

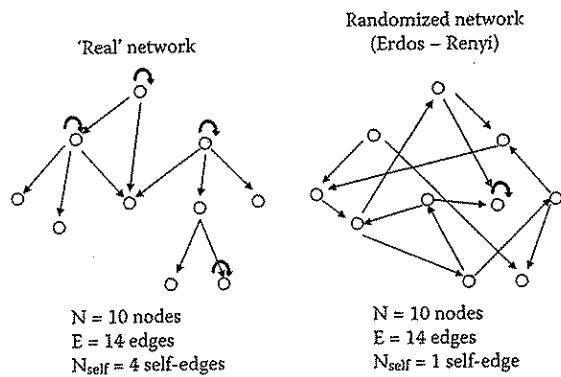
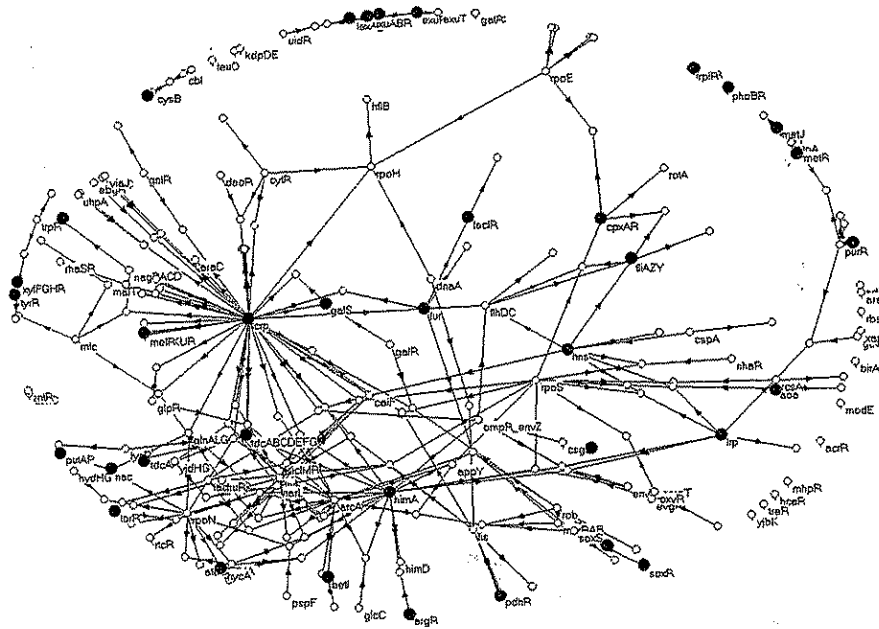
TABLE 2.1 Typical Parameter Values for the Bacterial *E. coli* Cell, the Single-Celled Eukaryote *Saccharomyces cerevisiae* (Yeast), and a Mammalian Cell (Human Fibroblast)

Property	<i>E. coli</i>	Yeast ( <i>S. cerevisiae</i> )	Mammalian (Human Fibroblast)
Cell volume	$\sim 1 \mu\text{m}^3$	$\sim 1000 \mu\text{m}^3$	$\sim 10,000 \mu\text{m}^3$
Proteins/cell	$4 \cdot 10^6$	$\sim 4 \cdot 10^9$	$\sim 4 \cdot 10^{10}$
Mean size of protein	5 nm		
Size of genome	$4.6 \cdot 10^6$ bp 4500 genes	$1.3 \cdot 10^7$ bp 6600 genes	$3 \cdot 10^9$ bp $\sim 30,000$ genes
Size of: Regulator binding site	$\sim 10$ bp	$\sim 10$ bp	$\sim 10$ bp
Promoter	$\sim 100$ bp	$\sim 1000$ bp	$\sim 10^4$ to $10^5$ bp
Gene	$\sim 1000$ bp	$\sim 1000$ bp	$\sim 10^4$ to $10^6$ bp (with introns)
Concentration of one protein/cell	$\sim 1$ nM	$\sim 1$ pM	$\sim 0.1$ pM
Diffusion time of protein across cell	$\sim 0.1$ sec $D = 10 \mu\text{m}^2/\text{sec}$	$\sim 10$ sec	$\sim 100$ sec
Diffusion time of small molecule across cell	$\sim 1$ msec, $D = 1000 \mu\text{m}^2/\text{sec}$	$\sim 10$ msec	$\sim 0.1$ sec
Time to transcribe a gene	$\sim 1$ min 80 bp/sec	$\sim 1$ min	$\sim 30$ min (including mRNA processing)
Time to translate a protein	$\sim 2$ min 40 aa/sec	$\sim 2$ min	$\sim 30$ min (including mRNA nuclear export)
Typical mRNA lifetime	2–5 min	$\sim 10$ min to over 1 h	$\sim 10$ min to over 10 h
Cell generation time	$\sim 30$ min (rich medium) to several hours	$\sim 2$ h (rich medium) to several hours	20 h — nondividing
Ribosomes/cell	$\sim 10^4$	$\sim 10^7$	$\sim 10^8$
Transitions between protein states (active/inactive)	1–100 $\mu\text{sec}$	1–100 $\mu\text{sec}$	1–100 $\mu\text{sec}$
Timescale for equilibrium binding of small molecule to protein (diffusion limited)	$\sim 1$ msec (1 $\mu\text{M}$ affinity)	$\sim 1$ sec (1 nM affinity)	$\sim 1$ sec (1 nM affinity)
Timescale of transcription factor binding to DNA site	$\sim 1$ sec		
Mutation rate	$\sim 10^{-9}$ /bp/generation	$\sim 10^{-10}$ /bp/generation	$\sim 10^{-8}$ /bp/year

TABLE 2.2 Timescales for the Reactions in the Transcription Network of the Bacterium *E. coli* (Order of Magnitude)

Binding of a small molecule (a signal) to a transcription factor, causing a change in transcription factor activity	$\sim 1$ msec
Binding of active transcription factor to its DNA site	$\sim 1$ sec
Transcription + translation of the gene	$\sim 5$ min
Timescale for 50% change in concentration of the translated protein (stable proteins)	$\sim 1$ h (one cell generation)

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(b)

FIGURE 3.1 Self-regulating genes in a network of transcription interactions in *E. coli*. Nodes that correspond to genes that encode transcription factor proteins that regulate their own promoters (self-regulating genes, represented by self-edges) are shown in black. This network, which we will use as an example in the coming chapters, has about  $N = 420$  nodes,  $E = 520$  edges, and  $N_{self} = 40$  self-edges. (b) Example of a small network and its randomized Erdos-Renyi version, with the same number of nodes and edges.

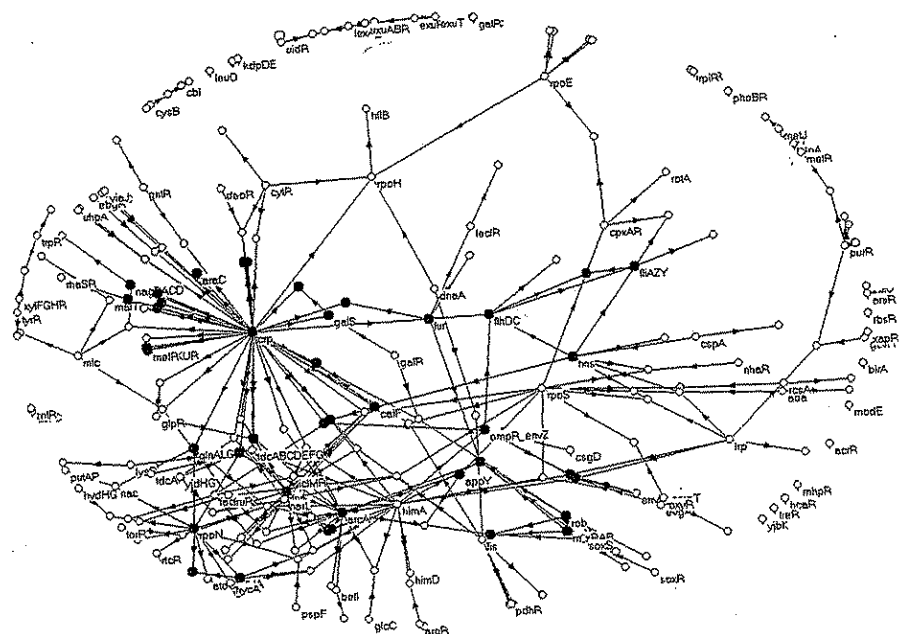


FIGURE 4.2 Feed forward loops in the *E. coli* transcription network. Black nodes participate in FFLs.