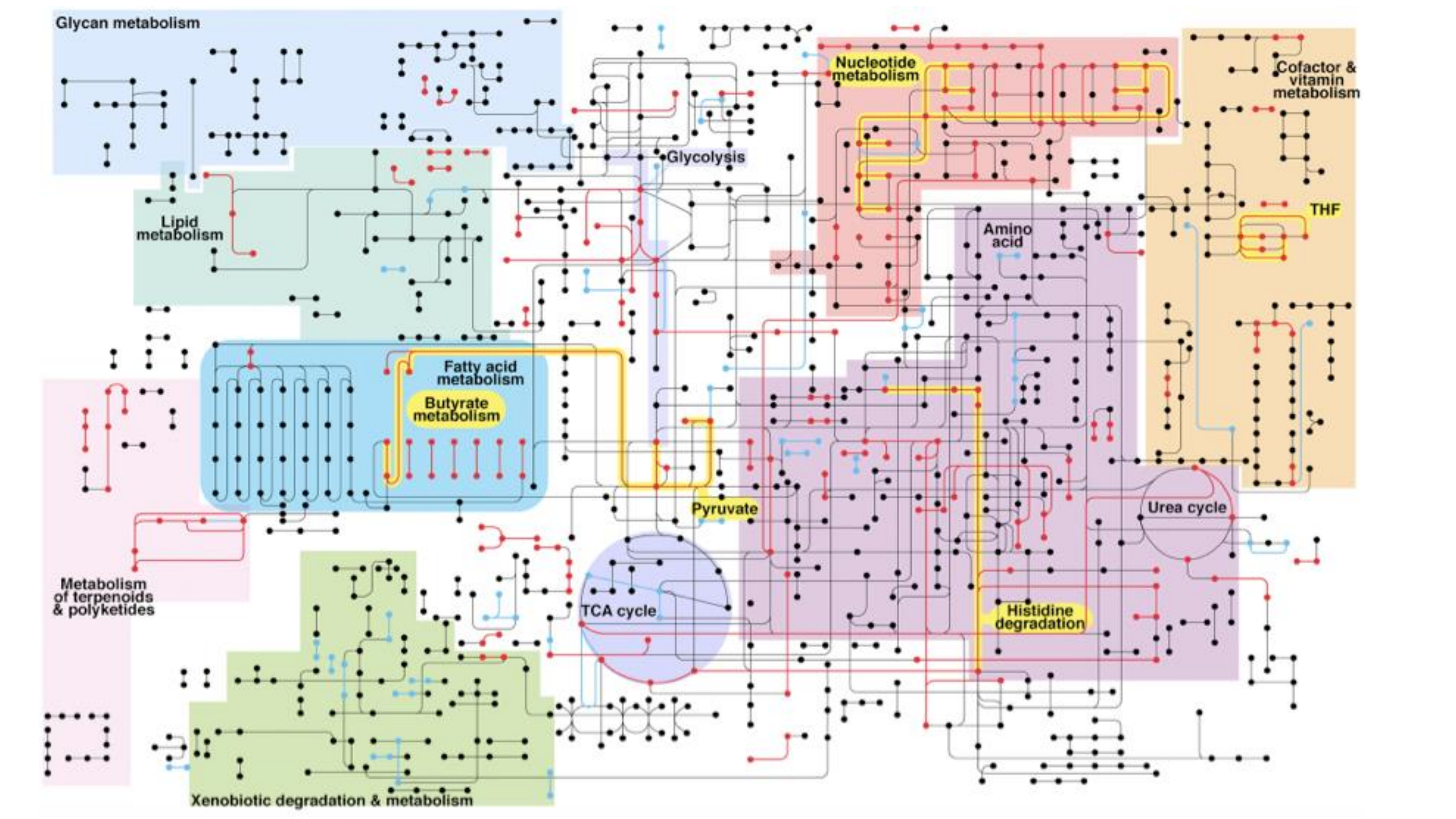


The cell as a bag of chemicals

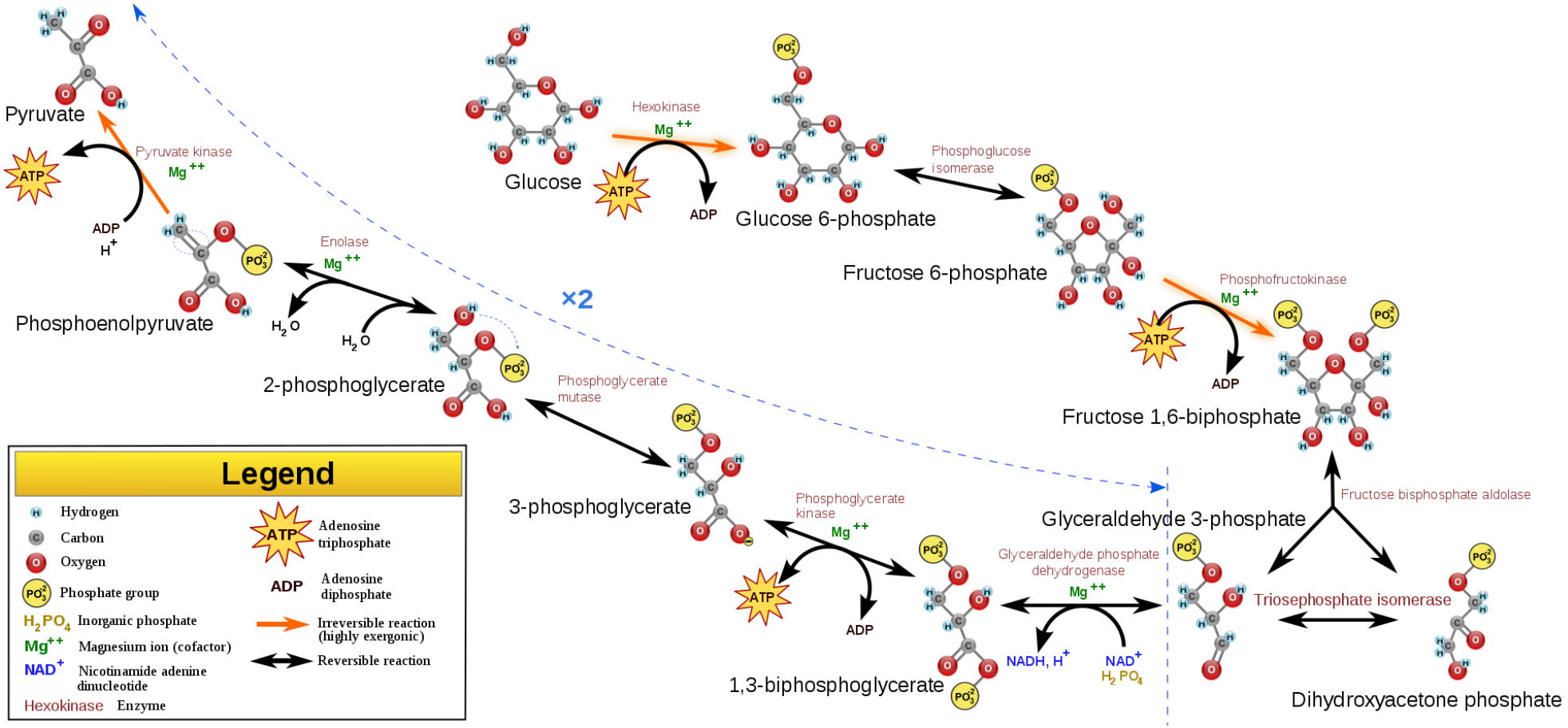
~ 10^3-10^4 molecular species

~10^4-10^5 chemical reactions



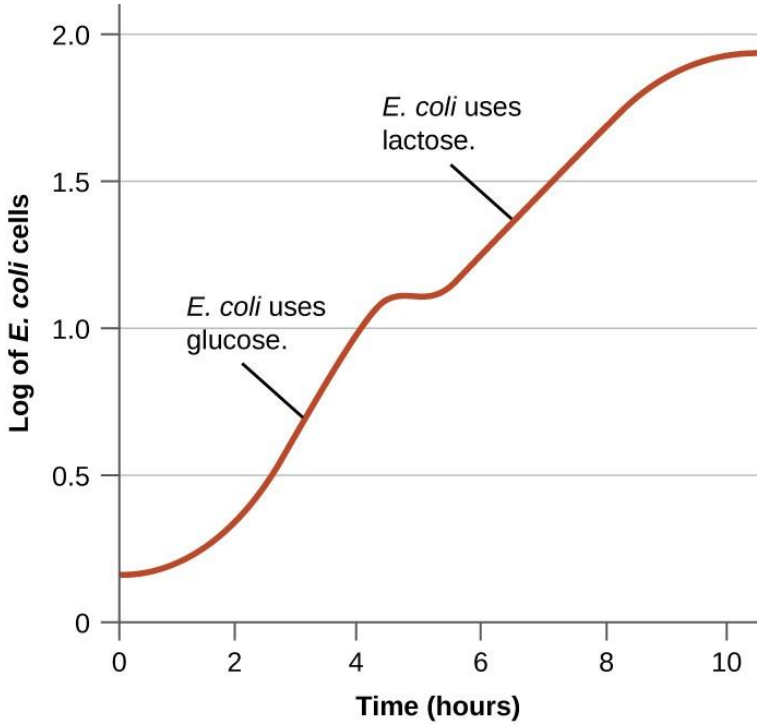

Glycan metabolism
Lipid metabolism
Fatty acid metabolism
Butyrate metabolism
Metabolism of terpenoids & polyketides
Xenobiotic degradation & metabolism
Glycolysis
Pyruvate
TCA cycle
Nucleotide metabolism
Amino acid
Histidine degradation
Urea cycle
Cofactor & vitamin metabolism
THF

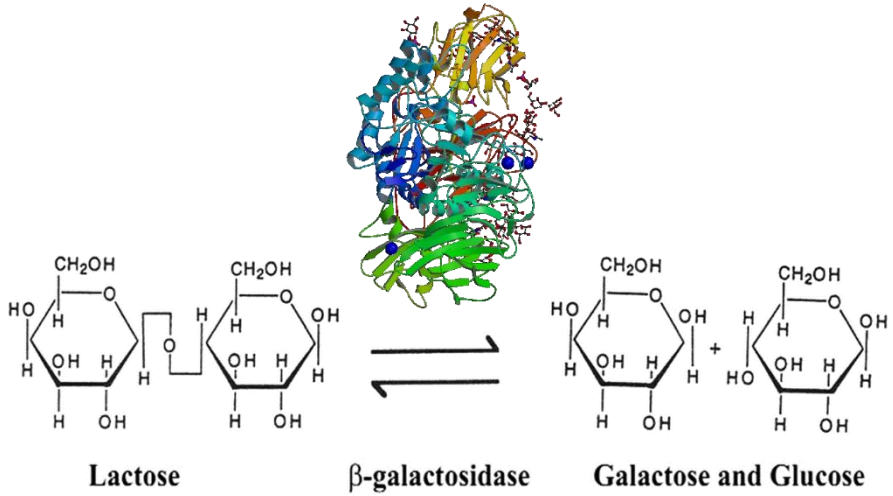
Glycolysis, a catabolic pathway

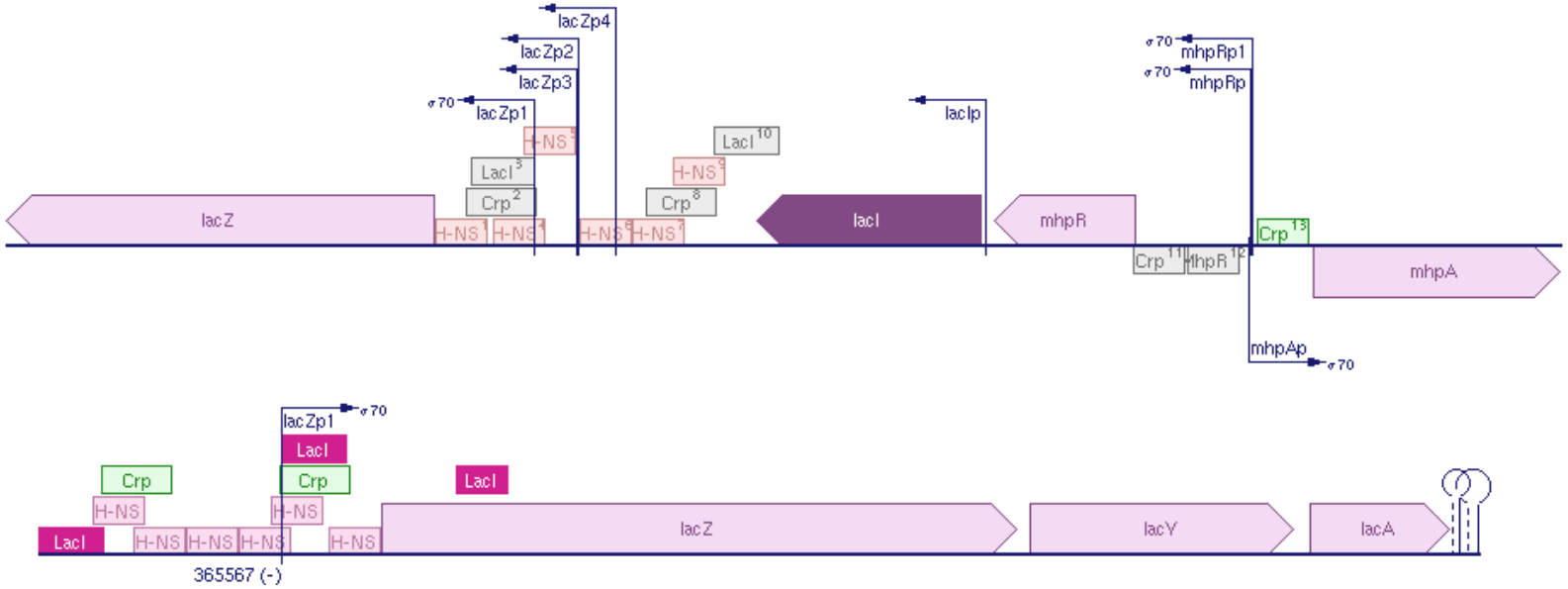


Diauxie

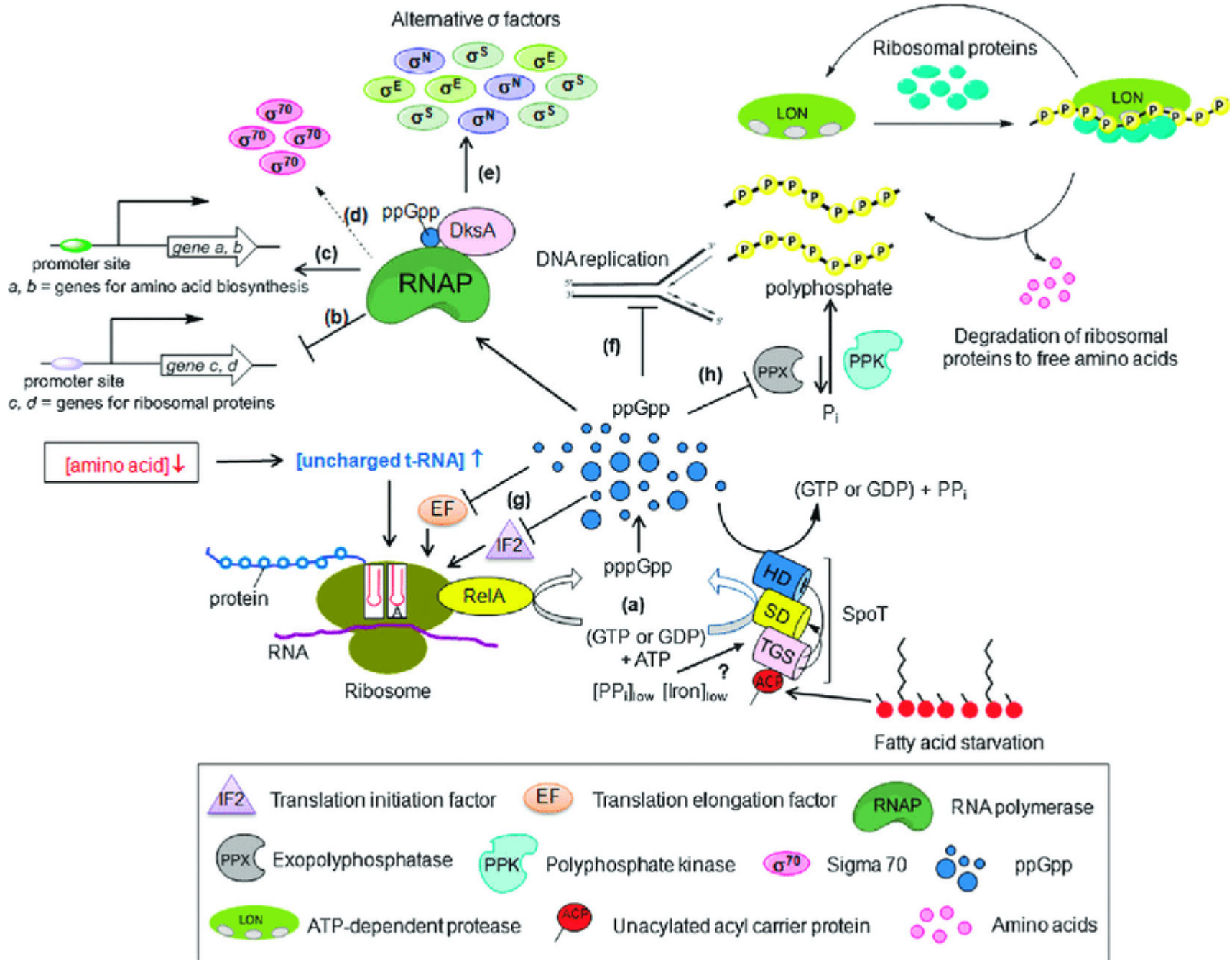
(Jacques Monod, 1940)





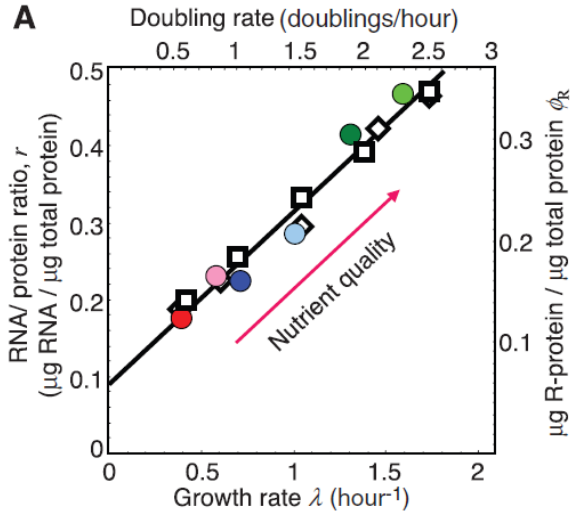


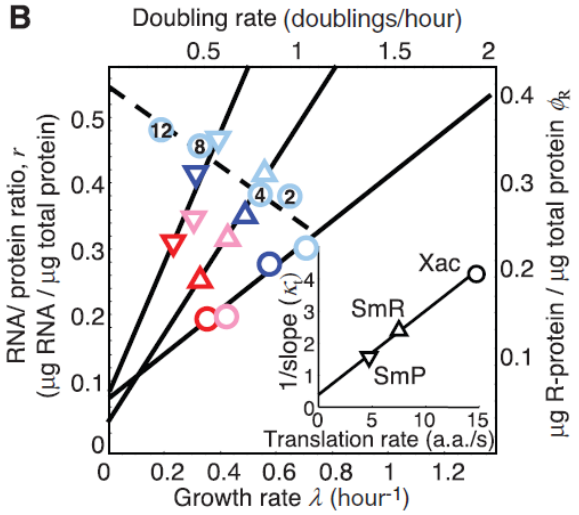
The stringent response

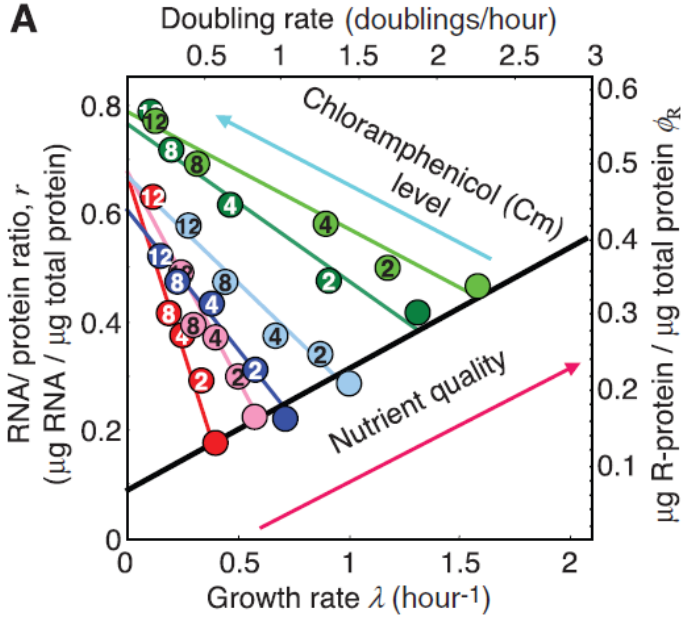


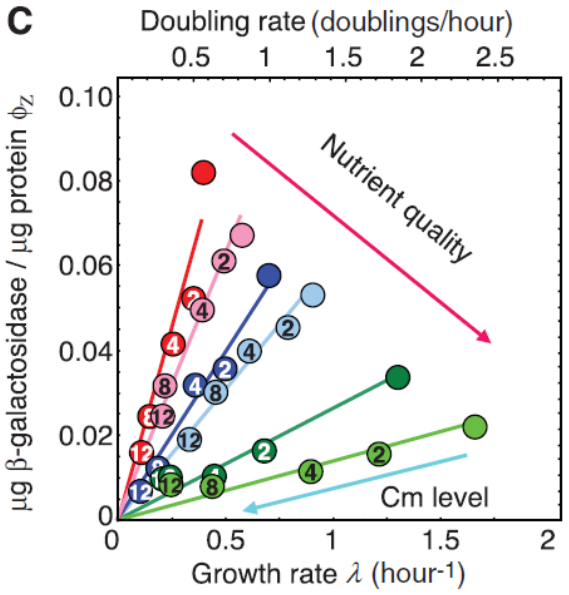
Growth laws experimental test

Scott, M., Gunderson, C. W., Mateescu, E. M., Zhang, Z., & Hwa, T. (2010). Interdependence of cell growth and gene expression: origins and consequences. *Science*, *330*(6007), 1099-1102.









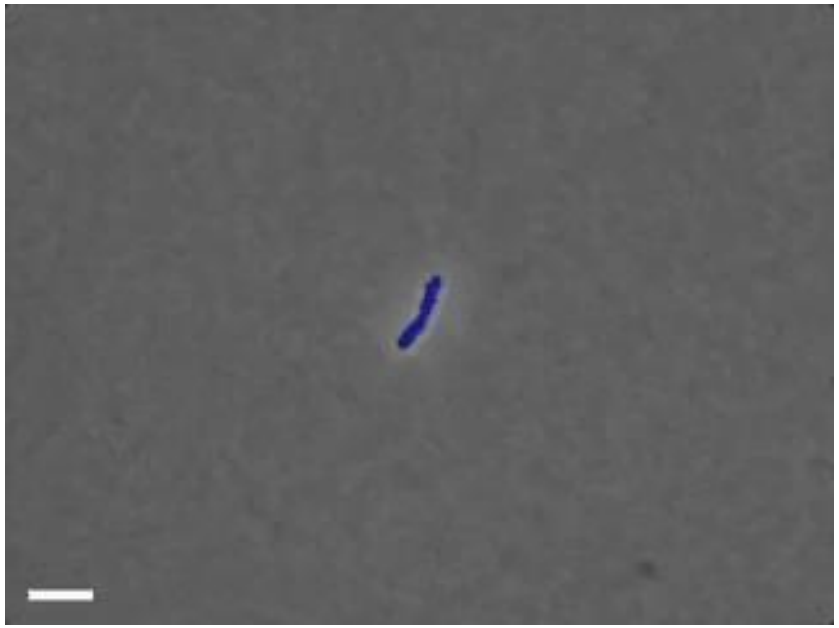
Strain / Medium	EQ2	Xac	SmR	SmP	Xac in cAA+glc Cm conc. (μM)	
M63+glyc	●	○	△	▽	2	2
M63+gluc	●	○	△	▽	4	4
cAA+glyc	●	○	△	▽	8	8
cAA+gluc	●	○	△	▽	12	12
RDM+glyc	●	Historical data: □ Strain B/r; Ref. (*10*) ◇ Strain 15τ-bar; Ref. (*12*)				
RDM+gluc	●					

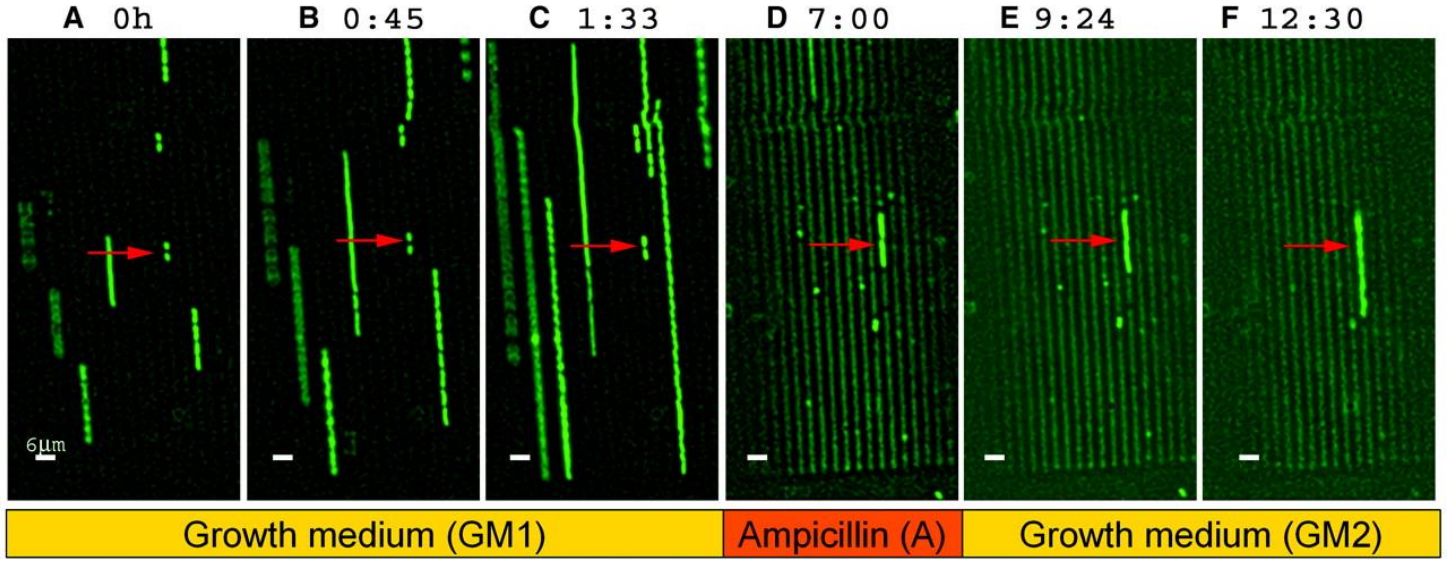
translation mutants

antibiotics

Strain / Medium	EQ2/EQ3 Chloramphenicol conc. (μM)				
	0	2	4	8	12
M63+glyc	●	2	4	8	12
M63+gluc	●	2	4	8	12
cAA+glyc	●	2	4	8	12
cAA+gluc	●	2	4	8	12
RDM+glyc	●	2	4	8	12
RDM+gluc	●	2	4	8	12

Phenotypic heterogeneity in bacteria





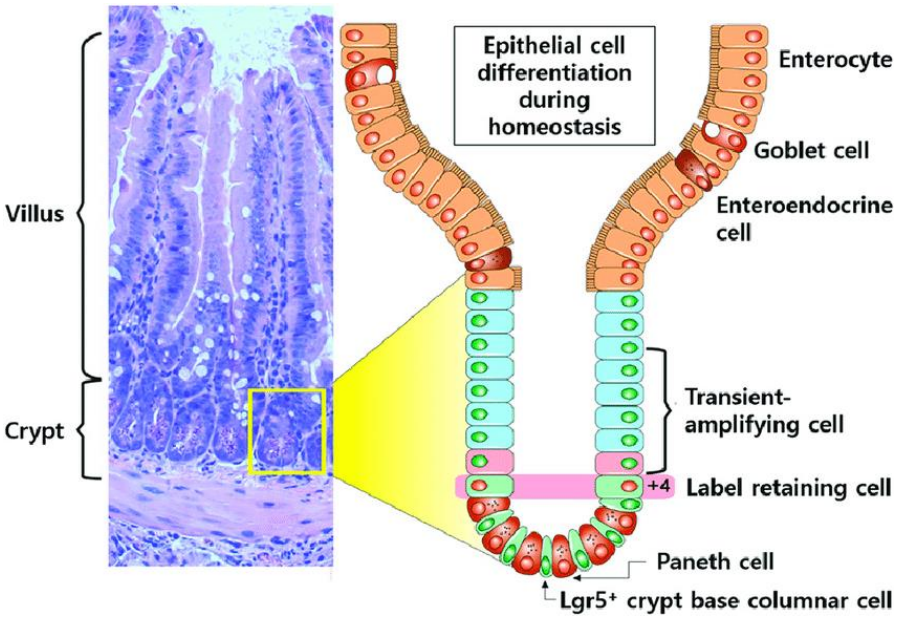
Bacterial persistence

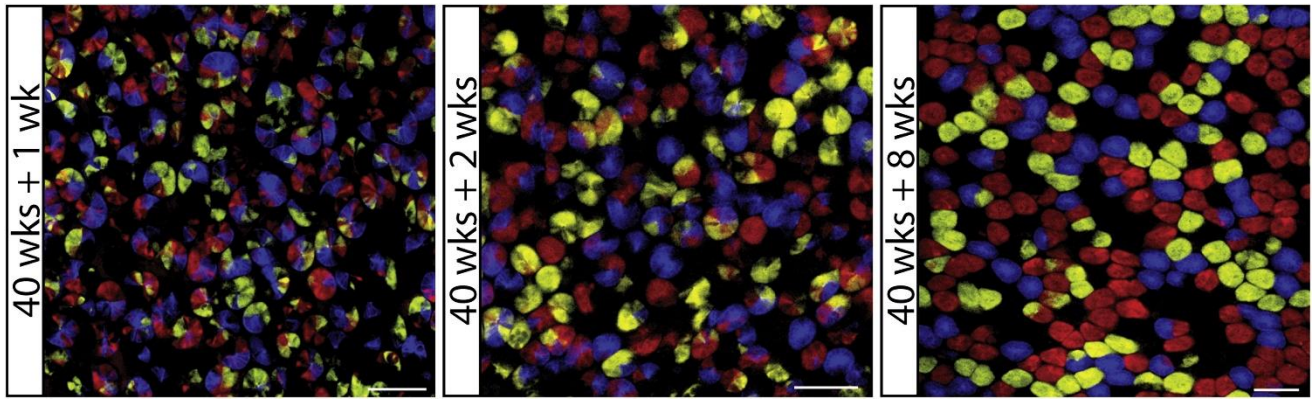
Dunlop, M. J., Cox, R. S., Levine, J. H., Murray, R. M., & Elowitz, M. B. (2008). Regulatory activity revealed by dynamic correlations in gene expression noise. *Nature genetics*, *40*(12), 1493-1498.

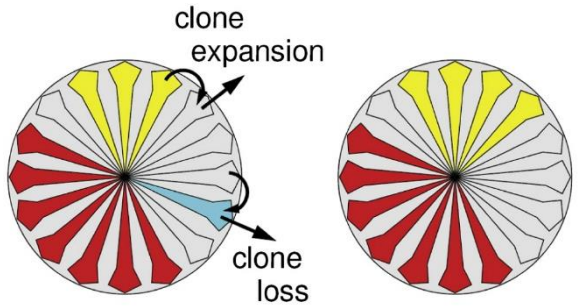
Balaban, N. Q., Merrin, J., Chait, R., Kowalik, L., & Leibler, S. (2004). Bacterial persistence as a phenotypic switch. *Science*, *305*(5690), 1622-1625.

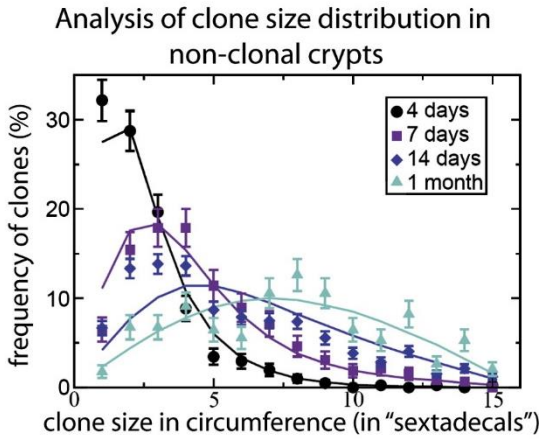
Stochasticity in cell differentiation

Intestinal crypts



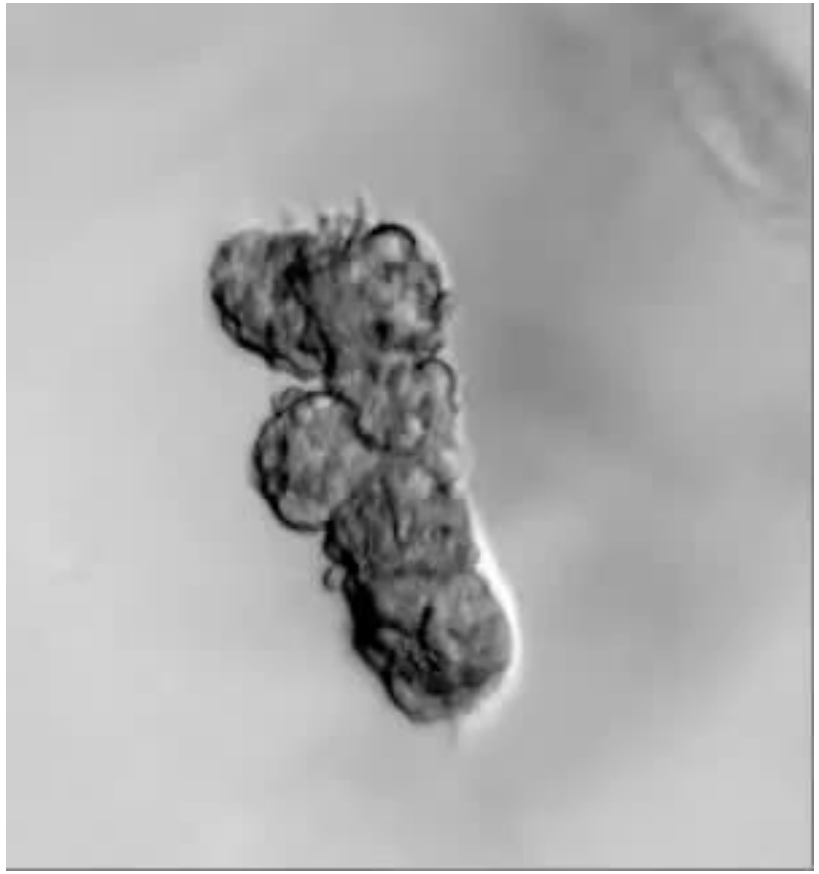






Snippert, Hugo J., et al. "Intestinal crypt homeostasis results from neutral competition between symmetrically dividing Lgr5 stem cells." *Cell* 143.1 (2010): 134-144.

Organoids



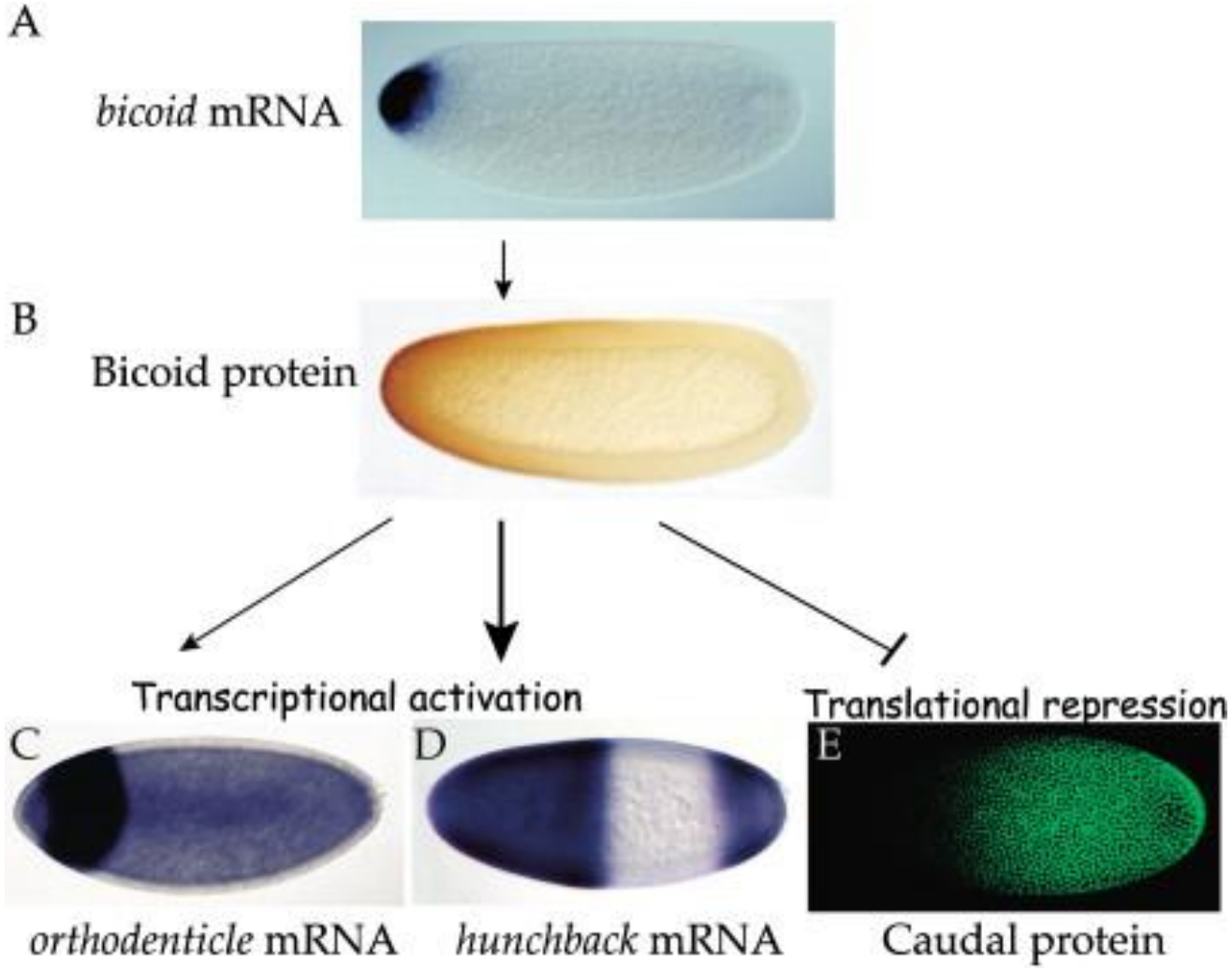
Drosophila Embryogenesis

Narrated by Philipp Keller, PhD
Group Leader, Janelia Research Campus

Bicoid in drosophilia

Ephrussi, A., & St Johnston, D. (2004). Seeing is believing: the bicoid morphogen gradient matures. *Cell*, *116*(2), 143-152.

https://www.ibiology.org/development-and-stem-cells/bicoid/



Principles of Development
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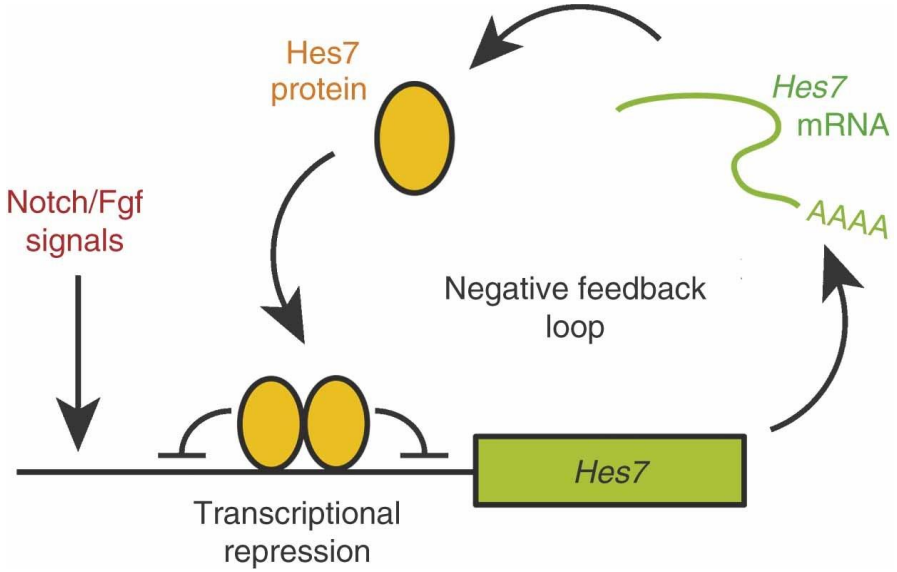
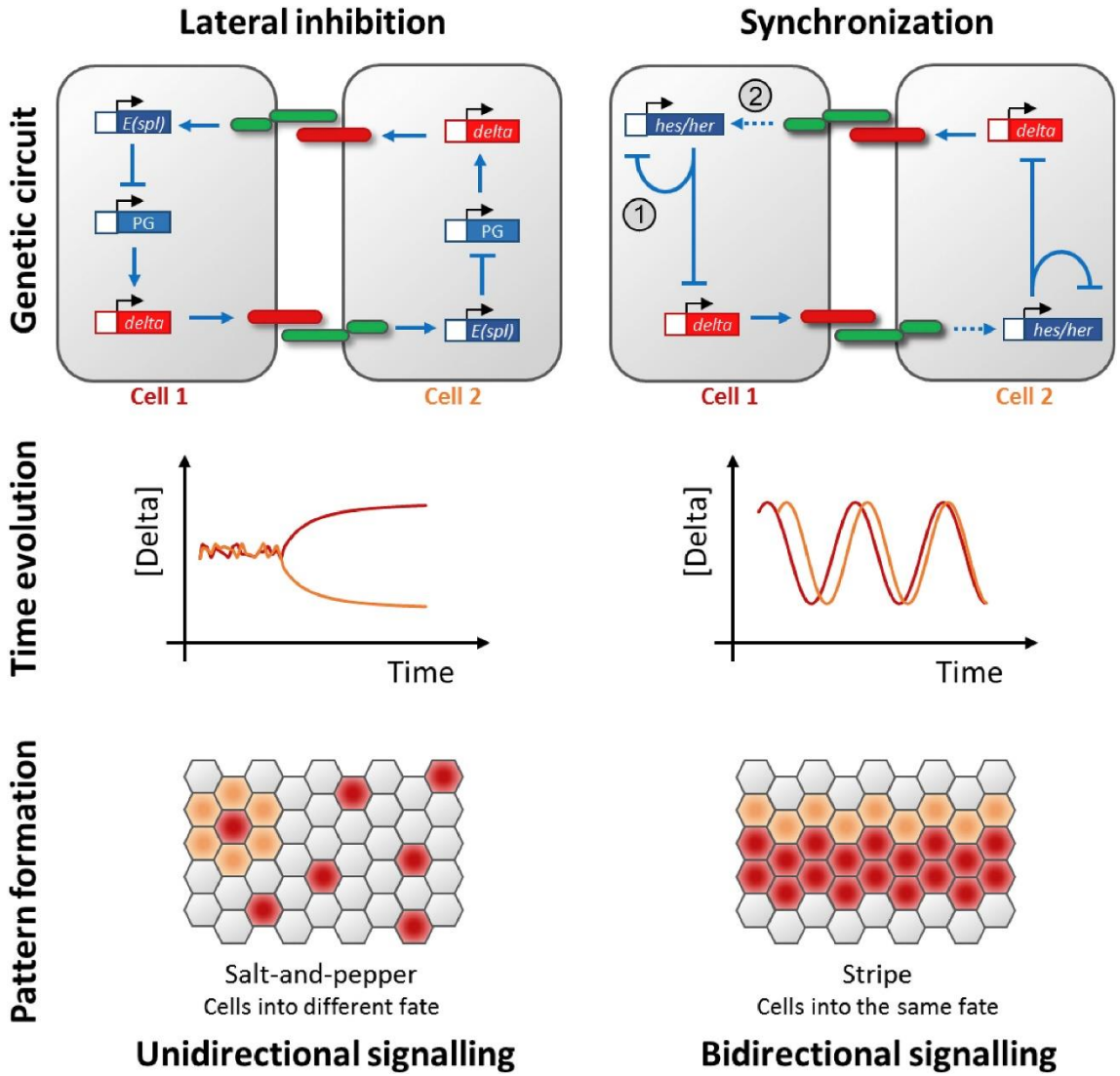
Zebrafish development from egg to embryo

Somitogenesis: vertebrates

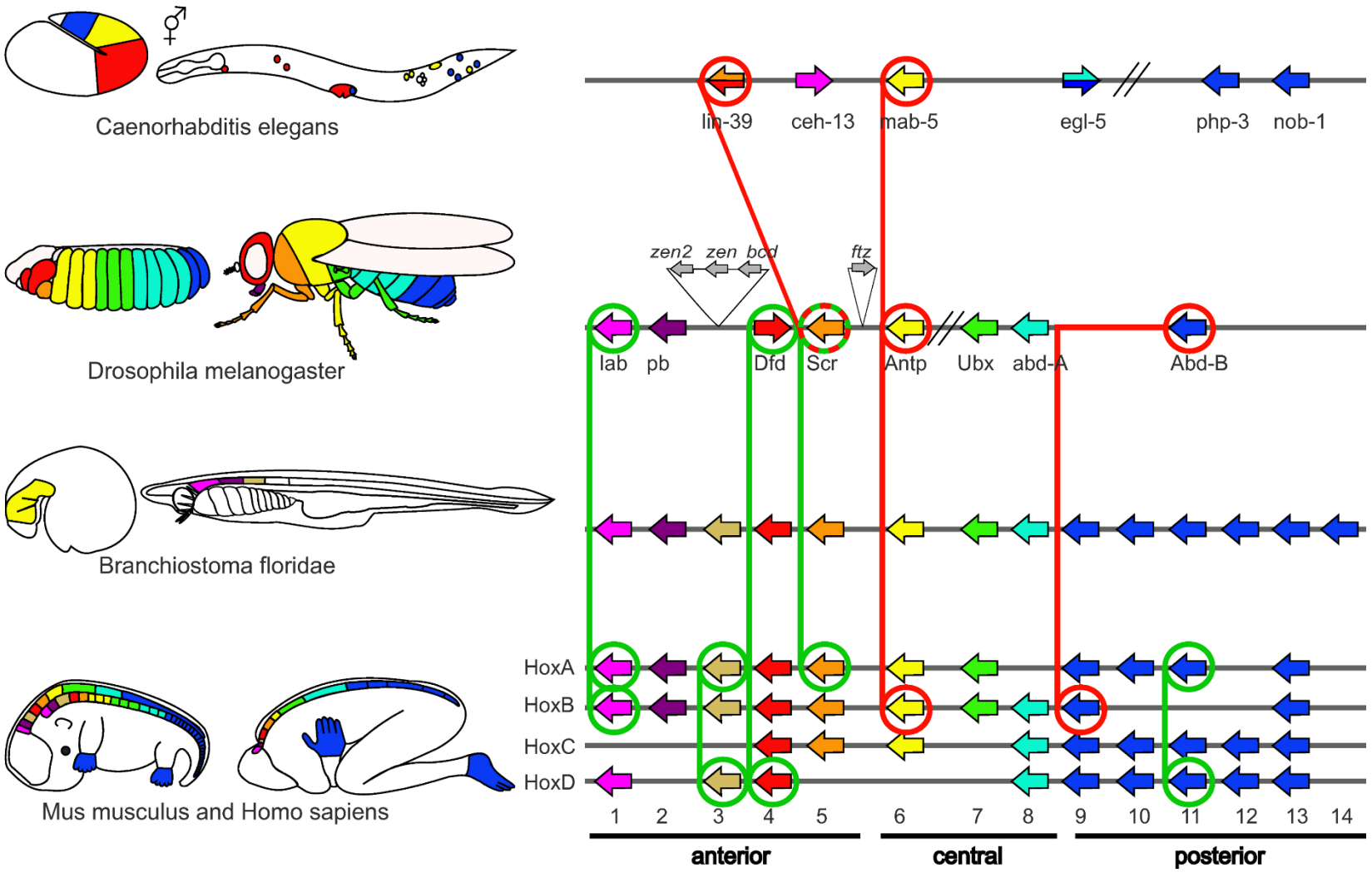




Kageyama, Ryoichiro, et al. "Oscillatory gene expression and somitogenesis." *Wiley Interdisciplinary Reviews: Developmental Biology* 1.5 (2012): 629-641.

Liao, Bo-Kai, and Andrew C. Oates. "Delta-Notch signalling in segmentation." *Arthropod structure & development* 46.3 (2017): 429-447.

Tissue specificiation: Hox genes



Hueber, S. D., Weiller, G. F., Djordjevic, M. A., & Frickey, T. (2010). Improving Hox protein classification across the major model organisms. *PloS one*, *5*(5), e10820.