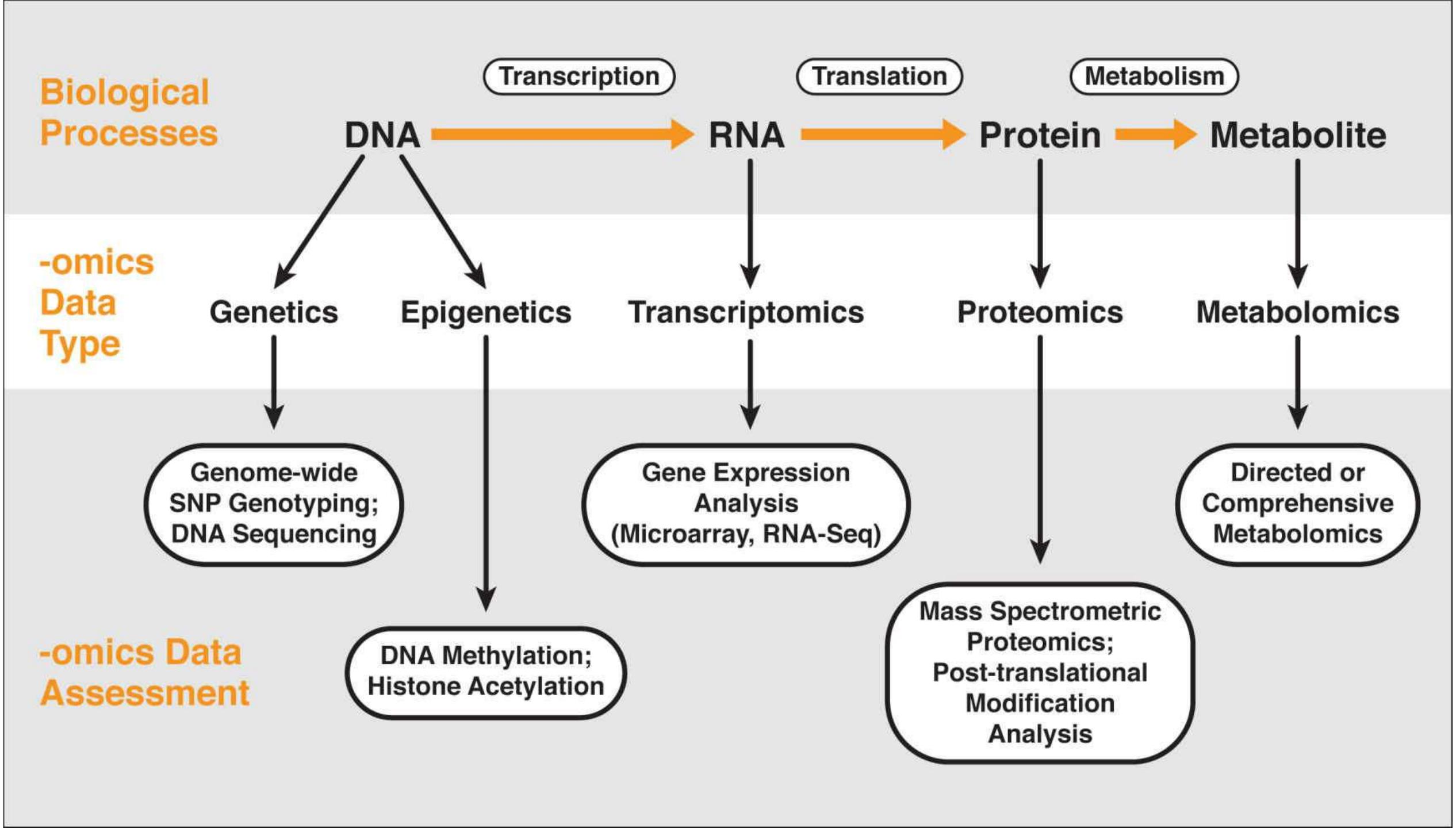
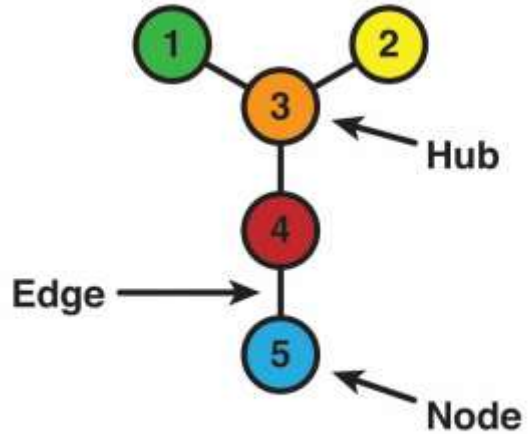
NETWORK MEDICINE

Complex Systems in Human Disease and Therapeutics

Edited by Joseph Loscalzo, Albert-László Barabási, and Edwin K. Silverman

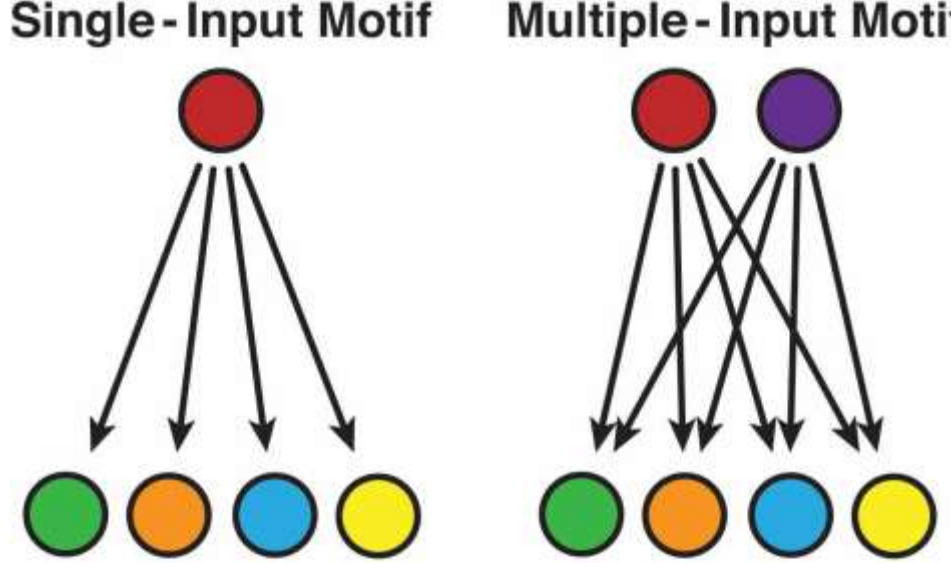

Biological Processes
Transcription
Translation
Metabolism
DNA
RNA
Protein
Metabolite
-omics Data Type
Genetics
Epigenetics
Transcriptomics
Proteomics
Metabolomics
Genome-wide SNP Genotyping; DNA Sequencing
Gene Expression Analysis (Microarray, RNA-Seq)
Directed or Comprehensive Metabolomics
-omics Data Assessment
DNA Methylation; Histone Acetylation
Mass Spectrometric Proteomics; Post-translational Modification Analysis

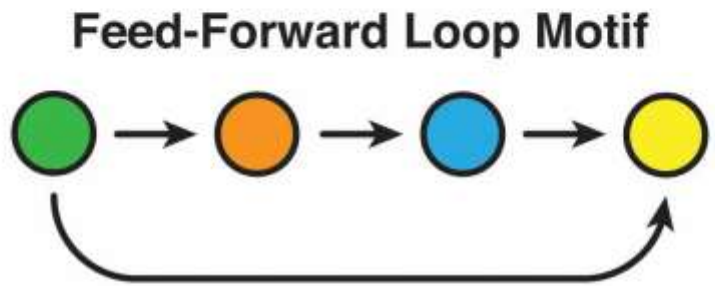
Network

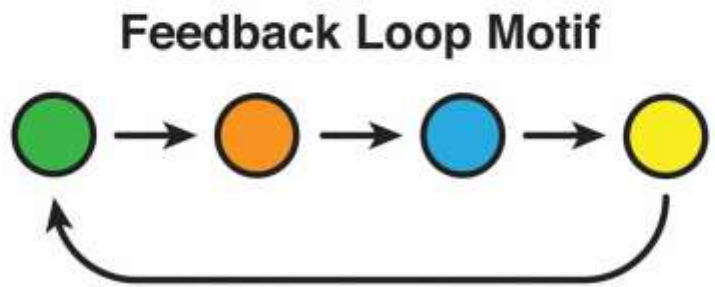


Adjacency Matrix

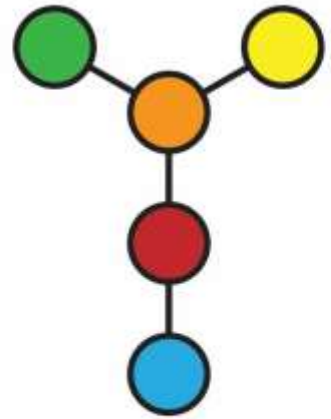
$$\begin{pmatrix} 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 \end{pmatrix}$$


Single-Input Motif
Multiple-Input Motif

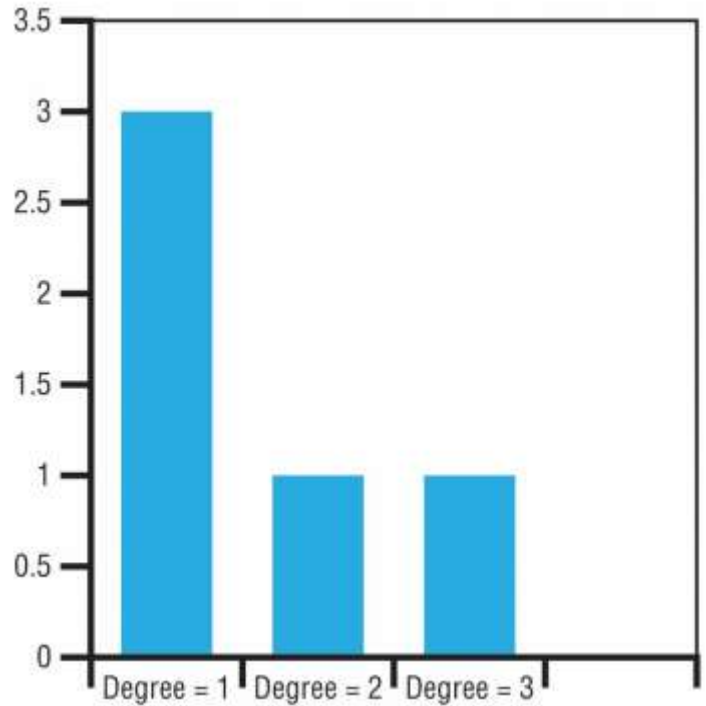

Feed-Forward Loop Motif


Feedback Loop Motif

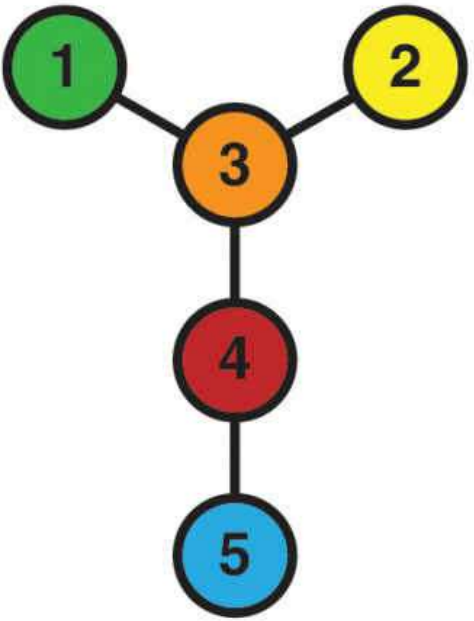
Network



Degree Distribution



a) Network



c) Betweenness Centralities

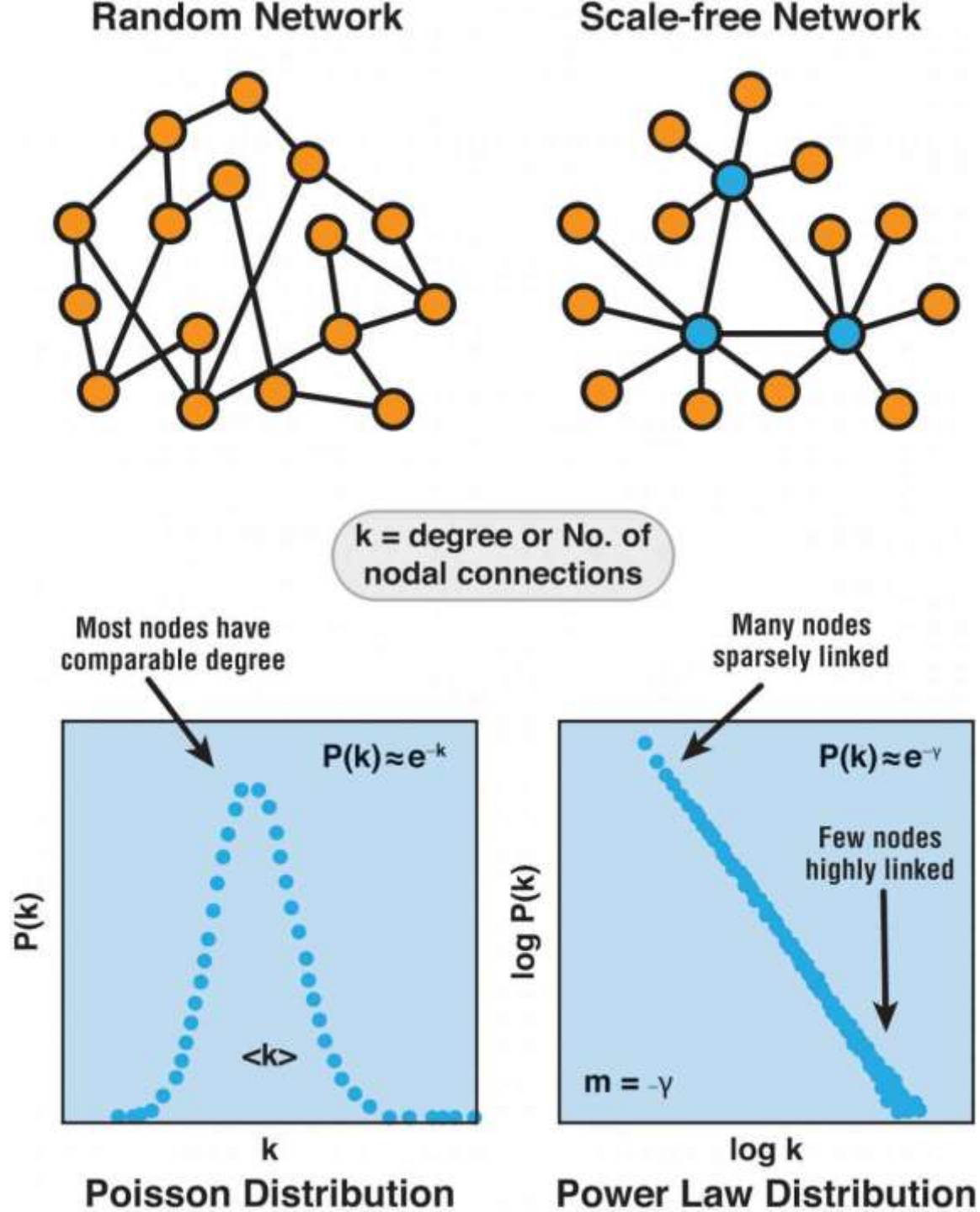
Nodes	1	2	3	4	5
Shortest Paths Including Node	4	4	9	7	4
Betweenness	0.4	0.4	0.9	0.7	0.4

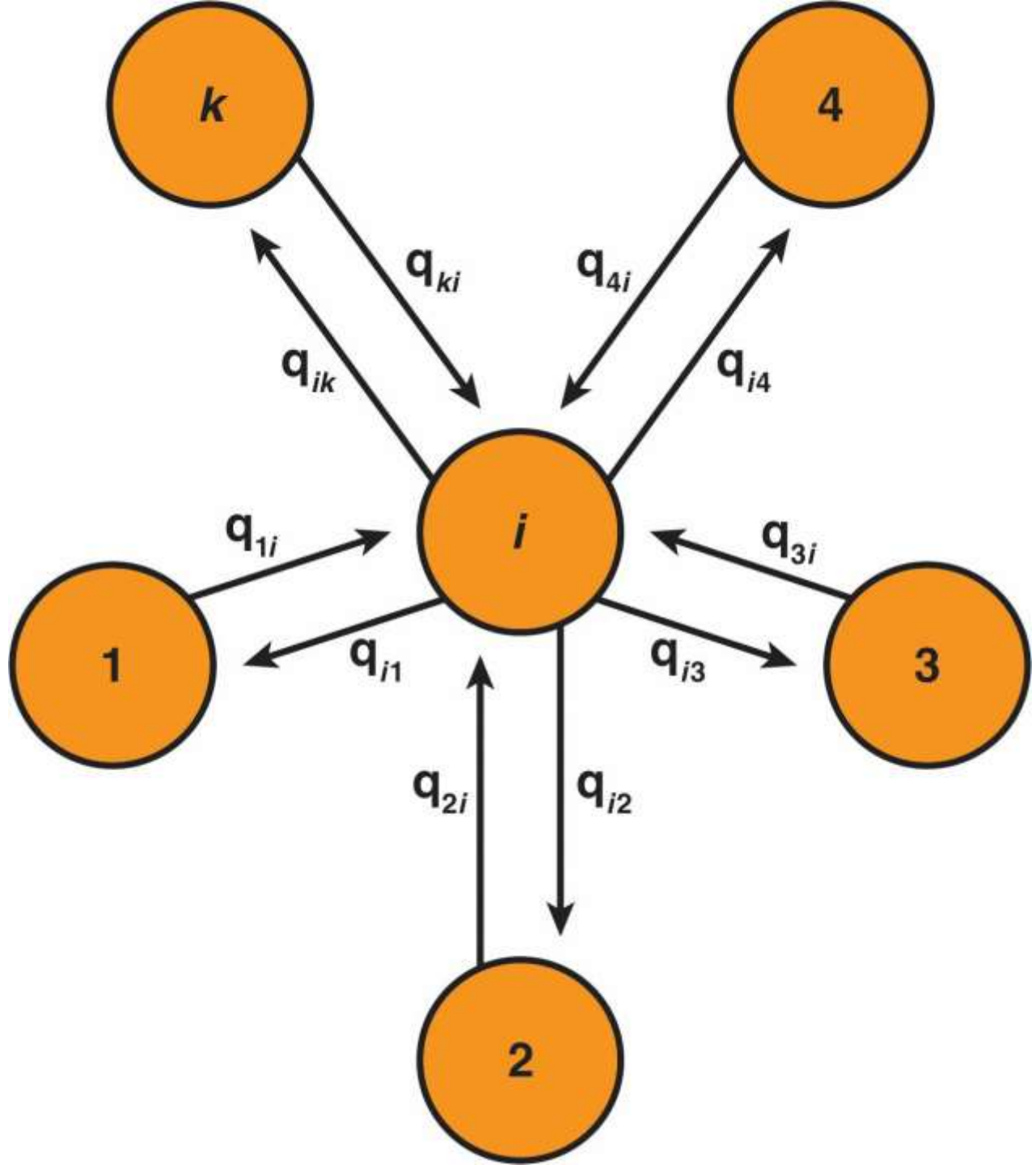
$$\text{Betweenness Centrality} = \frac{\text{(No. of Shortest Paths including Node)}}{\text{(No. of Shortest Paths)}}$$

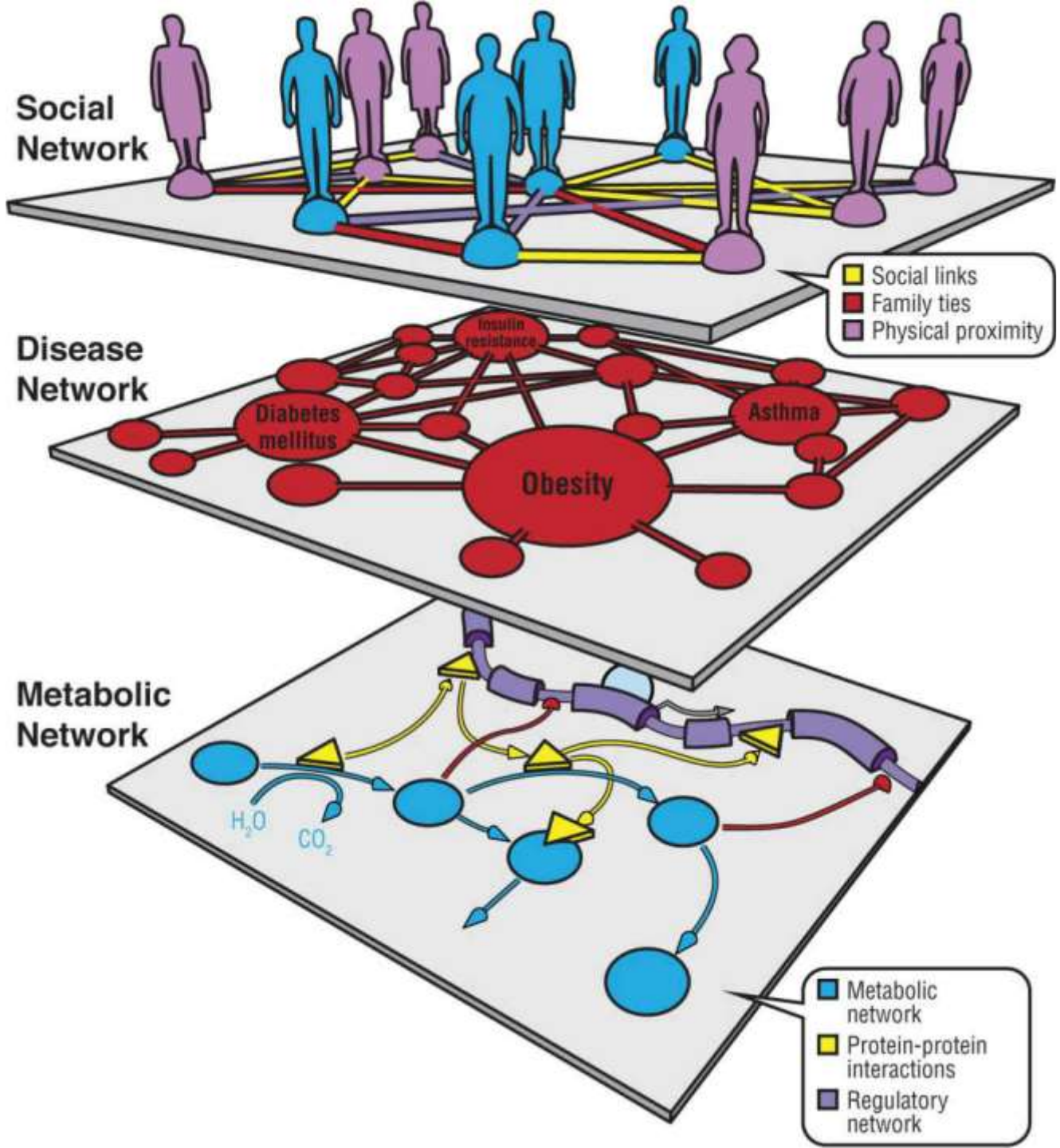
b) Shortest Path Lengths

Nodes	1–2	1–3	1–4	1–5	2–3	2–4	2–5	3–4	3–5	4–5
Shortest Paths	1–3–2	1–3	1–3–4	1–3–4–5	2–3	2–3–4	2–3–4–5	3–4	3–4–5	4–5
Path Length	2	1	2	3	1	2	3	1	2	1

Characteristic Path Length = Mean Shortest Path Length = 18/10 = 1.8


Random Network
Scale-free Network
k = degree or No. of nodal connections
Most nodes have comparable degree
P(k)≈e^-k
<k>
P(k)
k
Poisson Distribution
Many nodes sparsely linked
P(k)≈e^-γ
Few nodes highly linked
m = -γ
log P(k)
log k
Power Law Distribution


k
4
q_{ki}
q_{4i}
q_{ik}
q_{i4}
q_{1i}
i
q_{3i}
1
q_{i1}
q_{i3}
3
q_{2i}
q_{i2}
2


Social
Network
Social links
Family ties
Physical proximity
Disease
Network
Insulin resistance
Diabetes mellitus
Asthma
Obesity
Metabolic
Network
H_2O
CO_2
Metabolic network
Protein-protein interactions
Regulatory network