

BIOINFORMATICS

Network Biology & Systems Biology

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NETWORK BIOLOGY & SYSTEMS BIOLOGY SESSION

Lecture 1: Networks in biology

Practice 1: Cytoscape tutorial

Lecture 2: Analyze molecular interaction network

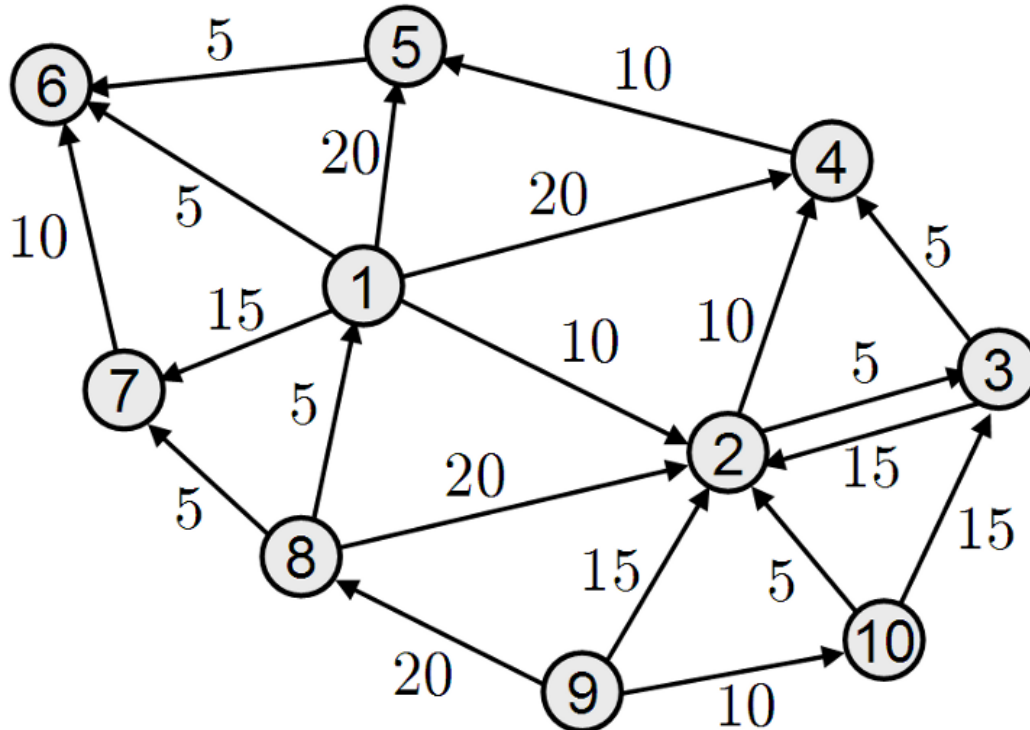
Practice 2: Analyze and integrate data with Cytoscape

Lecture 2: Dynamics of molecular interaction networks

Practice 2: Network dynamic in Cytoscape



GRAPH THEORY



The bridges of Königsberg

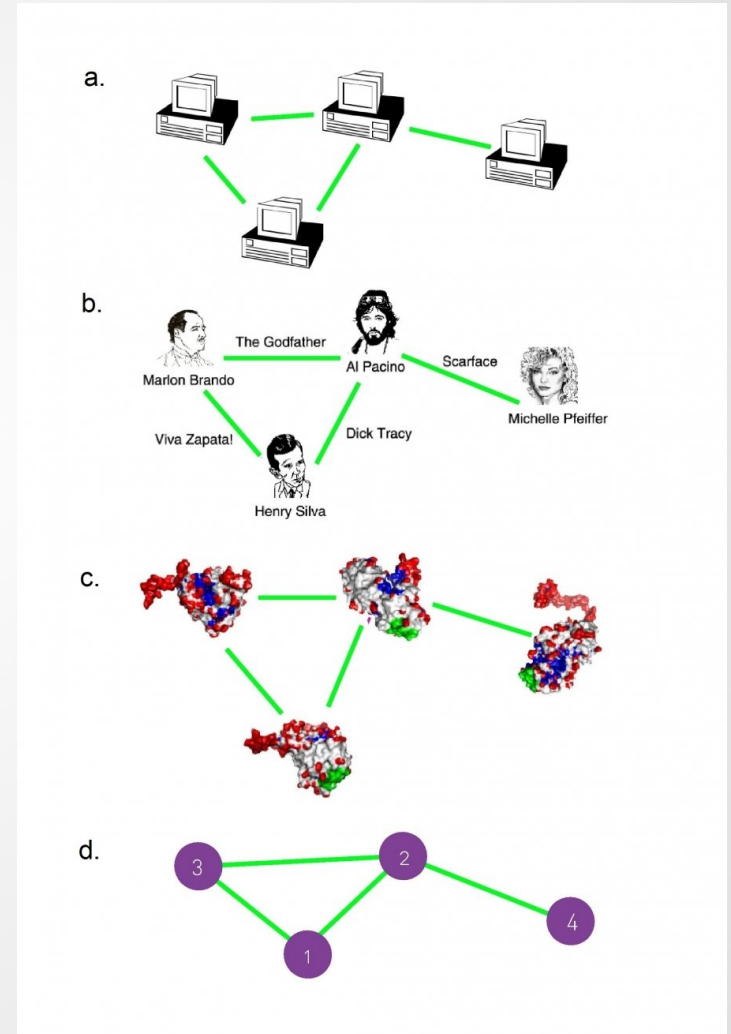


Graph theory

- **The bridges of Königsberg - Euler - 1735**
- **Graph**
 - **Definition:** graph is a structure amounting to a set of objects in which some pairs of the objects are in some sense "related"
- **Graph types:**
 - **By edge:**
 - directed, undirected, weighted, multi graph, ...
 - **By topology:**
 - Tree, circle, star, ...

Networks

- **Graph**
 - abstract mathematical representation, data structure
- **Network**
 - phenomenon modelled by graph



Networks

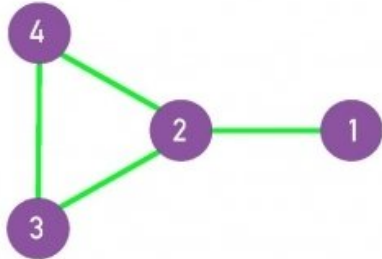
Network	Nodes	Links	Directed / Undirected	N	L	$\langle K \rangle$
Internet	Routers	Internet connections	Undirected	192,244	609,066	6.34
WWW	Webpages	Links	Directed	325,729	1,497,134	4.60
Power Grid	Power plants, transformers	Cables	Undirected	4,941	6,594	2.67
Mobile-Phone Calls	Subscribers	Calls	Directed	36,595	91,826	2.51
Email	Email addresses	Emails	Directed	57,194	103,731	1.81
Science Collaboration	Scientists	Co-authorships	Undirected	23,133	93,437	8.08
Actor Network	Actors	Co-acting	Undirected	702,388	29,397,908	83.71
Citation Network	Papers	Citations	Directed	449,673	4,689,479	10.43
E. Coli Metabolism	Metabolites	Chemical reactions	Directed	1,039	5,802	5.58
Protein Interactions	Proteins	Binding interactions	Undirected	2,018	2,930	2.90

Degree distribution

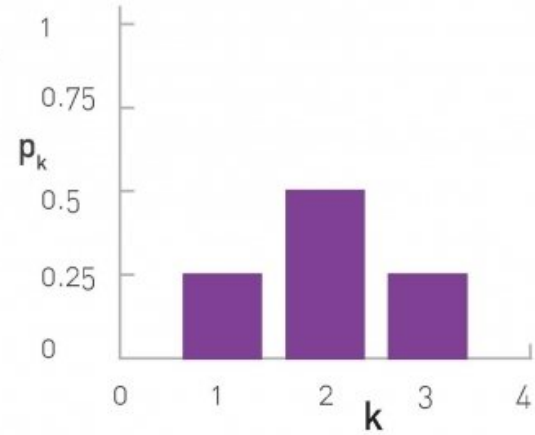
- **Degree**
 - The number of interaction of a given node
 - In case of directed graph separately in coming and outgoing degree
- **Degree distribution**
 - The histogram of degree of all node in a graph

Degree distribution

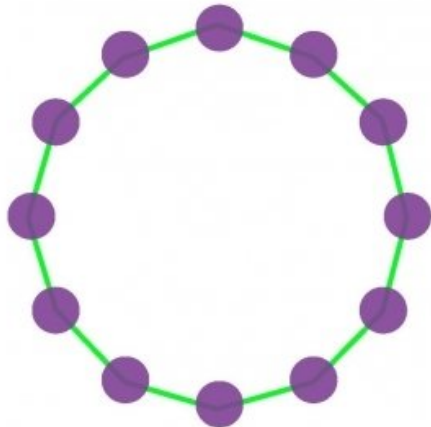
a.



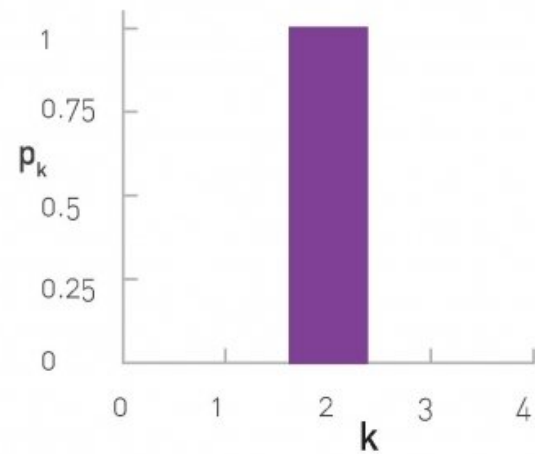
b.



c.

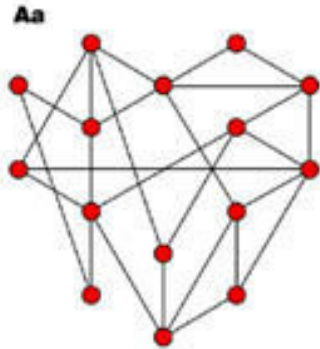


d.

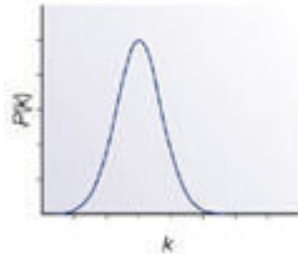


Degree distribution

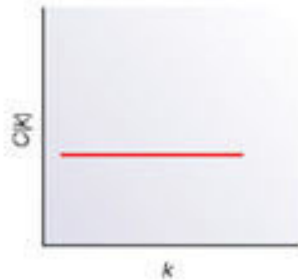
A Random network



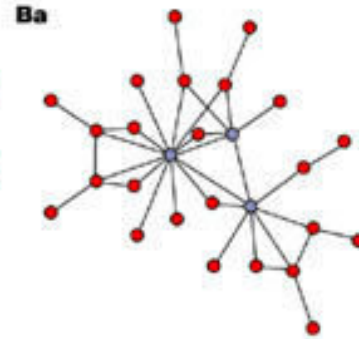
Ab



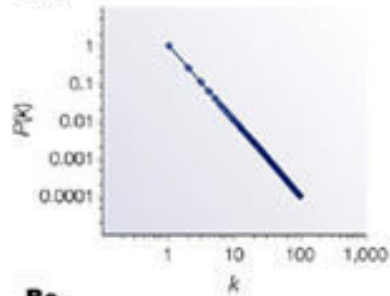
Ac



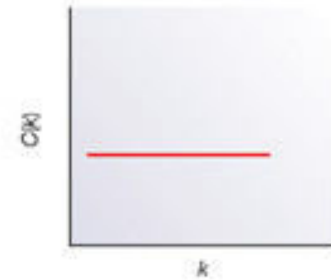
B Scale-free network



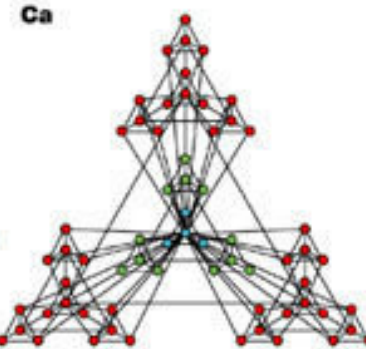
Bb



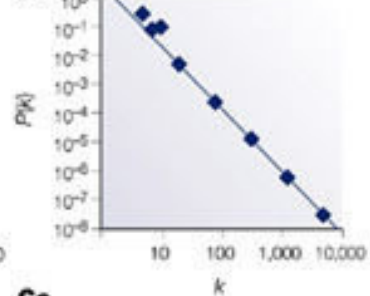
Bc



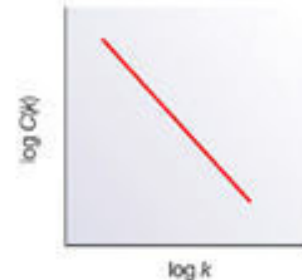
C Hierarchical network



Cb



Cc

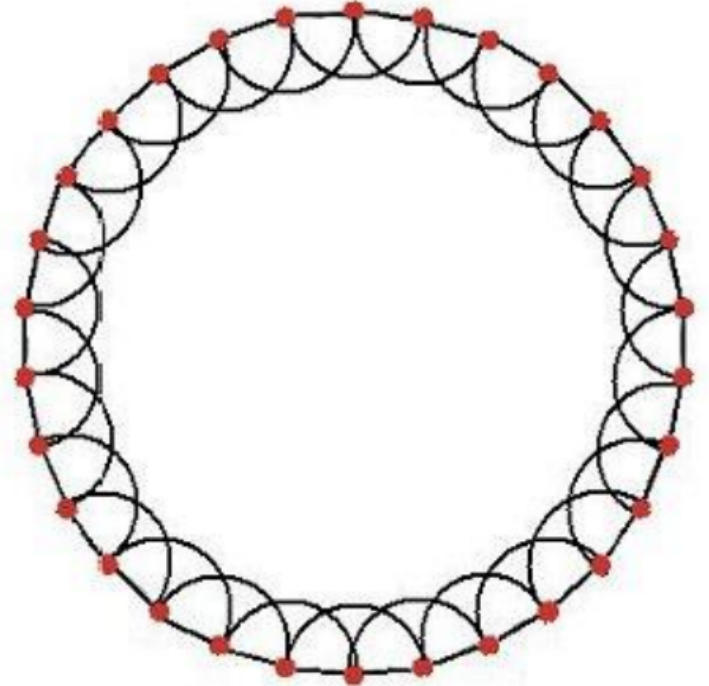
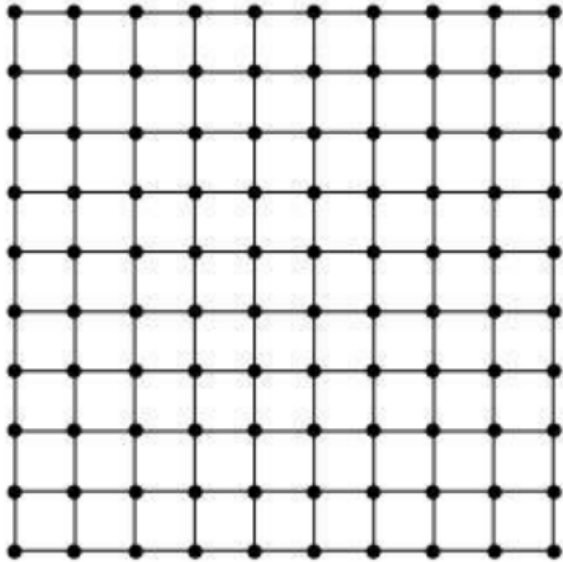


NETWORK TOPOLOGY



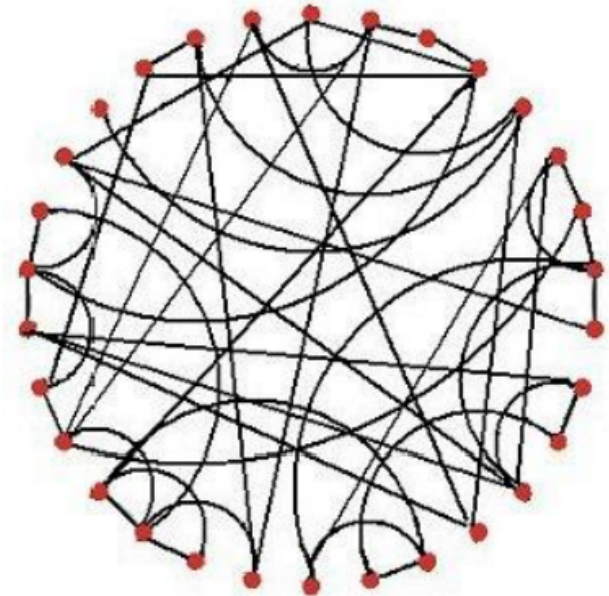
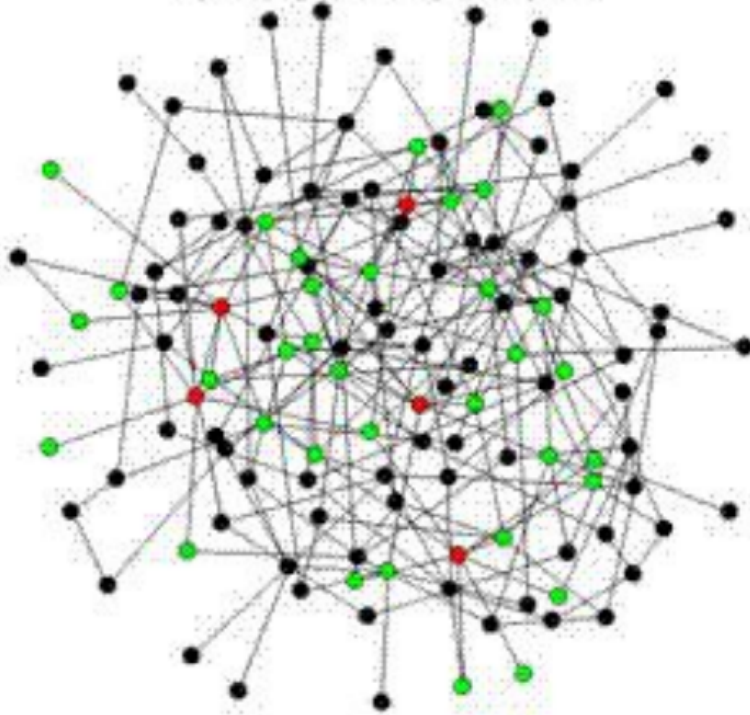
Network types: regular network

Lattice Network



Network types: random network (Erdős-Rényi model)

random network

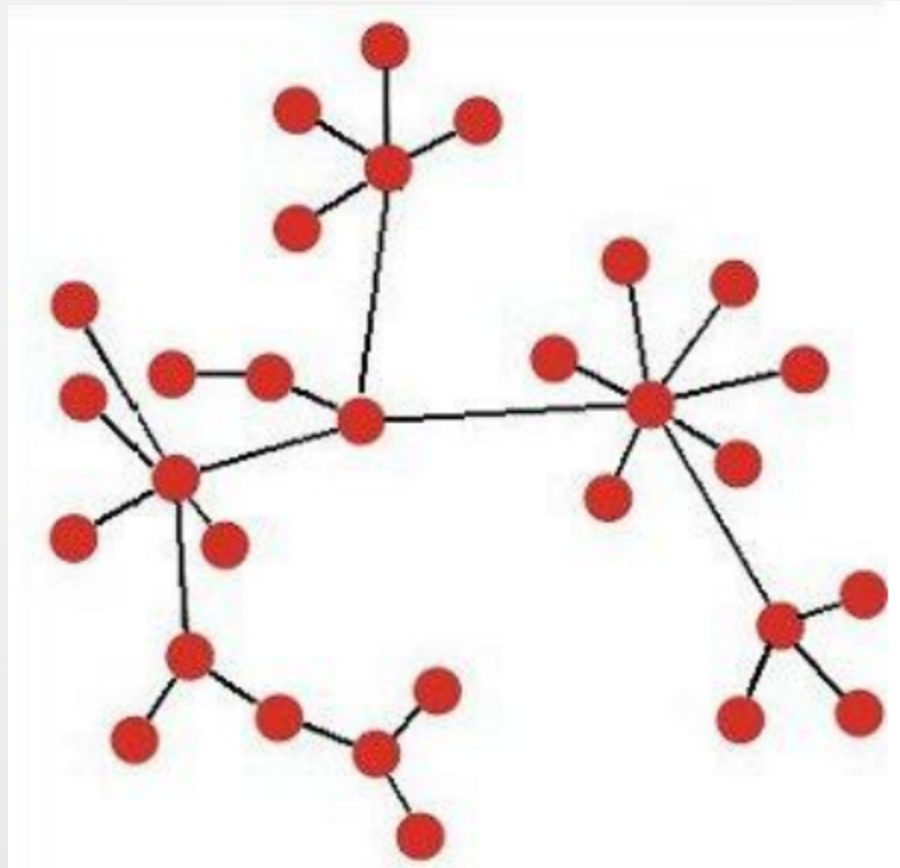


Network types: random network (Erdős-Rényi model)

Random Graphs
Emergence of the Giant Component



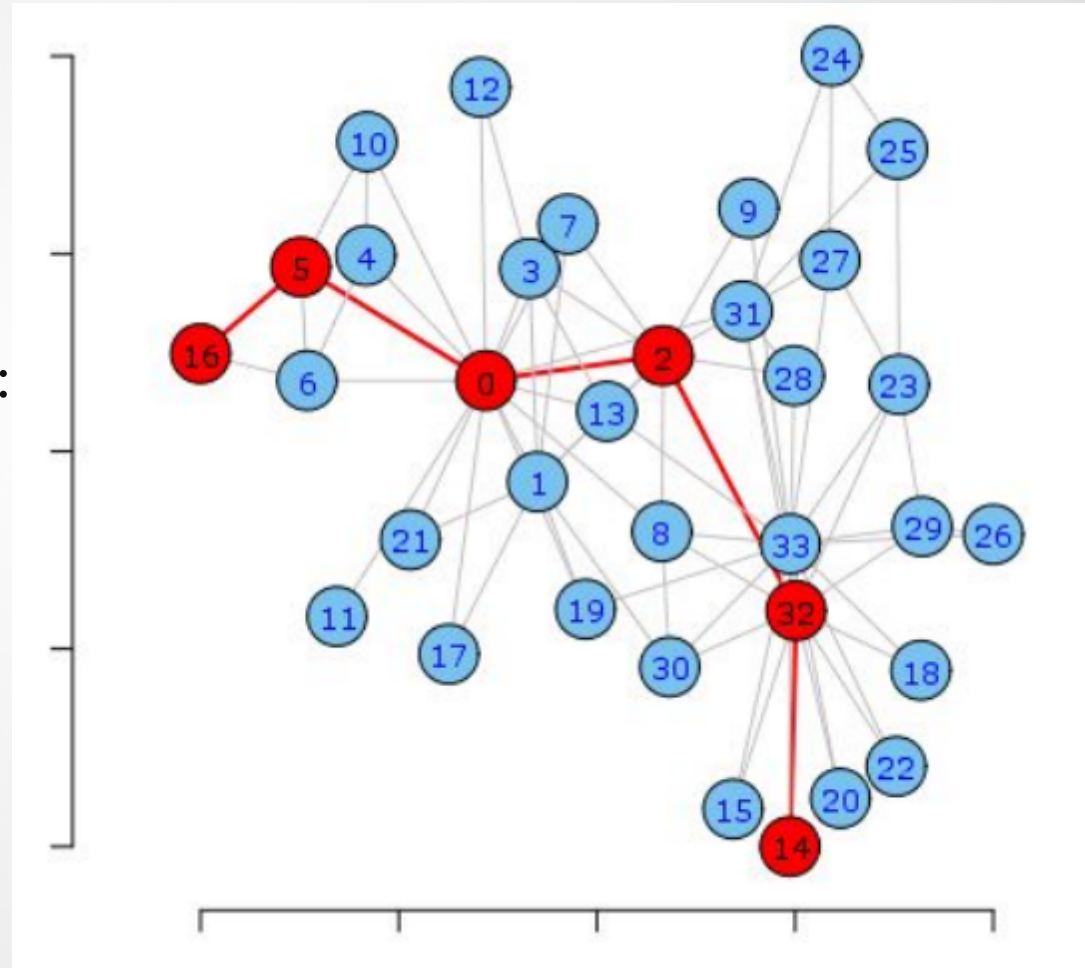
Network types: scale-free network (Barabási-Albert model)



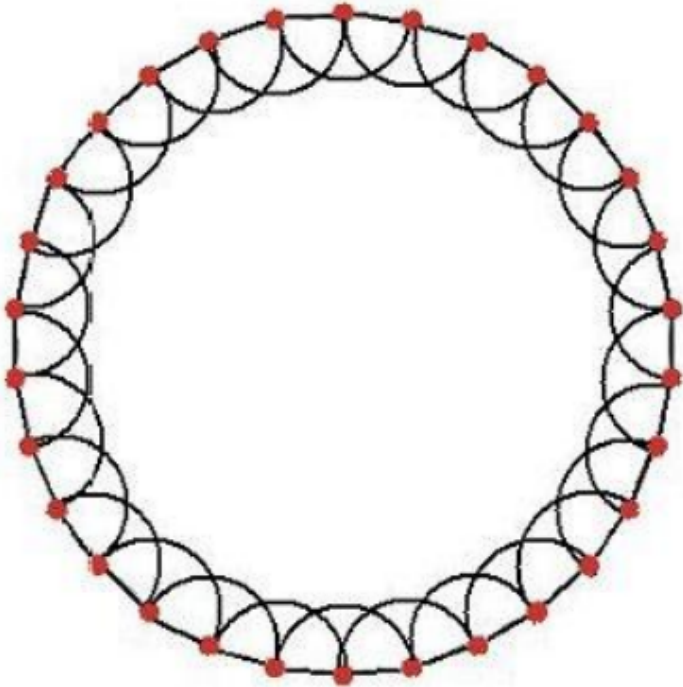
Diameter of the network

- **Definition:**

- The longest shortest-path :
- The longest of all the possible shortest-path among node pair in the network

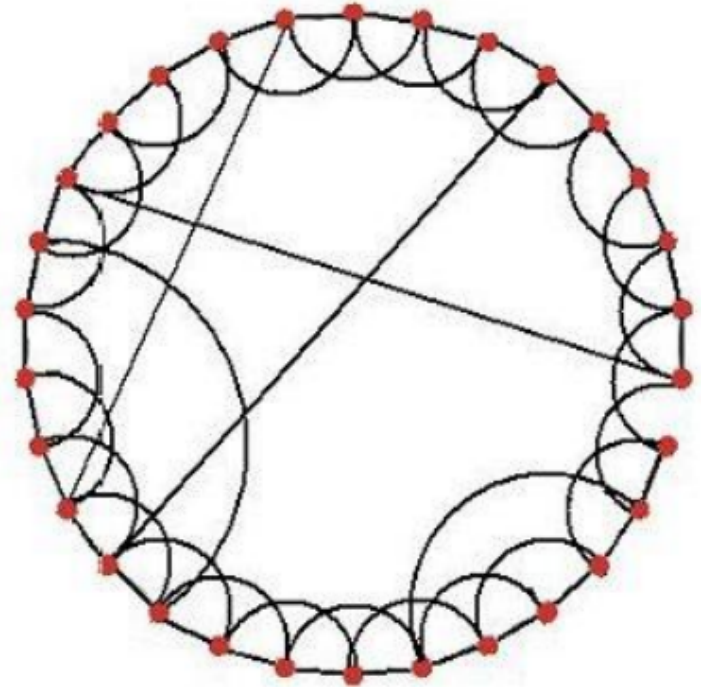


Network types: small world



Regular network

uniform degrees of distribution
big diameter

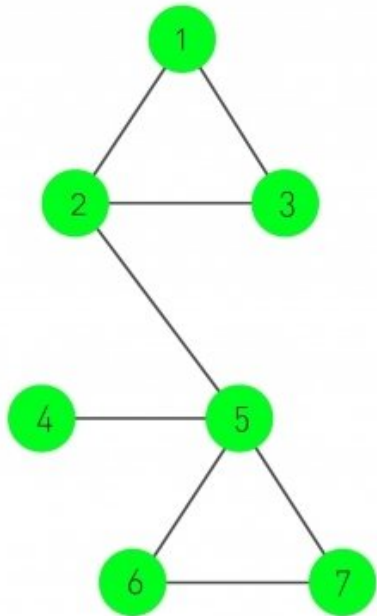


Small world network

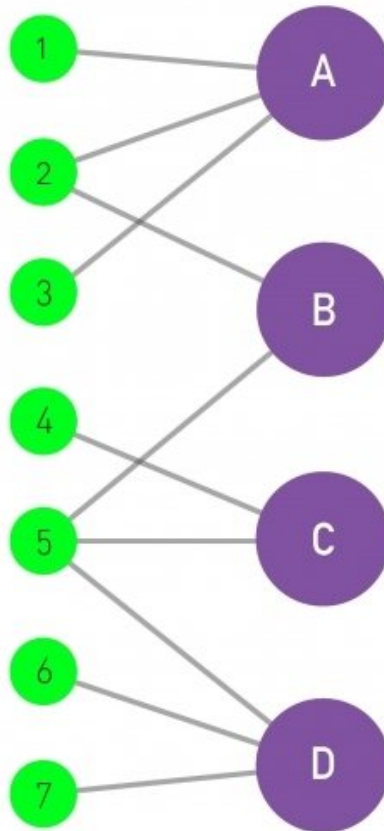
uniform degrees of distribution
small diameter

Network types: Bipartite

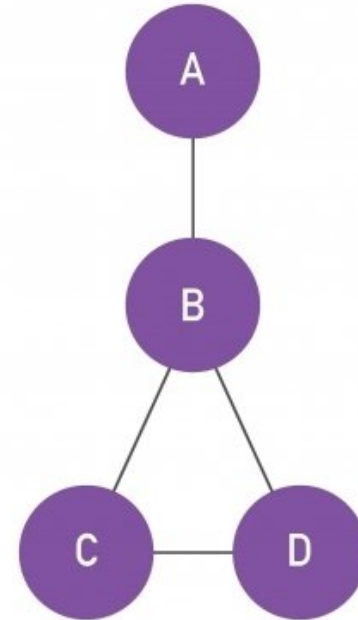
PROJECTION U U



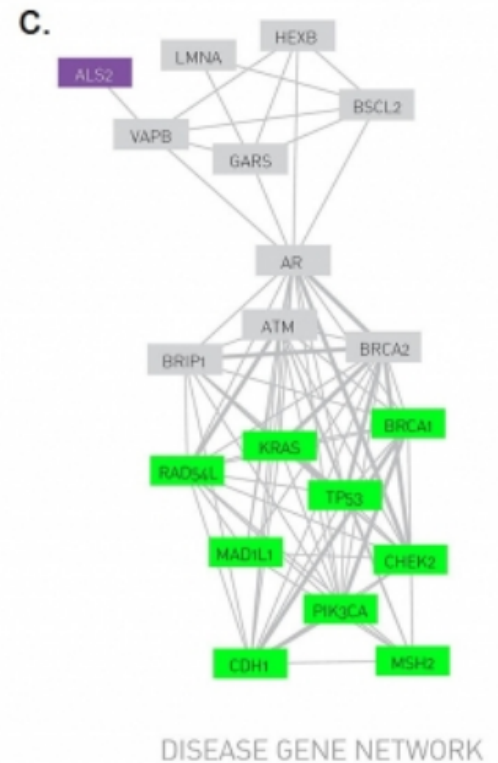
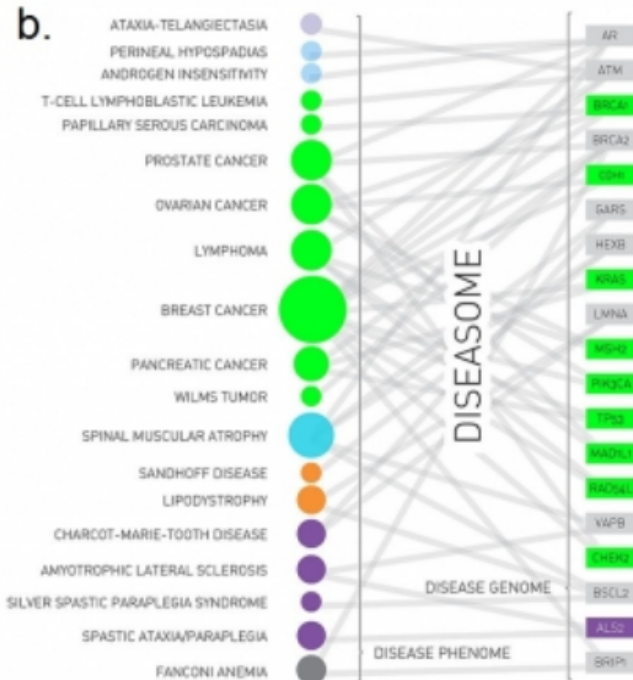
U V



PROJECTION V

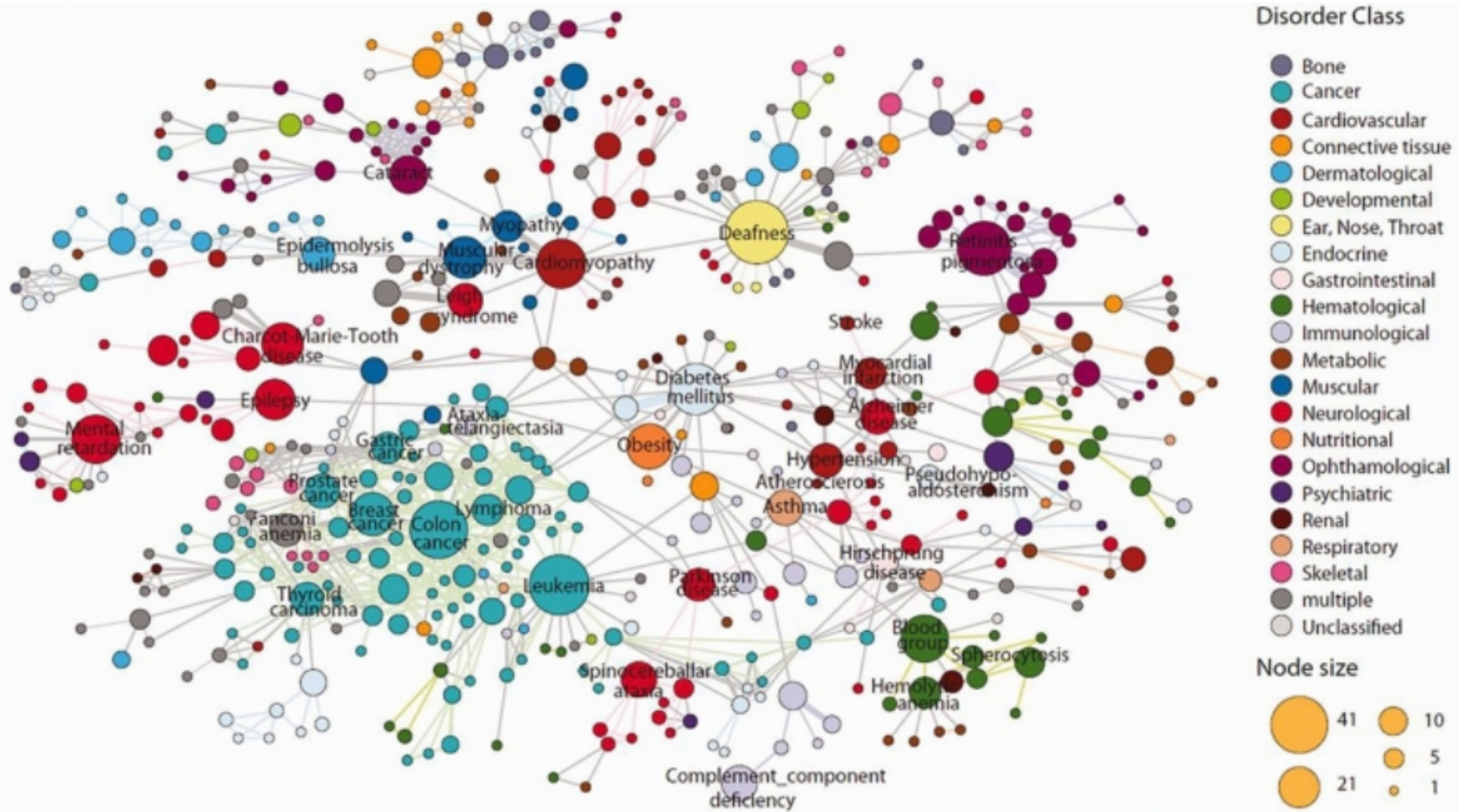


Network types: Bipartite



Network types: Bipartite

d.





Cytoscape

Session: New Session

Control Panel

Network Style Select

PSIMI 25 Style

Properties

Def. Map. Byp.

Color (Unselected)

Label

Label Color

Label Font Size

Line Type

Source Arrow Shape

Source Arrow Unselected Paint

Stroke Color (Unselected)

Target Arrow Shape

Target Arrow Unselected Paint

Tooltip

Transparency

Width

Edge color to arrows

Node Edge Network

Table Panel

Node Layout Tools

Scale Selected Only

1/8 1/4 1/2 1 2 4 8

Width Height Reset Scale

Align

Distribute

Stack

Rotate Selected Only

-180 -90 0 90 180

Table Panel

UniProt (2017/03/23 1:09:23 午後, PDT)

shared name	name	Taxonomy ID	Taxonomy Name	Human Readable Label	uniprotkb_accession	uniprot	psi-msi	intact	Interactor Type	Interactor Type ID	Xref	Xref ID
Q12250	Q12250	559292	yeast	RPNS	Q12250	[NA55, Proteas...	[RPNS, rpn5_...	[EBI-15935]	[protein]	[M:0326]	[proteaso...	[4CR2, 4CR3, ...
Q03981	Q03981	559292	yeast	C5N9	Q03981	[D0V5G1, CSN...	[CSN9, csn9_...	[EBI-33535]	[protein]	[M:0326]	[COP9 sign...	[GO:0008180...
Q04368	Q04368	559292	yeast	CS11	Q04368	[Q04368, CS11...	[CS11, cs11_ye...	[EBI-28044]	[protein]	[M:0326]	[cytoplasm...	[S000004627...
P62195	P62195	9606	human	PSMC5	P62195	[AKK763, P42...	[PSMC5, prs8...	[EBI-357245]	[protein]	[M:0326]	[Wnt signal...	[GO:0060071...
Q39460	Q39460	9606	human	PSMD1	Q39460	[Q24800, QEP...	[psmd1, huma...	[EBI-357874]	[protein]	[M:0326]	[Wnt signal...	[GO:0060071...
P33299	P33299	559292	yeast	RPT1	P33299	[CIMS, Tat-bi...	[rpt1, yeast...	[EBI-13910]	[protein]	[M:0326]	[ATPase ac...	[IPR027417, 4...
Q9Y5K5	Q9Y5K5	9606	human	UCHL5	Q9Y5K5	[Q8TB54, Ubiqu...	[uchl5, huma...	[EBI-1051183]	[protein]	[M:0326]	[lateral ven...	[ENSG000003...
Q13200	Q13200	9606	human	PSMD2	Q13200	[E9PC53, TRAP...	[PSMD2, psm...	[EBI-357648]	[protein]	[M:0326]	[membrane...	[ENSG000001...
O00231	O00231	9606	human	PSMD11	O00231	[Q53Y75, PSM...	[psd11, huma...	[EBI-357816]	[protein]	[M:0326]	[Wnt signal...	[GO:0060071...
Q9JUN6	Q9JUN6	9606	human	PSMD13	Q9JUN6	[S65, proteaso...	[PSMD13, psd...	[EBI-105847...	[protein]	[M:0326]	[Inosin 1...	[GO:007127...
Q9P255	Q9P255	9606	human	WRAP73	Q9P255	[WD repeat-co...	[wrap73, huma...	[EBI-1054904]	[protein]	[M:0326]	[Centriole...	[ENSG000002...
PSK1044	PSK1044	10088	muscle	Bruc42	PSK1044	[T9C6, proteaso...	[bruc42, musc...	[EBI-0910041]	[protein]	[M:0326]	[Proteasom...	[IPR_091532A...

Node Table Edge Table Network Table

Memory

Recommended literature

- Péter Csermely: The strength of hidden networks
- Albert-László Barabási: Linked
- Albert-László Barabási: Network science

