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
Part of the *E. coli* regulatory network

Figure from Wei et al., *Biochemical Journal* 2004
A signaling network

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

- LacI protein encoded by lacI won't bind to the operator (O) region.

- Presence of lactose: LacI protein is not available to bind to the operator (O) region, allowing transcription to proceed.

The lac operon: activation by glucose

- CAP protein promotes binding by RNA polymerase:
  - CAP protein binds to the lac operon in conditions of low glucose.
  - CAP protein promotes transcription by RNA polymerase.

- Absence of glucose: CAP protein binds to the lac operon, promoting transcription.

- 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.