

Eberhard O. Voit

# **A First Course in Systems Biology**

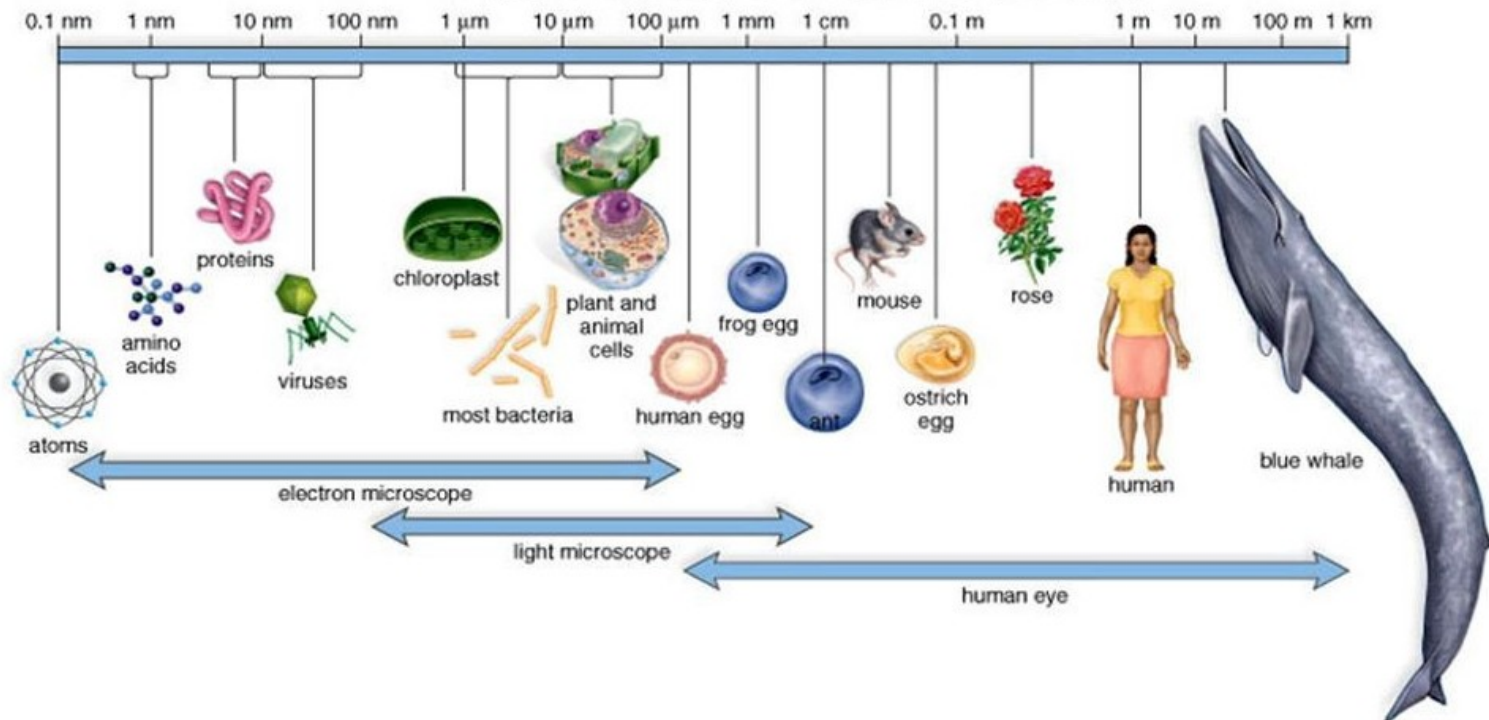
Chapter 1  
Biological Systems

# Systems Biology: Definition

Systems biology is the research endeavor that provides the scientific foundation for successful synthetic biology. It is based on the comprehensive study of the molecular diversity of living systems, both natural and synthetic, the identification of simplifying general principles and patterns that are recurring features in living and engineered systems, and the integration of our biological knowledge in complex models of the regulatory networks that characterize life.

Boogerd F. C., Bruggeman F. J., Hofmeyr J.-H. S., Westerhoff H. V. “Towards philosophical foundations of Systems Biology: introduction”, *Systems Biology: Philosophical Foundations*

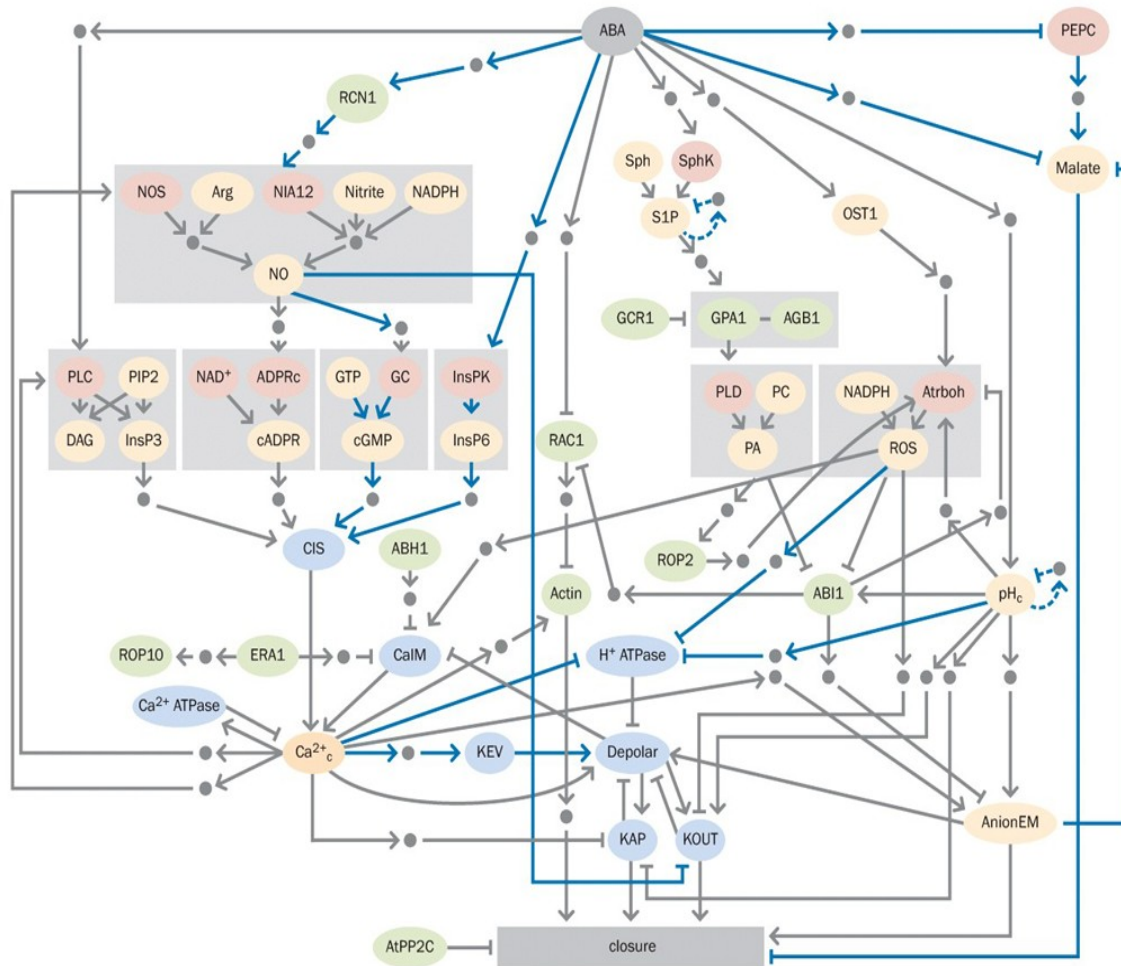
# Sizes of living things (logarithmic scale)



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# Complicated response to drought in plants



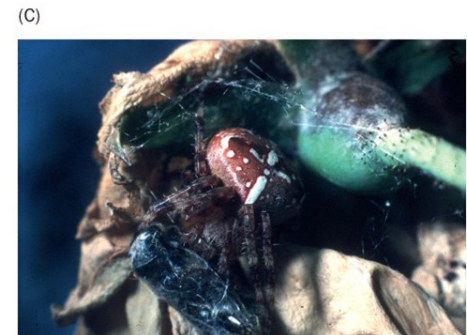
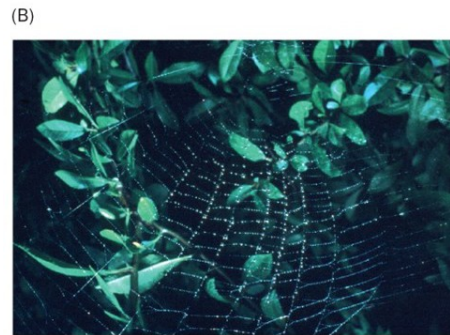
# Why is it difficult to understand?

- We understand what we design, even if they are complicated
- Living things are very complicated and we do not understand the design
- Even bacteria are very complicated!



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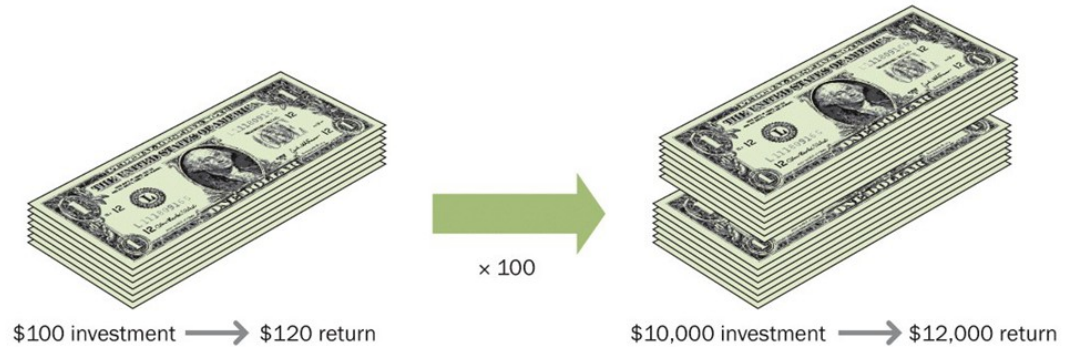
- Size of problems, such as network size, does not necessarily reflect the complexity.



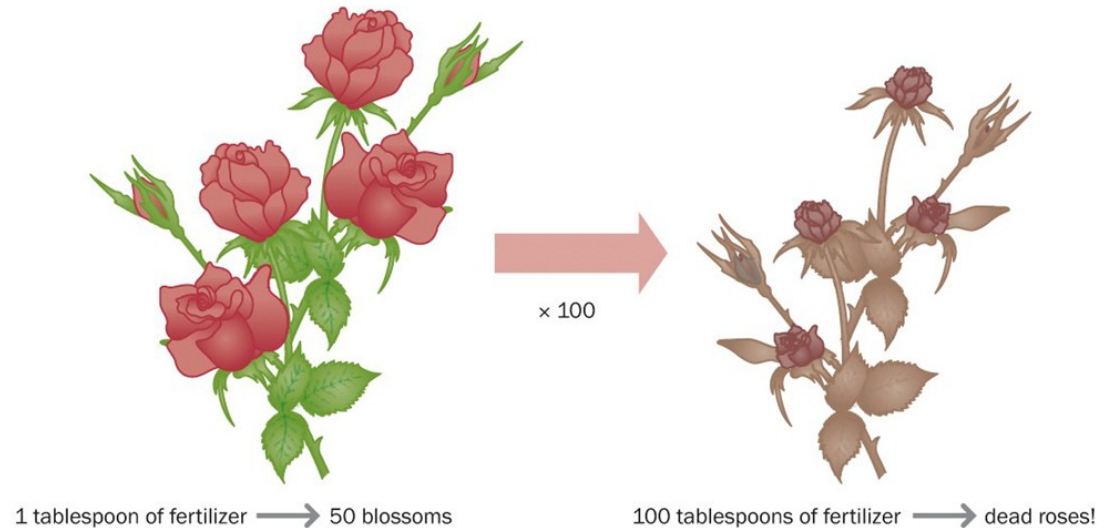
# Why is it difficult to understand?

- Size of problems, such as network size, does not necessarily reflect the complexity.
- Common understanding/intuition does not work for biological processes. These are not linear.

(A)



(B)





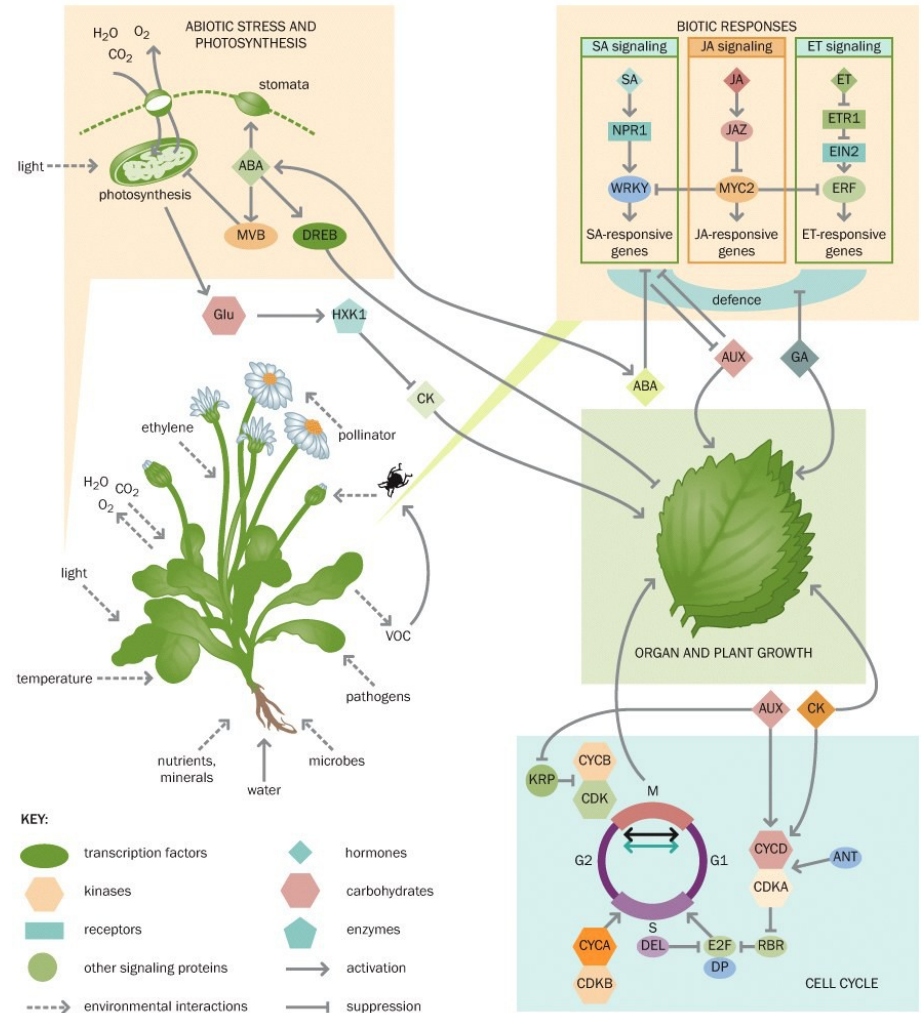
# Reductionism vs Systems Biology

- Collect information to understand individual components



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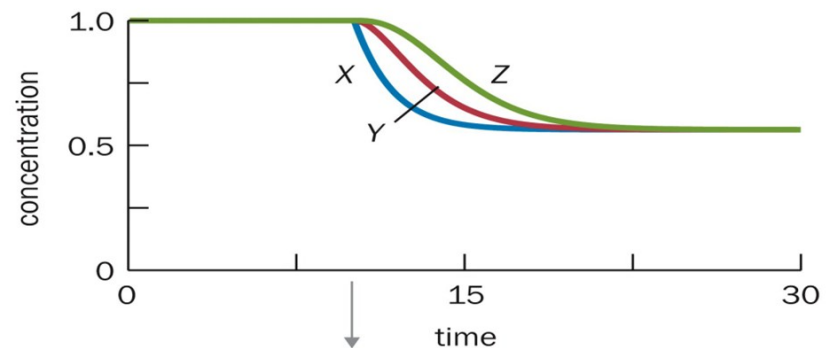
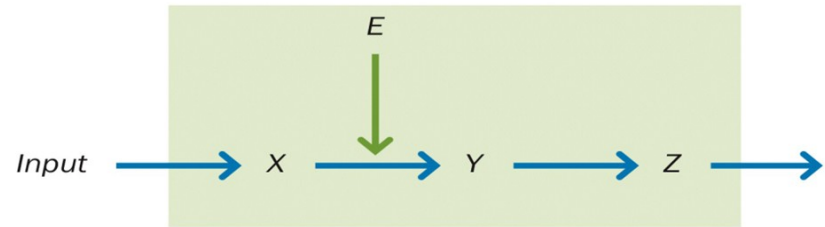
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- Put them together to understand!
- This is incredibly difficult even for 'simple' biological systems.

$$\dot{X} = \text{Input} - aEX^{0.5}$$

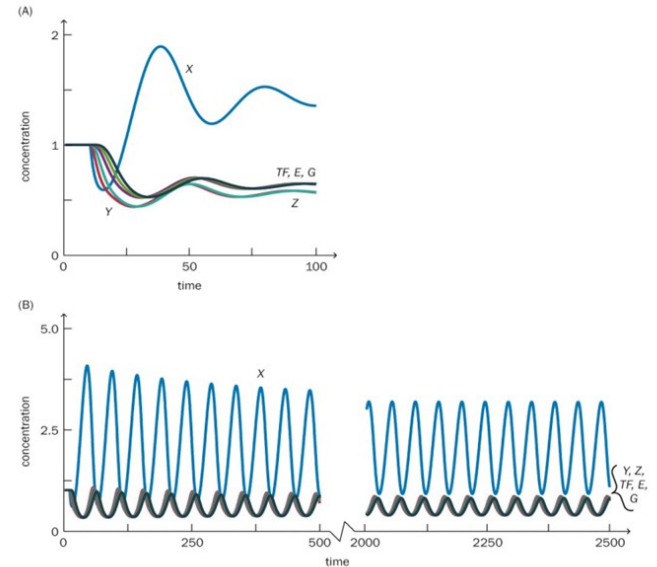
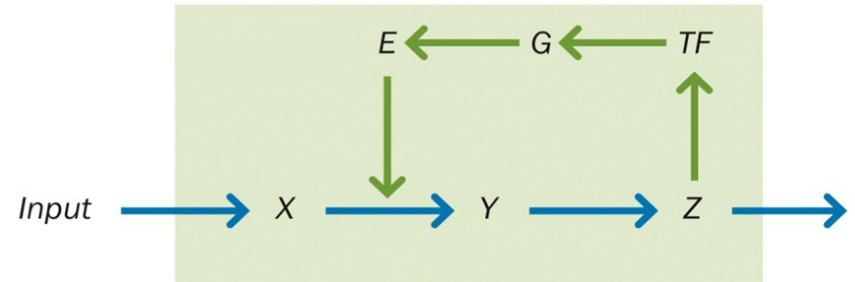
$$\dot{Y} = aEX^{0.5} - bY^{0.5}$$

$$\dot{Z} = bY^{0.5} - cZ^{0.5}$$



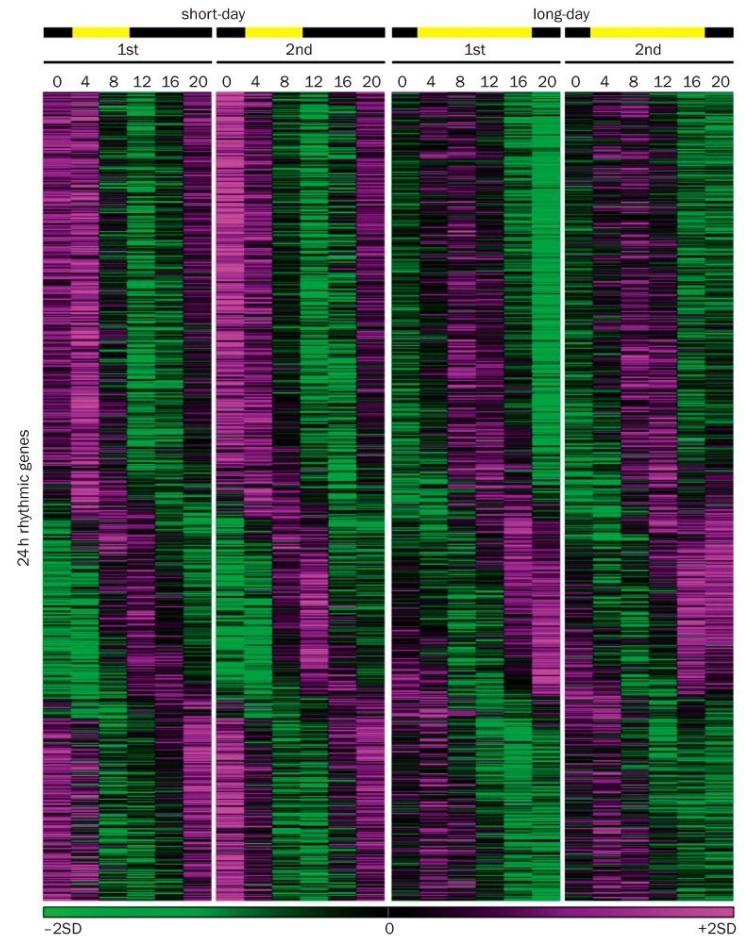
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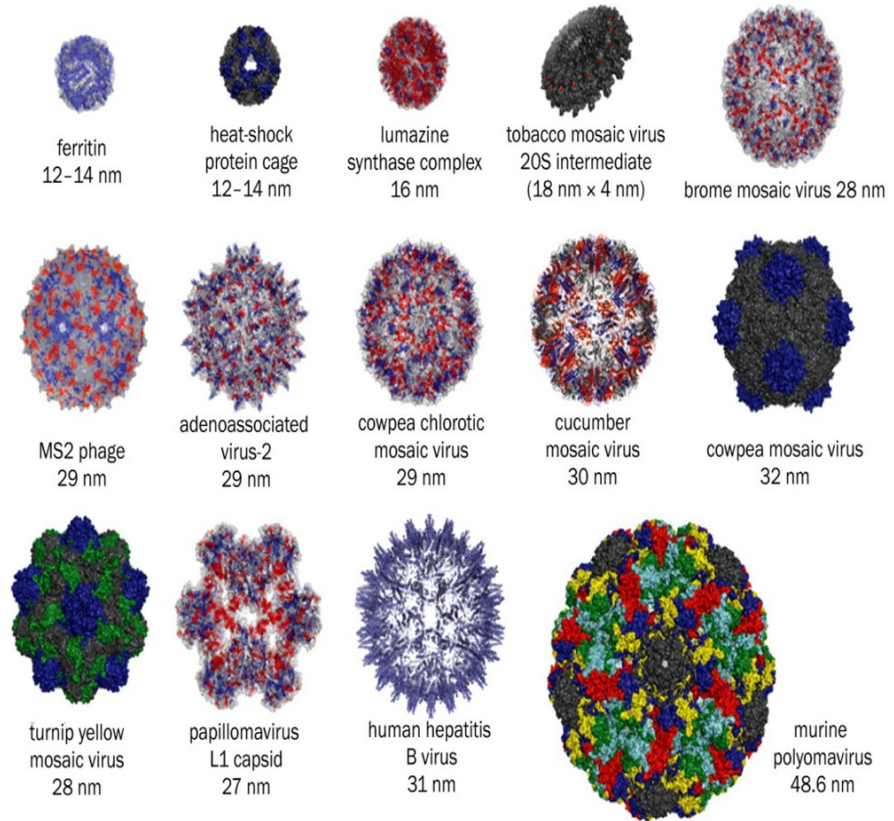
# Systems Biology: Why now?

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  - Availability of detailed biological information



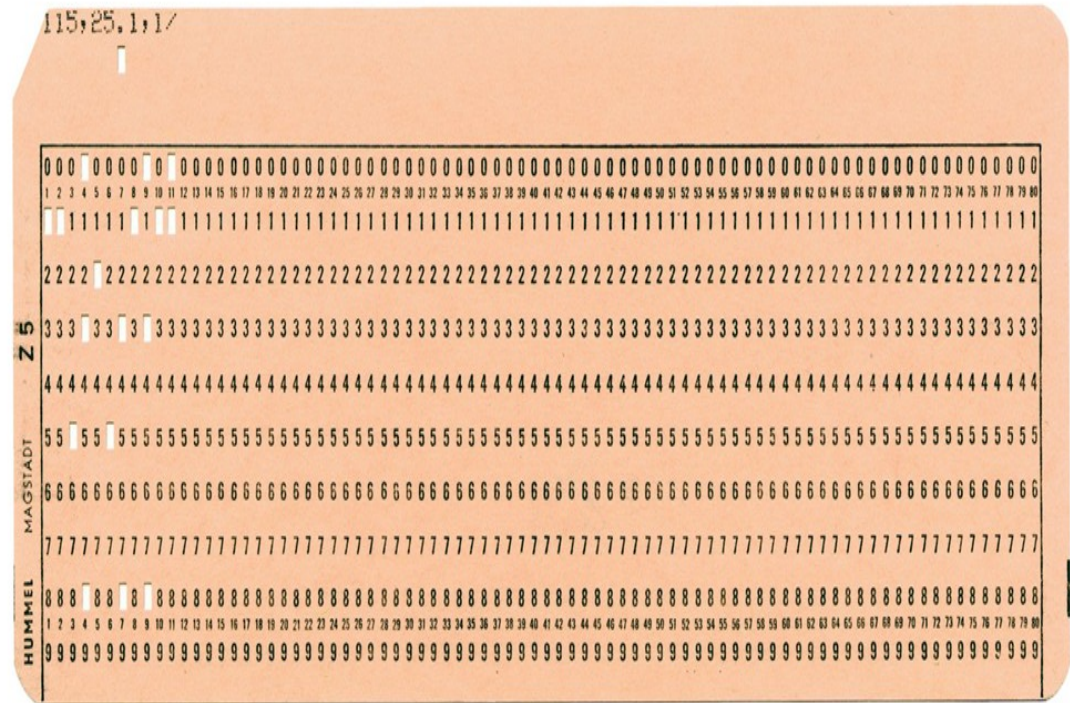
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  - Availability of detailed biological information
  - Availability of sophisticated tools to study *in vivo*
  - Co-evolution of mathematical, physical and computational techniques



# Systems Biology: Why now?

- Incredible advances and information is available
- Requires expertise from different fields

