

# Introduction to Cellular Networks

BMI/CS 576

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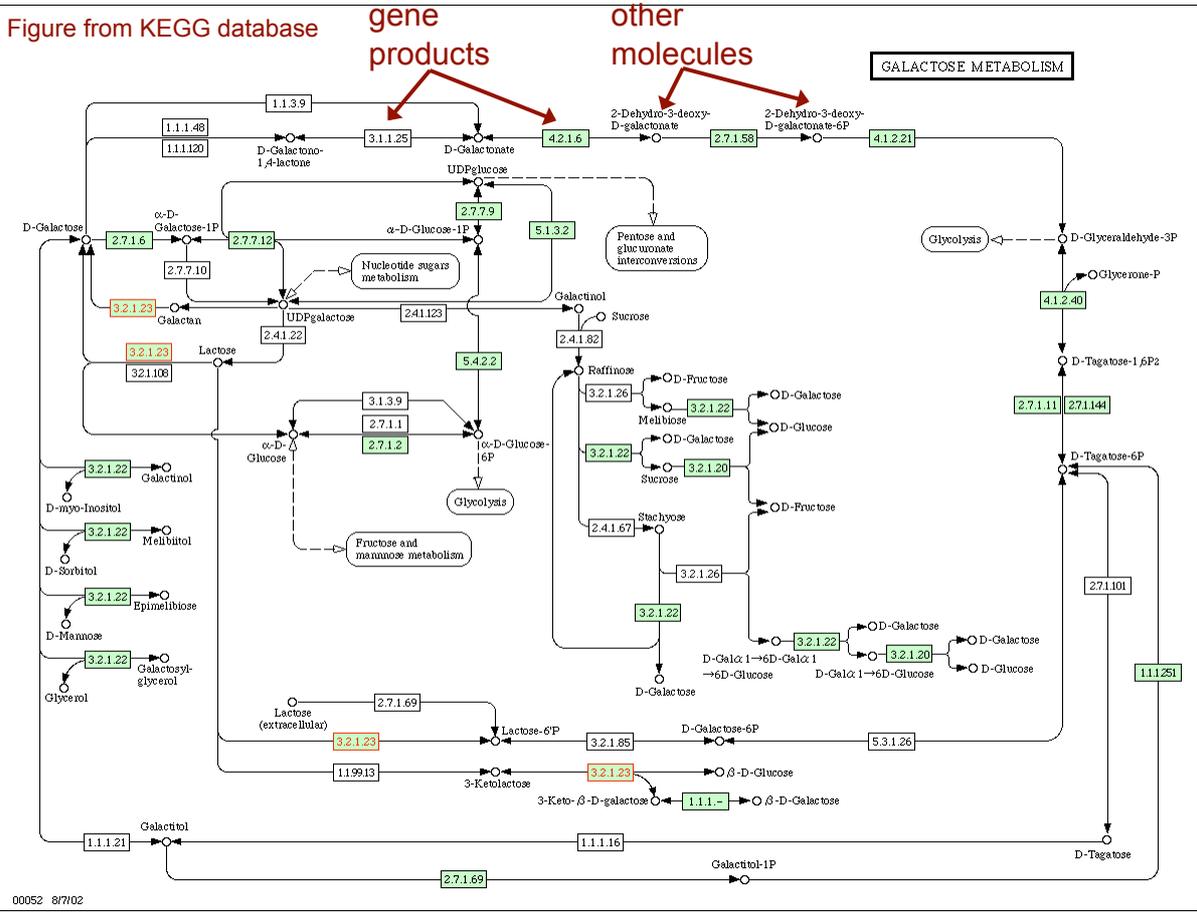
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## Various subnetworks within cells

- *metabolic*: describe reactions through which enzymes convert substrates to products
- *regulatory*: describe interactions that control expression of particular genes
- *signaling*: describe interactions among proteins and small molecules that relay signals from outside the cell to the nucleus
- note: these networks are linked together and the boundaries among them are not crisp

Figure from KEGG database



# Part of the *E. coli* regulatory network

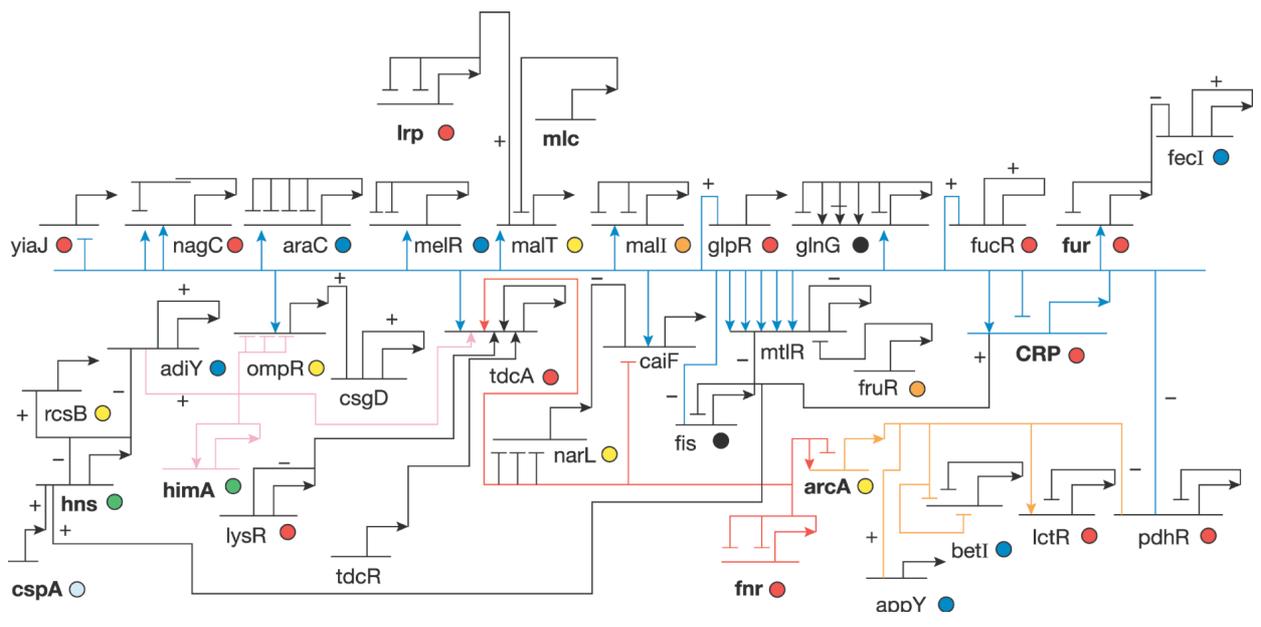


Figure from Wei et al., *Biochemical Journal* 2004

# A signaling network

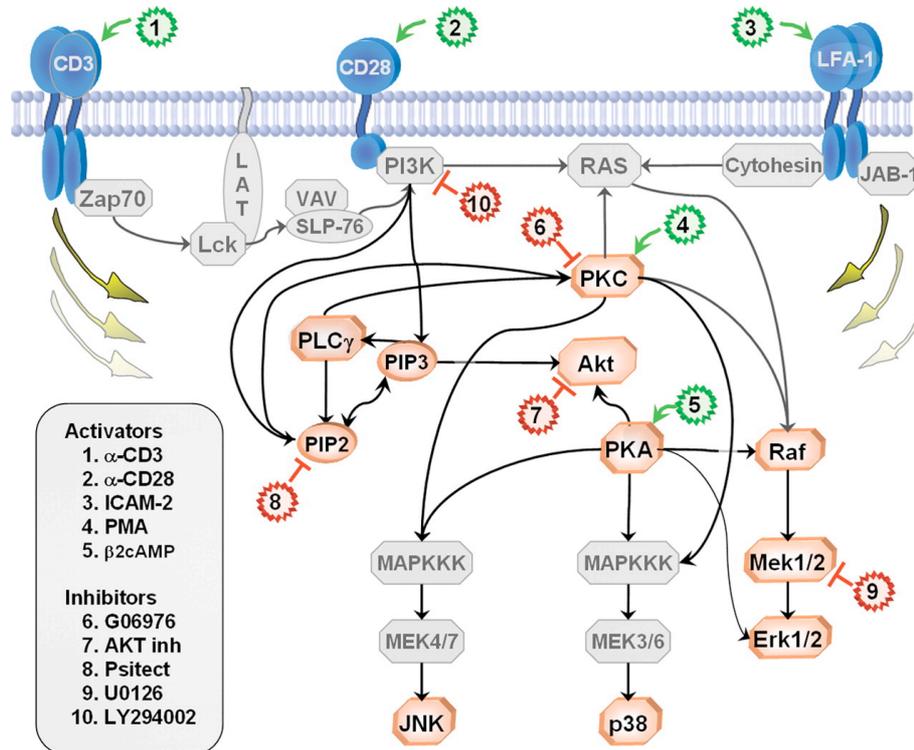


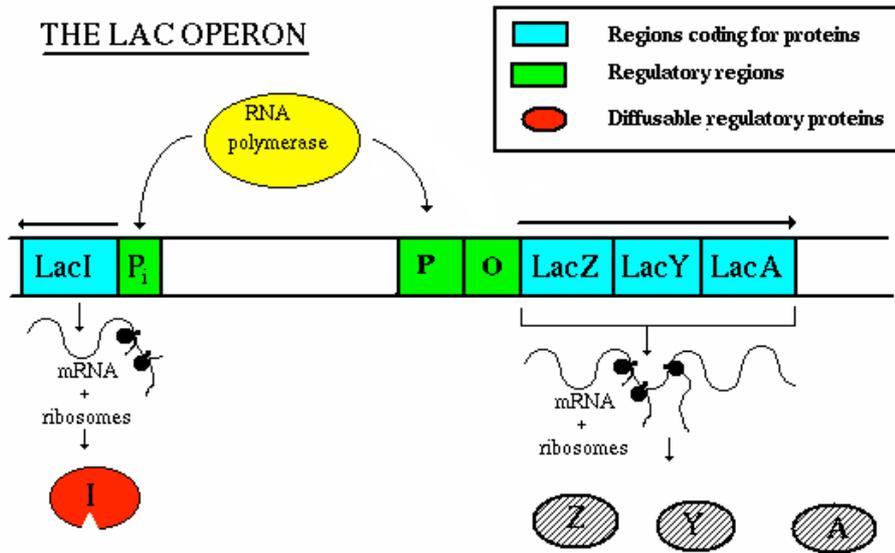
Figure from Sachs et al., *Science* 2005

## Two key tasks

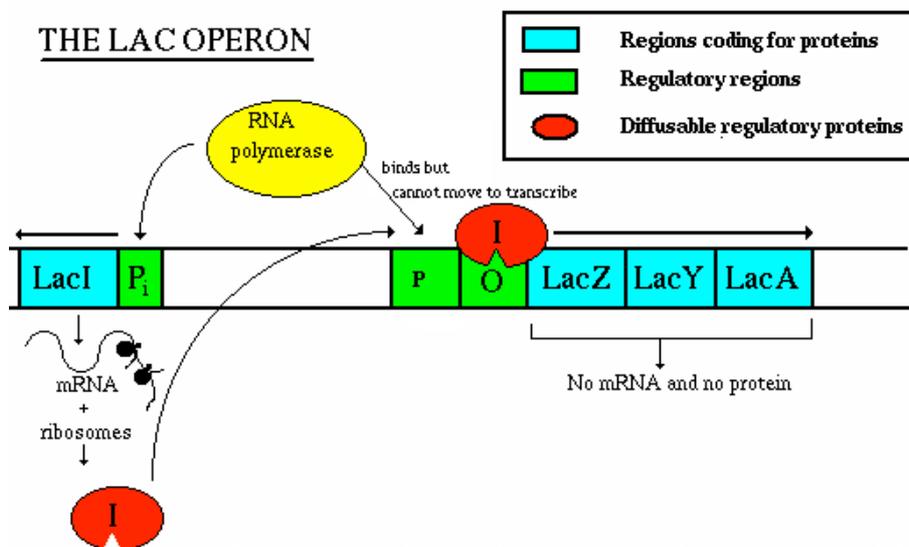
- *learning*: given background knowledge and high-throughput data, try to infer the (partial) structure/parameters of a network
- *inference*: given a (partial) network model, use it to predict an outcome of biological interest (e.g. will the cells grow faster in medium x or medium y?)
- both of these are challenging tasks because typically
  - data are noisy
  - data are incomplete – characterize a limited range of conditions
  - important aspects of the system not measured – some unknown structure and/or parameters

# Transcriptional regulation example: the lac Operon in *E. coli*

*E. coli* can use lactose as an energy source, but it prefers glucose. How does it switch on its lactose-metabolizing genes?

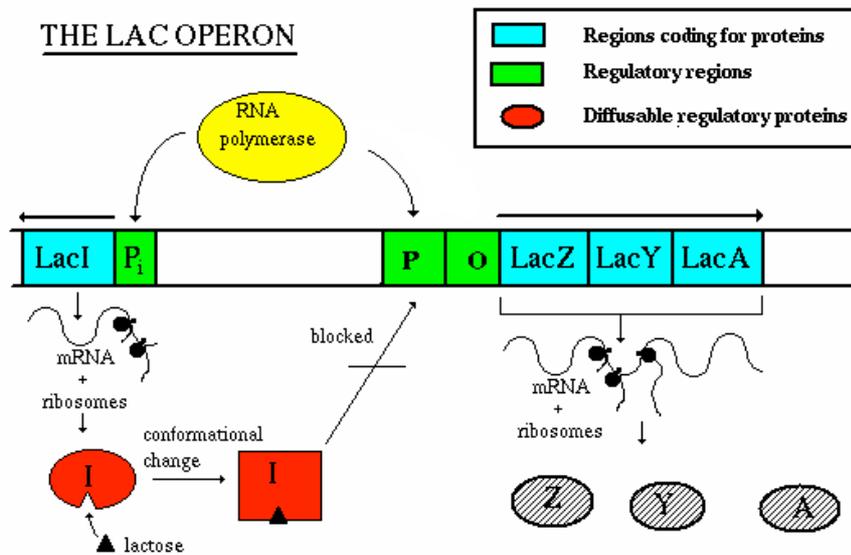


## The lac operon: repression by *LacI*



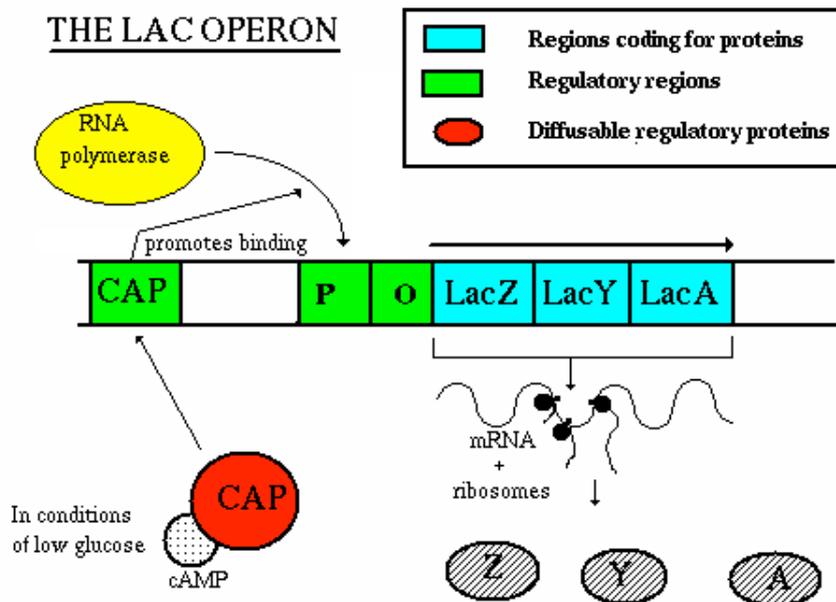
lactose absent  $\Rightarrow$  protein encoded by *lacI* represses transcription of the lac operon

## The lac operon: induction by *LacI*



lactose present  $\Rightarrow$  protein encoded by lacI won't bind to the operator (O) region

## The lac operon: activation by glucose



glucose absent  $\Rightarrow$  CAP protein promotes binding by RNA polymerase; increases transcription

# Network model representations

- directed graphs
- Boolean networks
- ✓ Bayesian networks and related graphical models
- differential equations
- Petri nets
- constraint-based models
- etc.