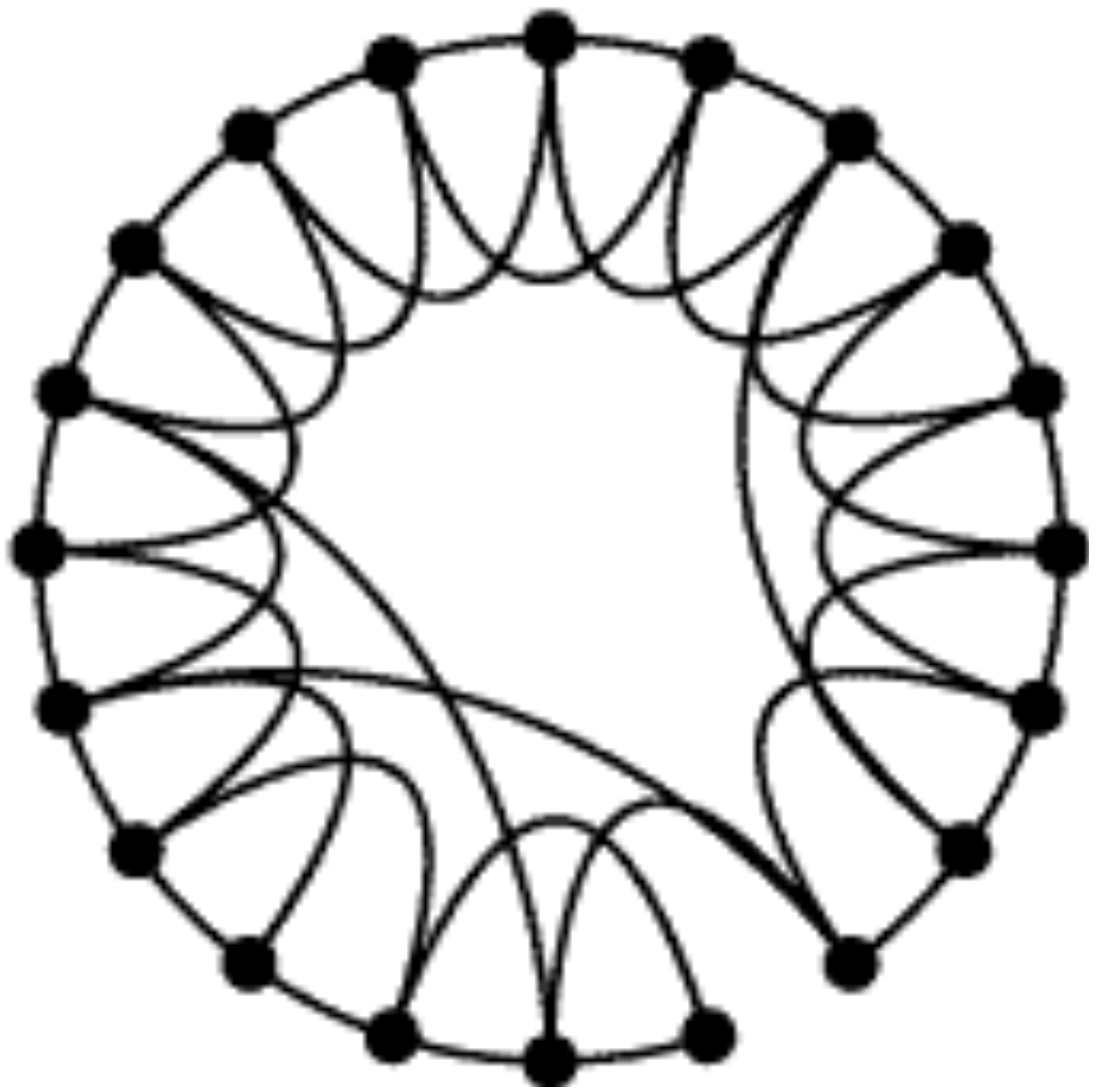
Class 24: Network models

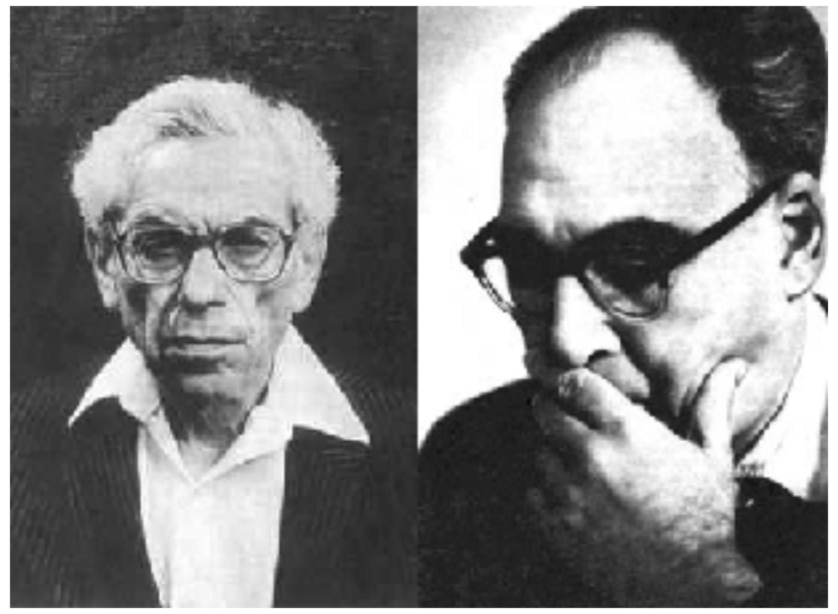
Instructor: Michael Szell

Nov 22, 2019

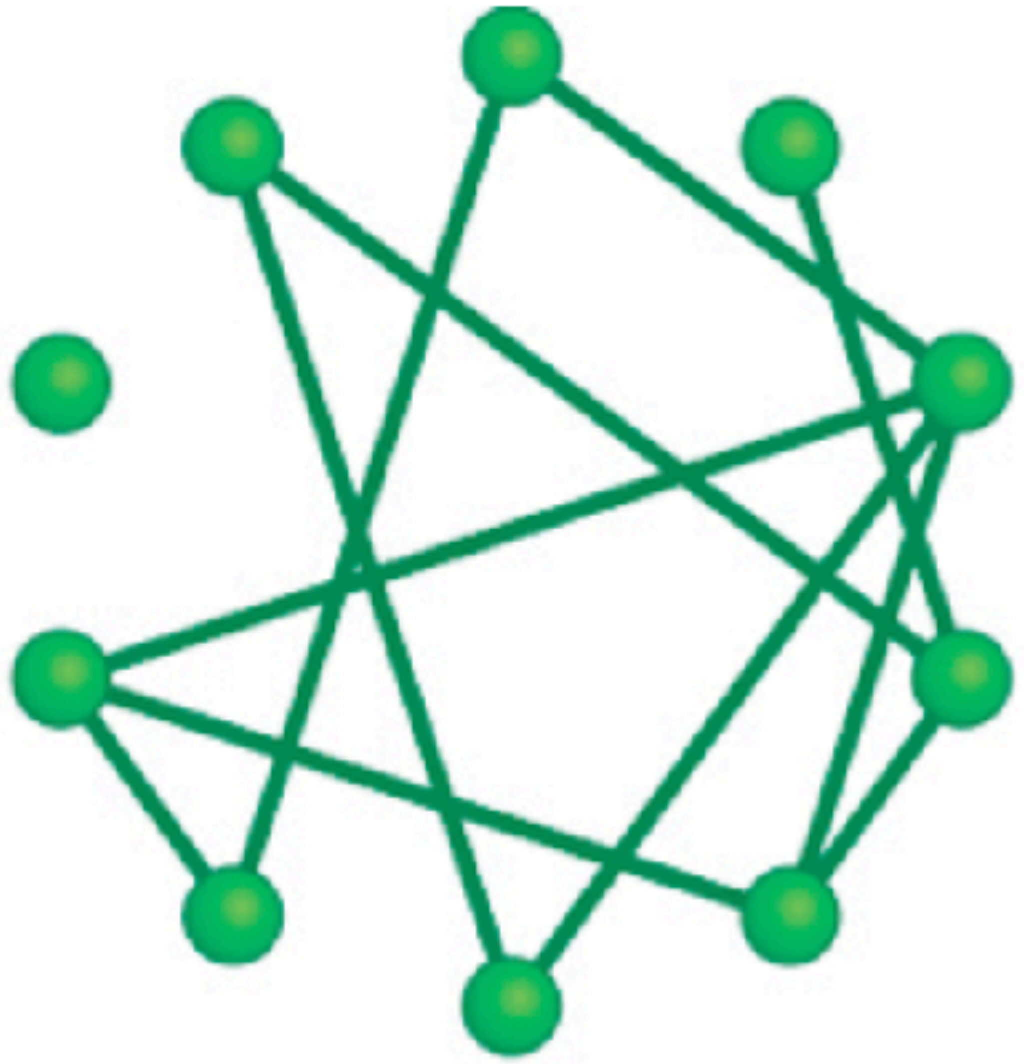


IT UNIVERSITY OF COPENHAGEN

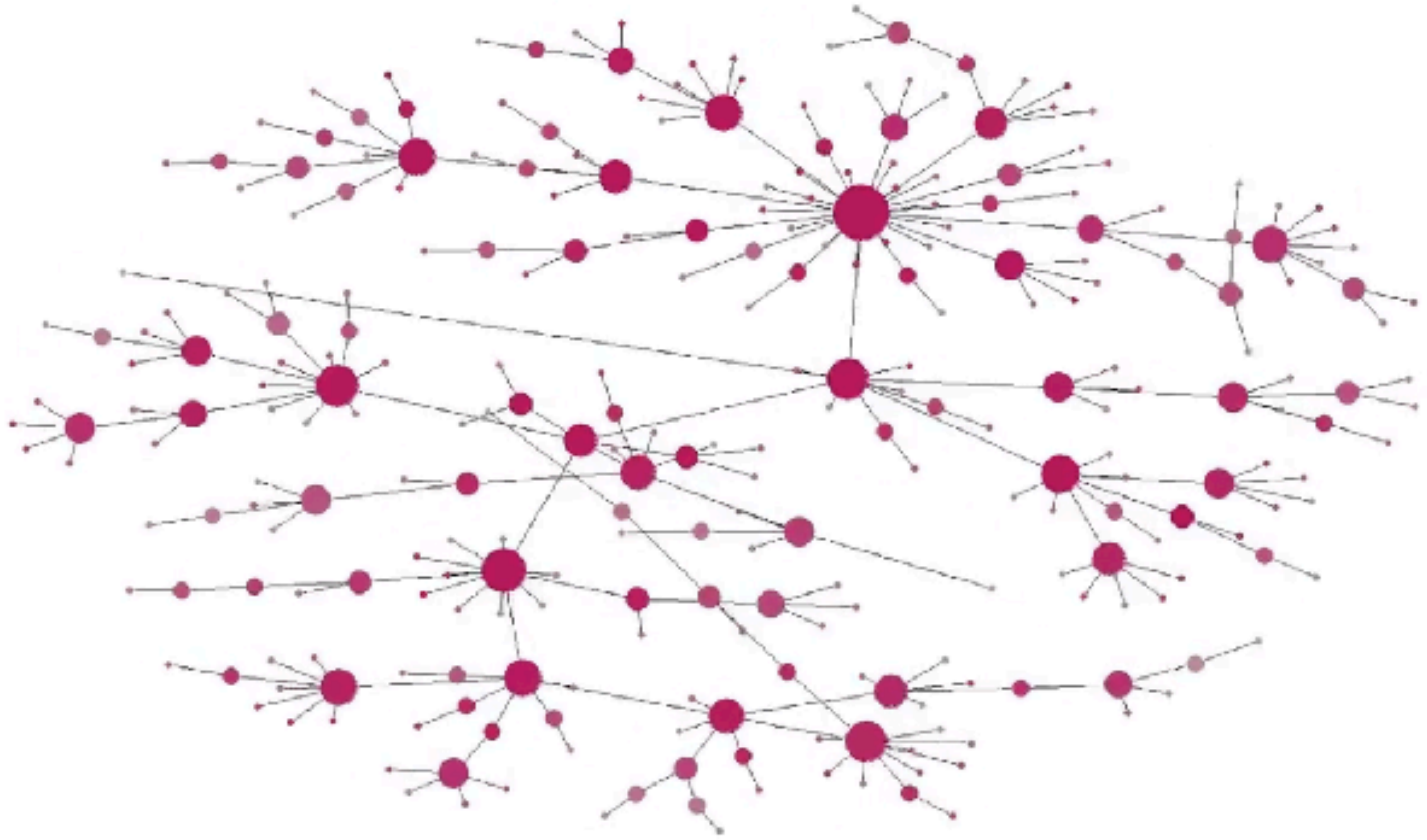
Today you will learn about generating synthetic networks



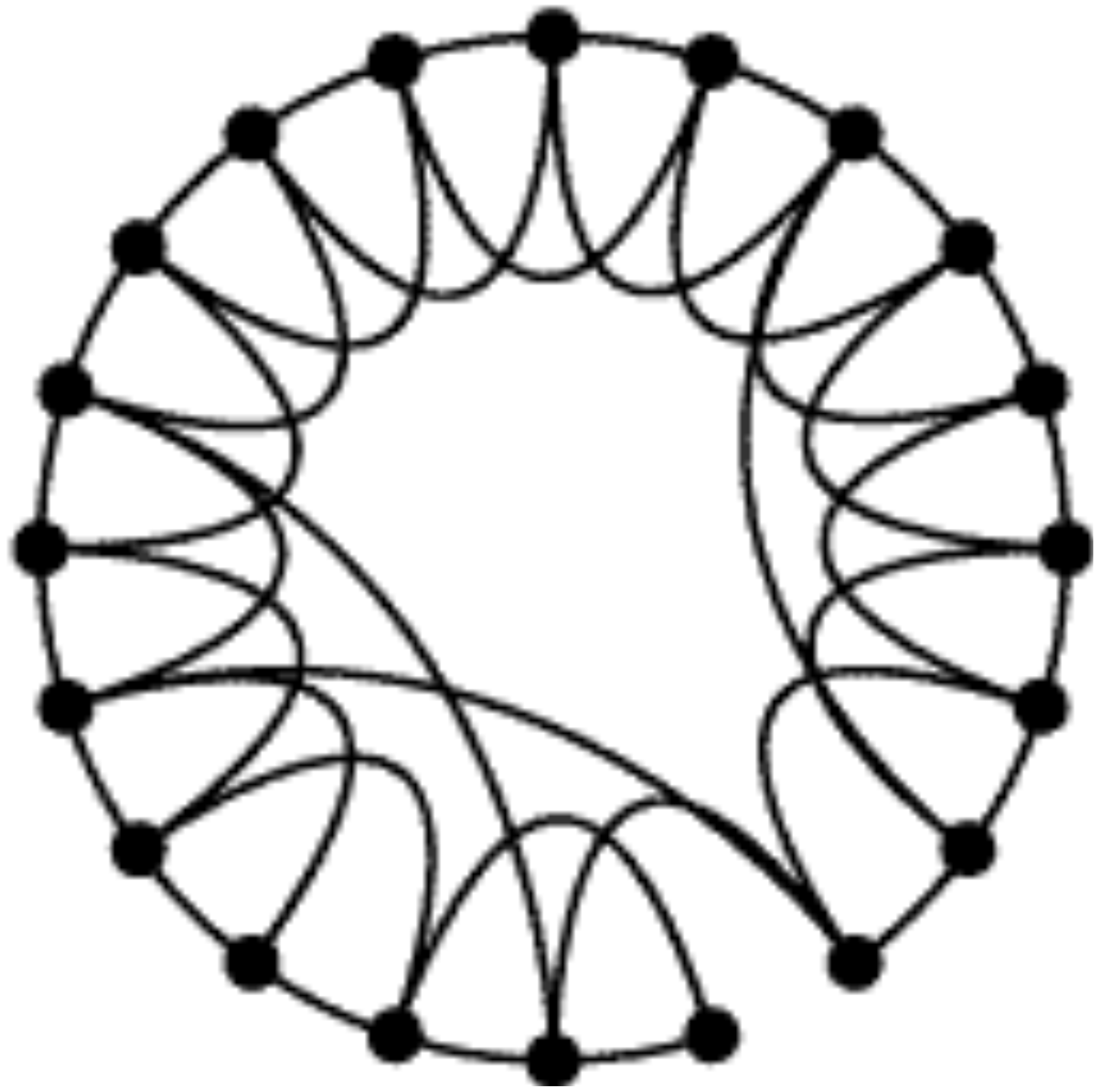
Erdős-Rényi
networks



Barabási-Albert
networks



Watts-Strogatz
networks



What is the simplest possible network model?

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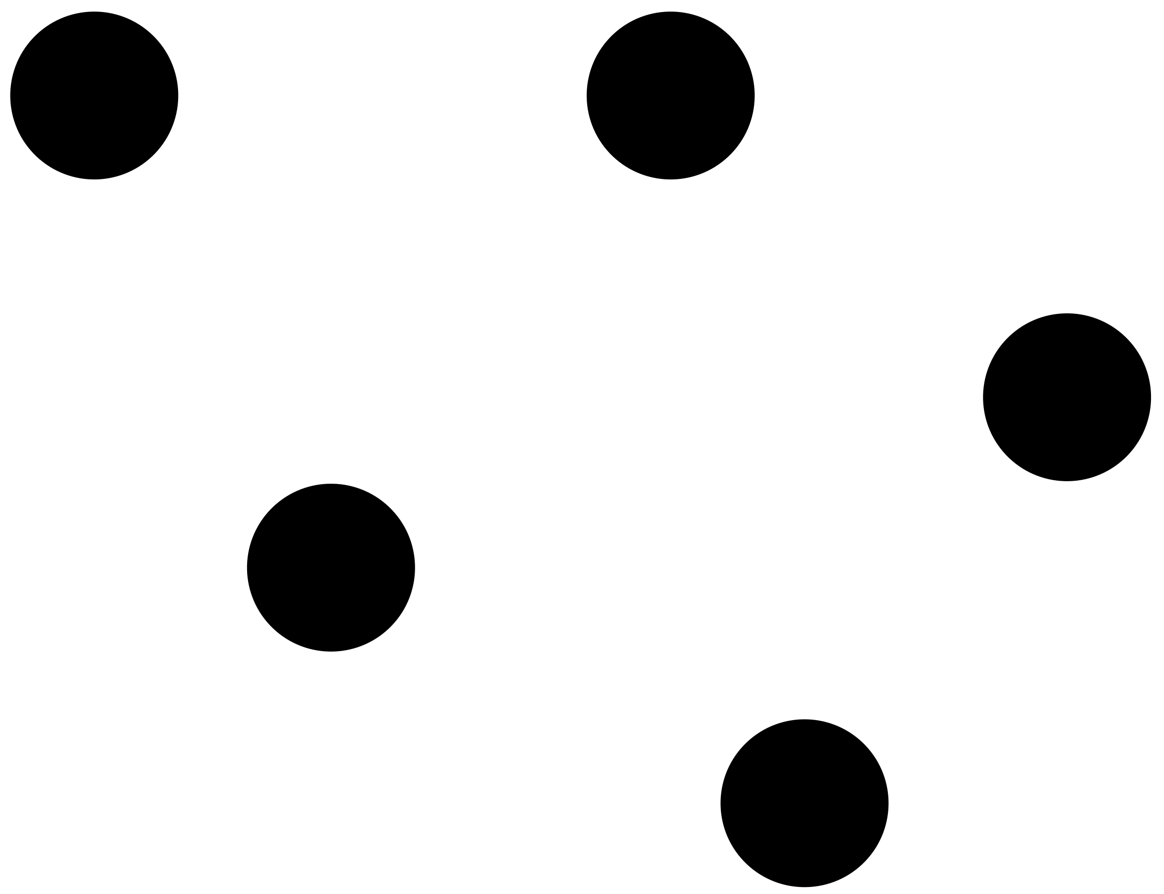
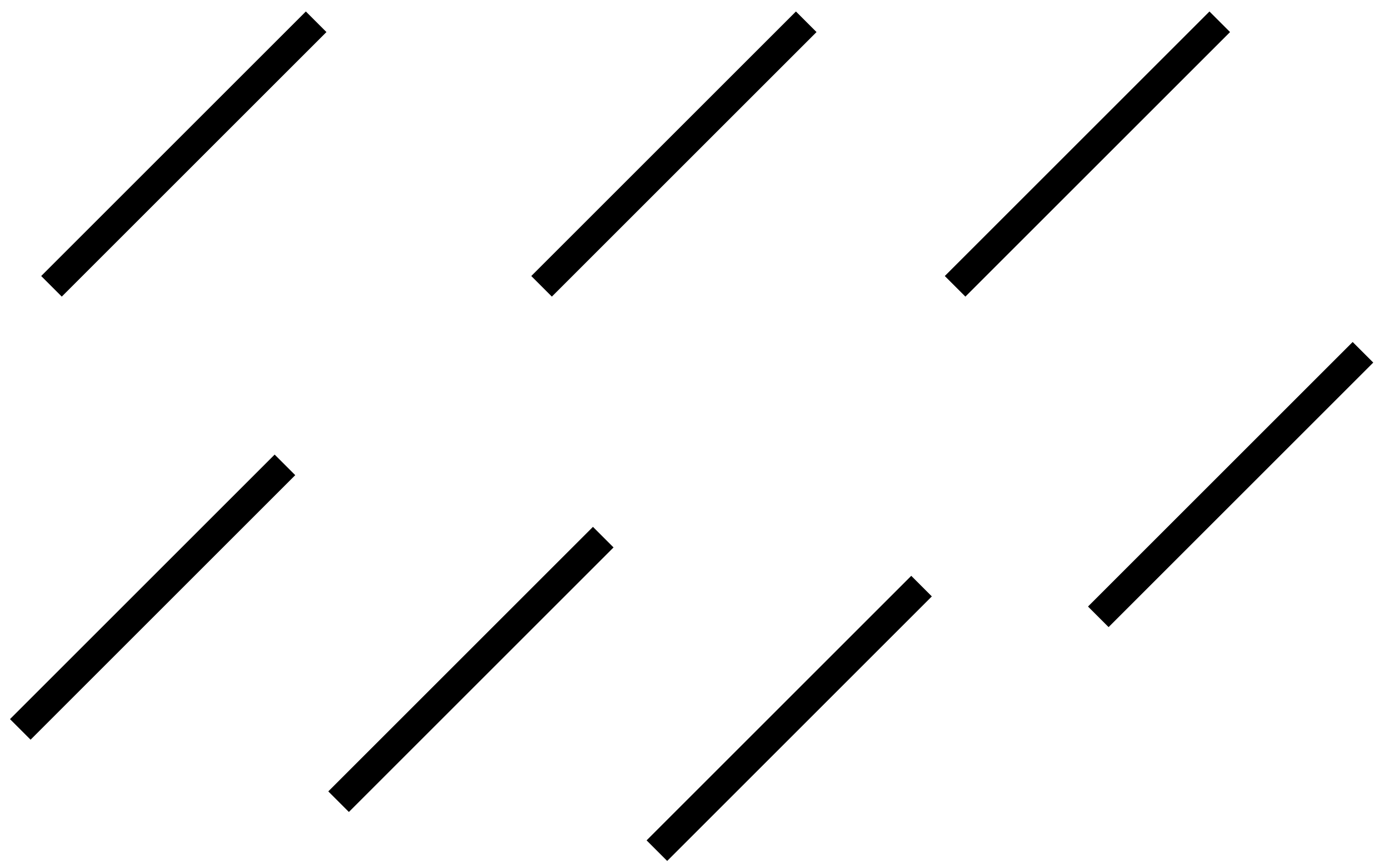
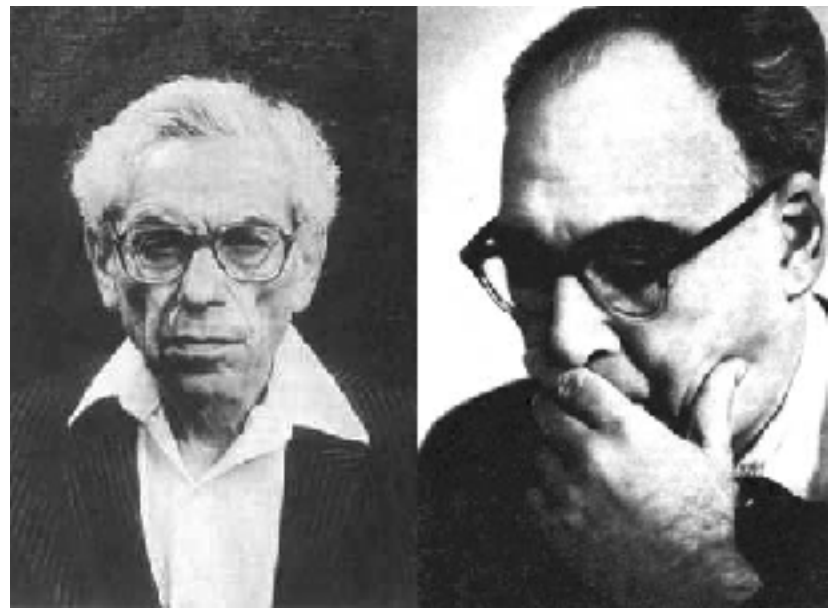
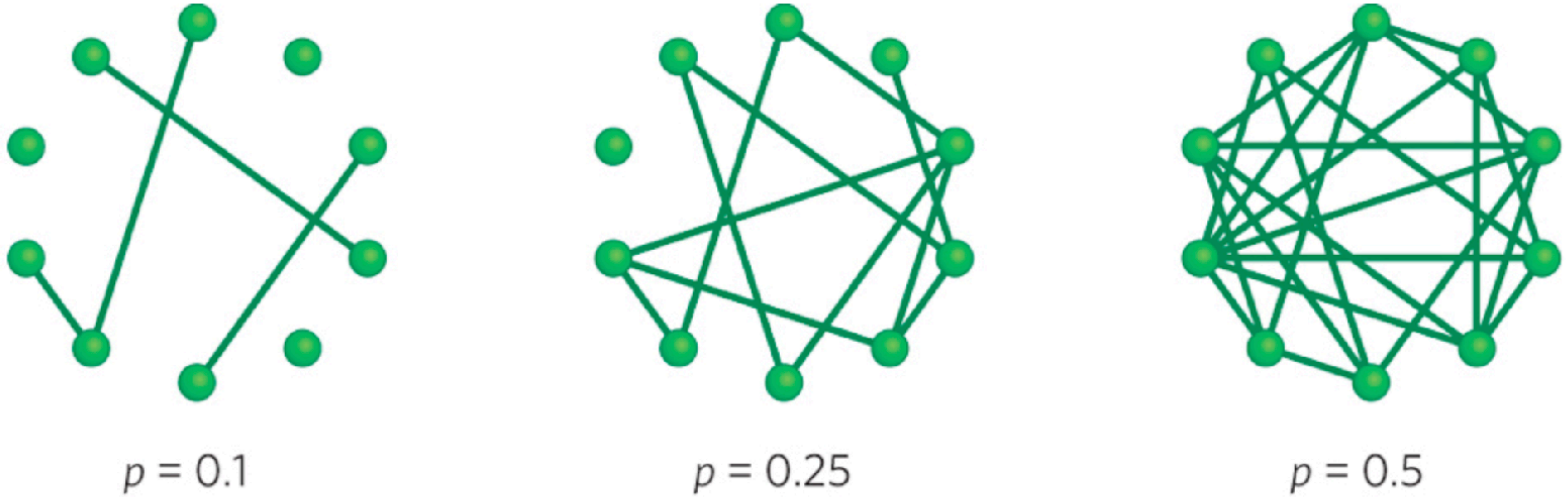




The Erdős-Rényi (ER) model creates a random graph

Take N nodes, connect each pair of nodes with probability p





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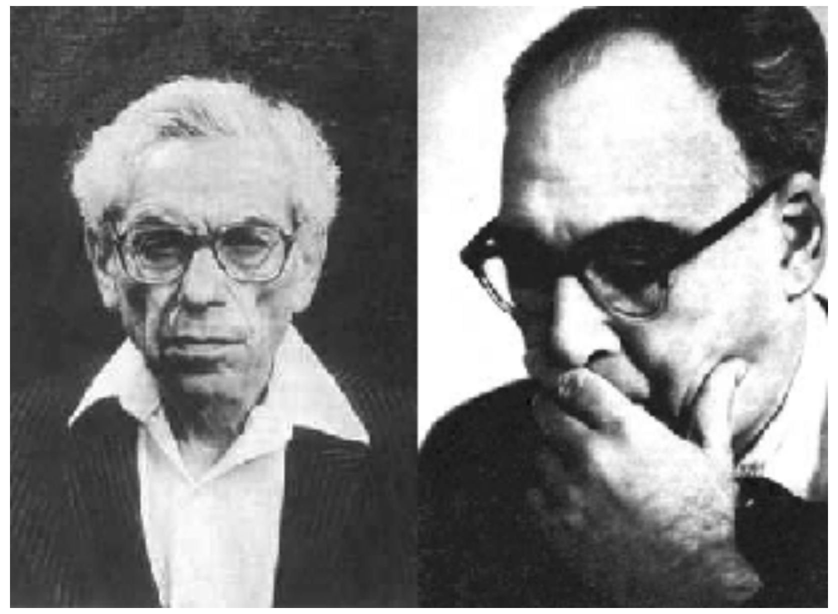

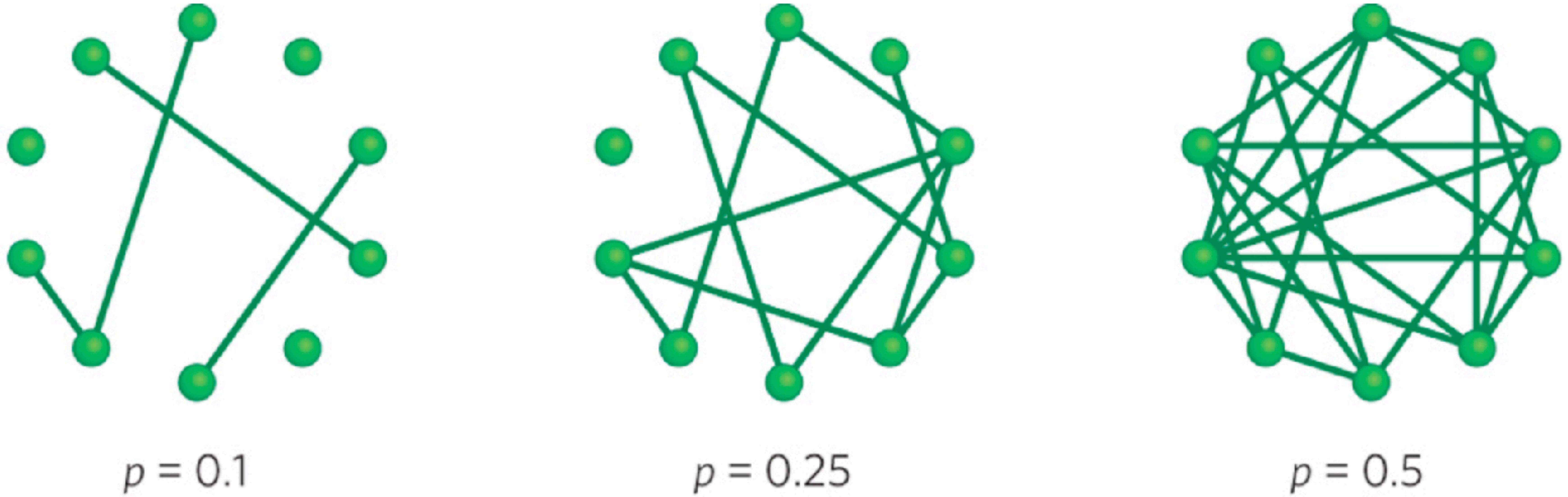

What is the degree distribution?

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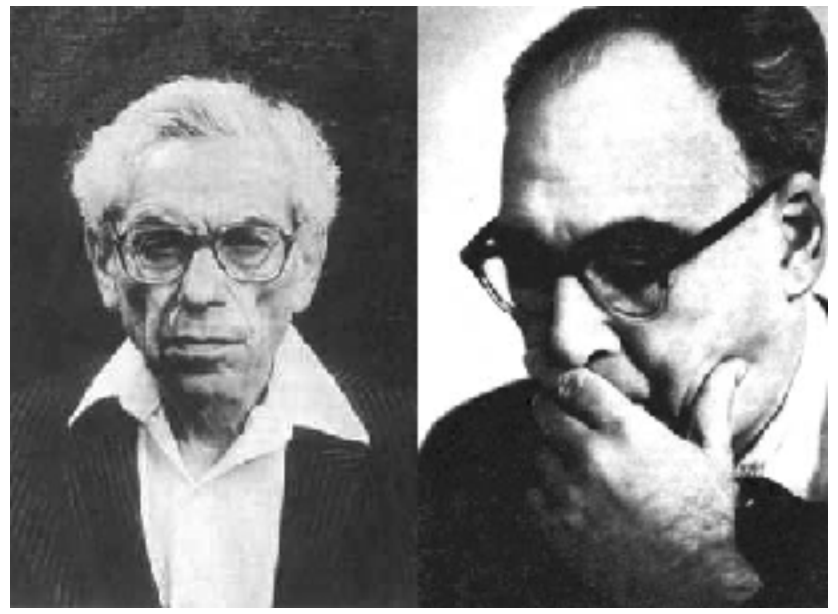

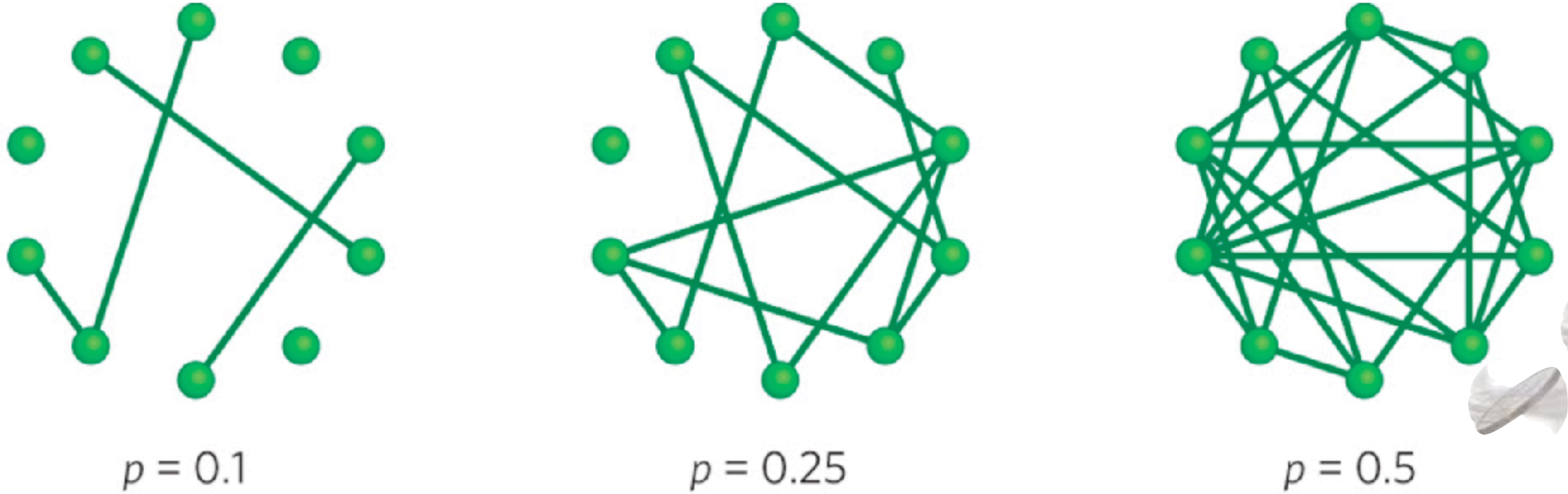

What is the degree distribution?

A single coin toss is modeled by a Bernoulli random variable

Consider a biased coin, probability for head is p.

$$X = \begin{cases} 1 & \text{if a head,} \\ 0 & \text{if a tail.} \end{cases}$$

$p(x)$?

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$$X = \begin{cases} 1 & \text{if a head,} \\ 0 & \text{if a tail.} \end{cases}$$

$$p(x) = \begin{cases} p & \text{if } x = 1, \\ 1 - p & \text{if } x = 0. \end{cases}$$

Bernoulli distribution

Multiple tosses are modeled by a Binomial random variable

Consider a biased coin, probability for head is p.

The coin is tossed n times.

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The probability to toss k heads is:

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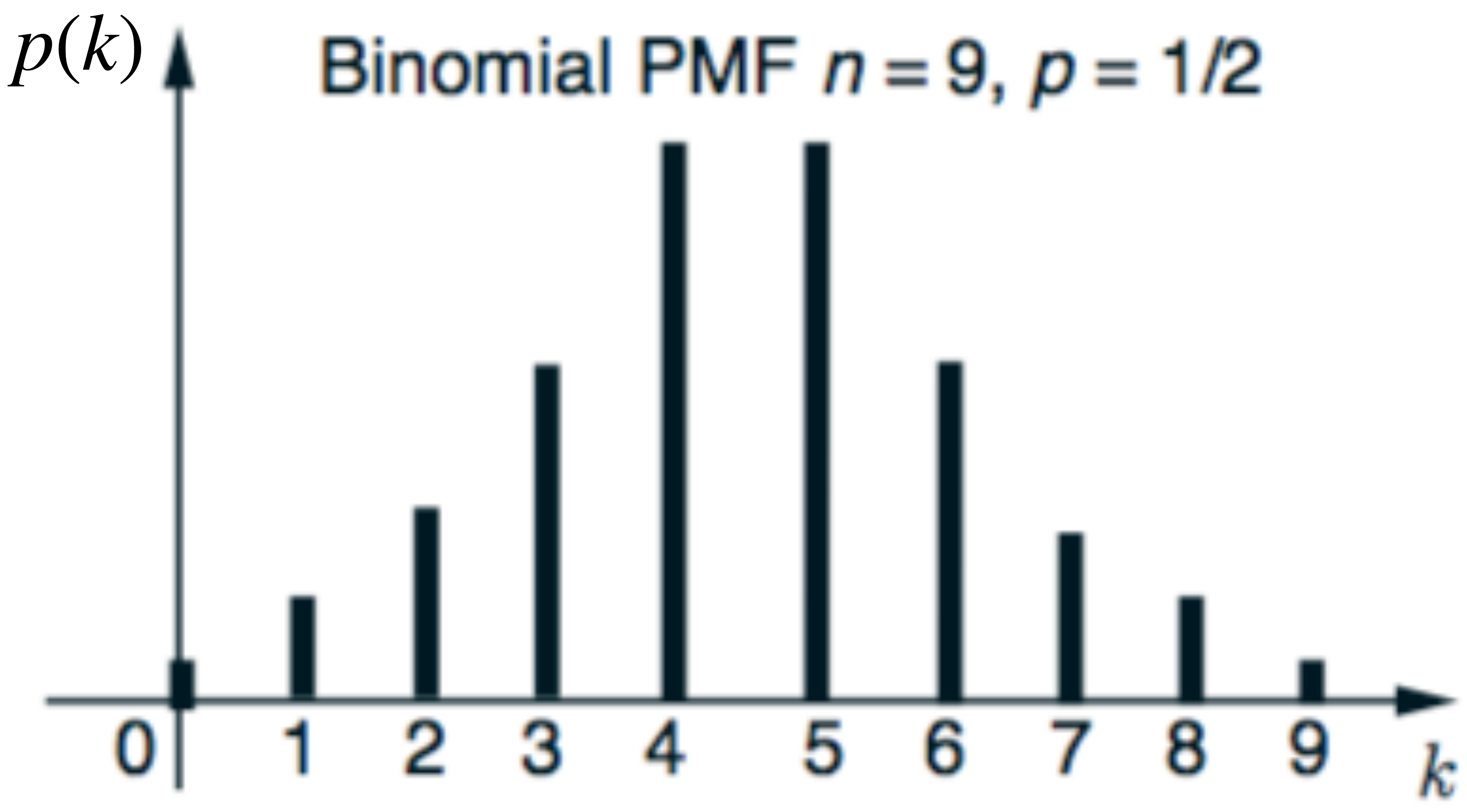
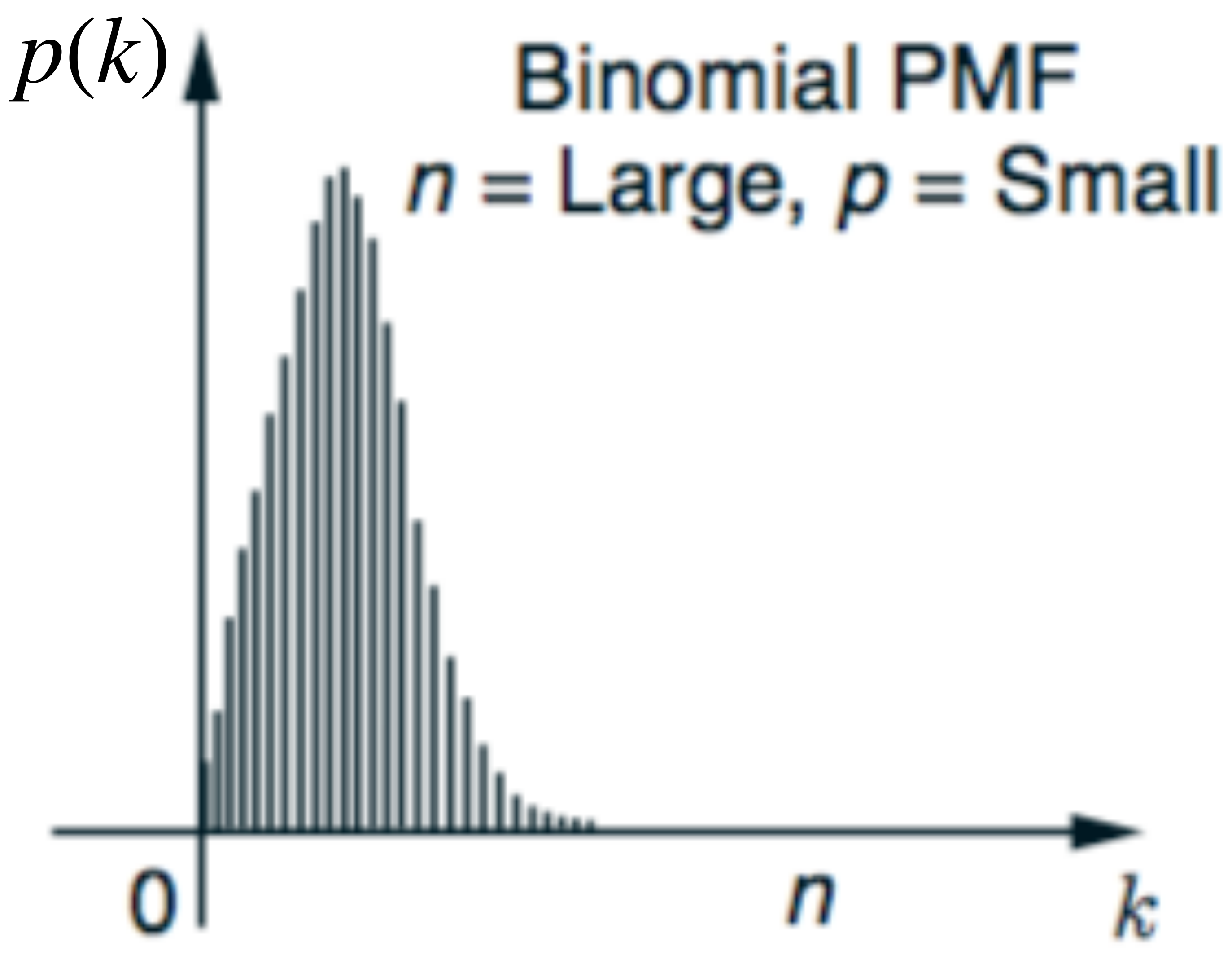
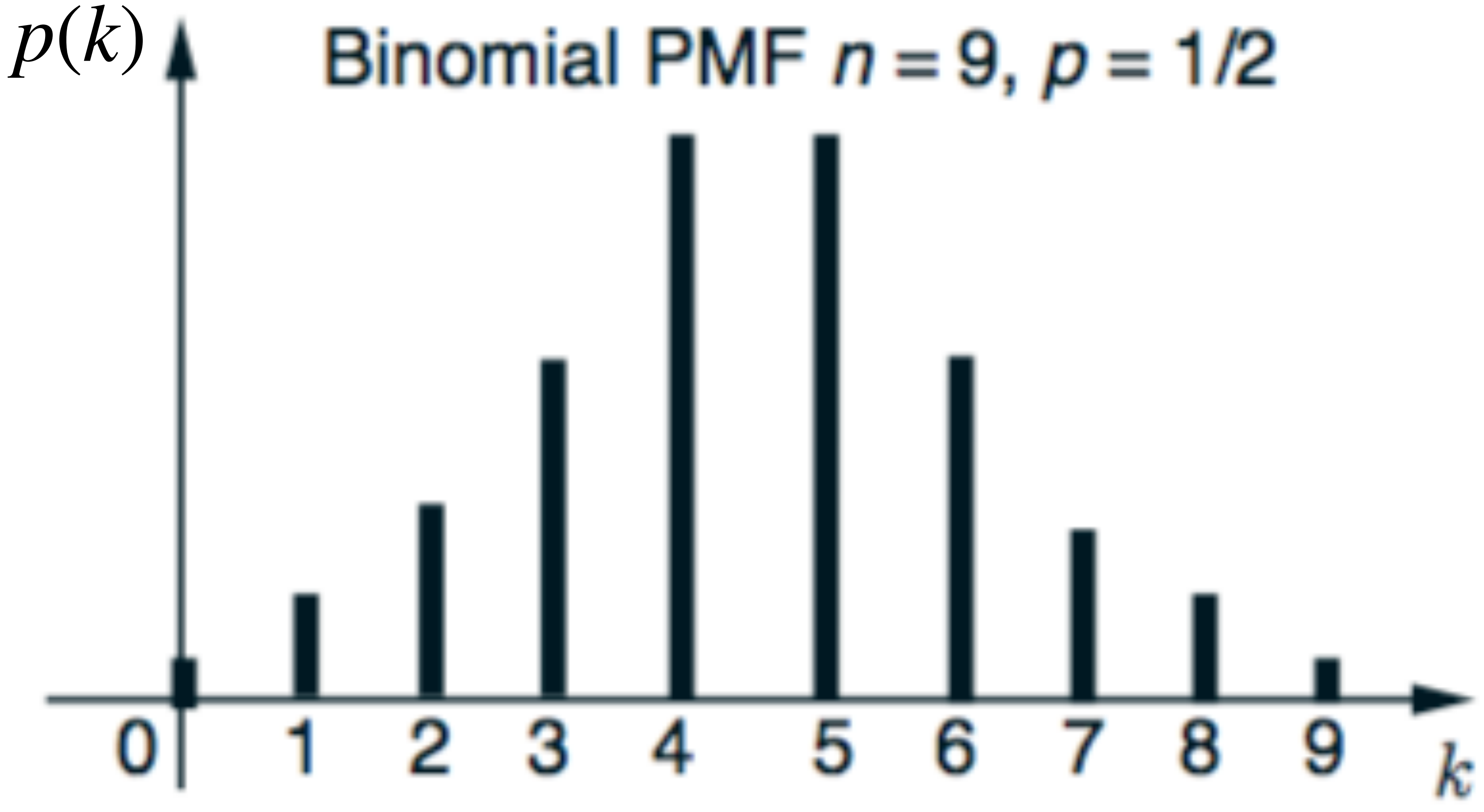
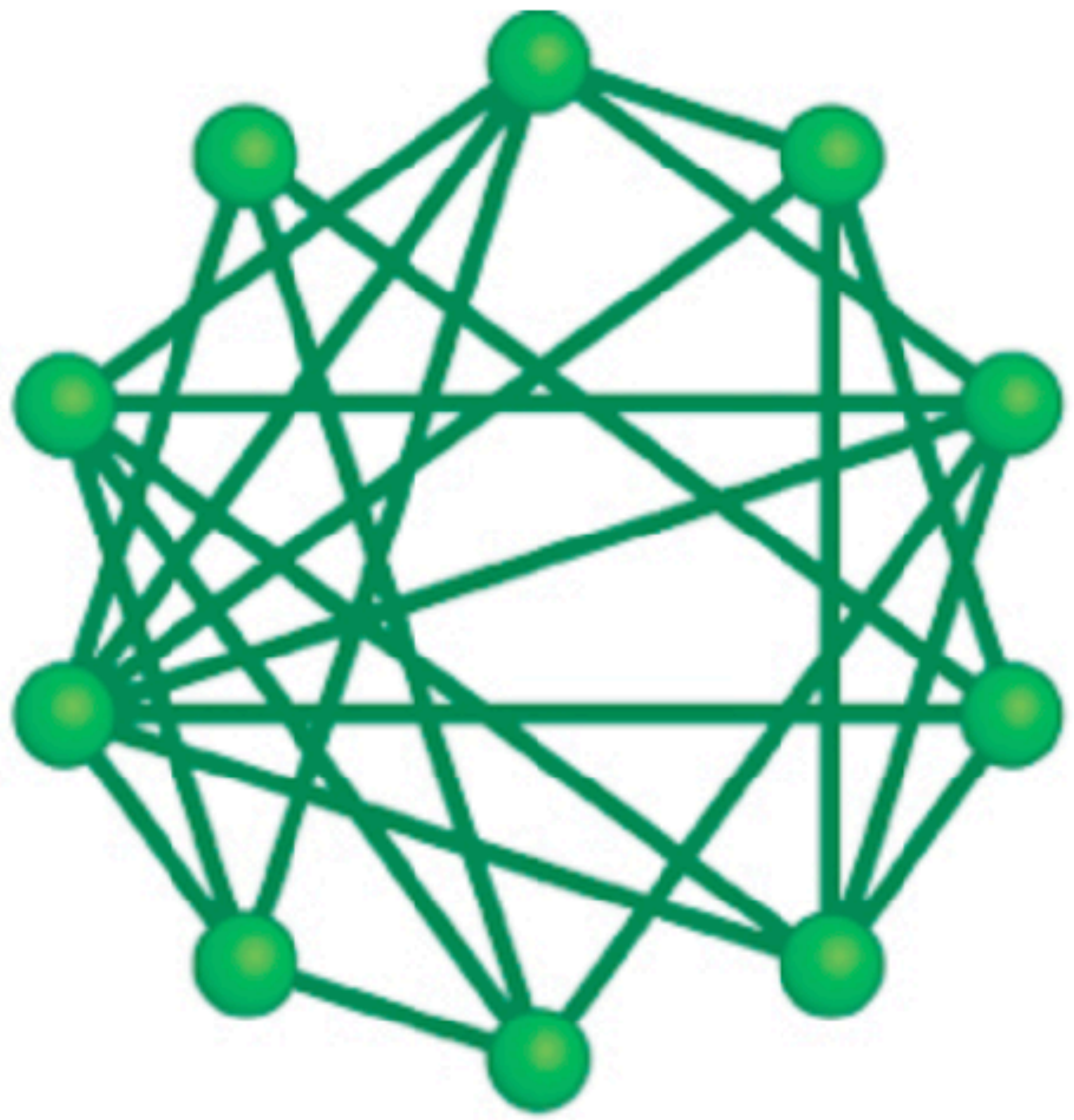




The ER network has a binomial degree distribution

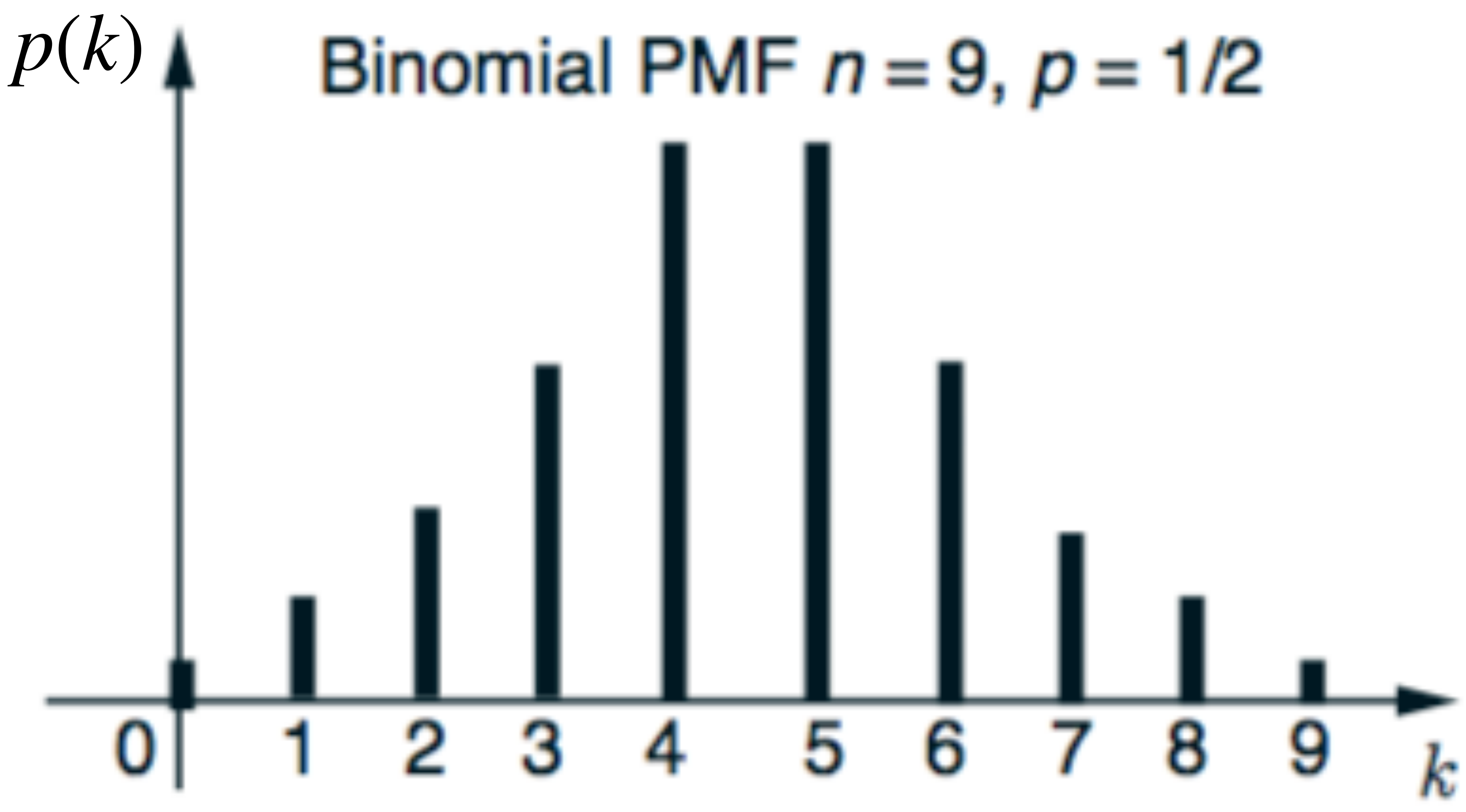


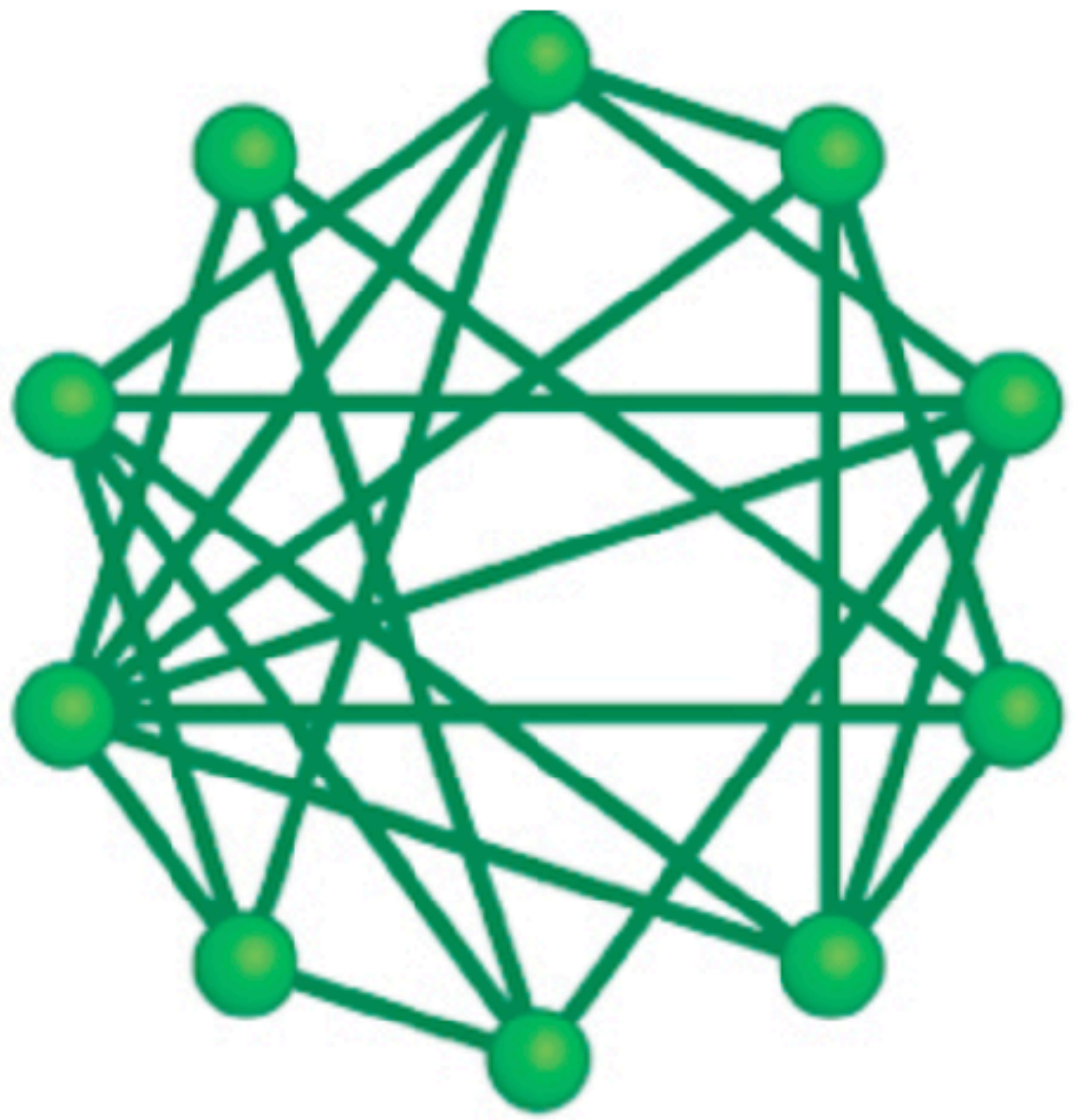


$p = 0.5$

The ER network has a binomial degree distribution

Is this network from Mediocristan or Extremistan?





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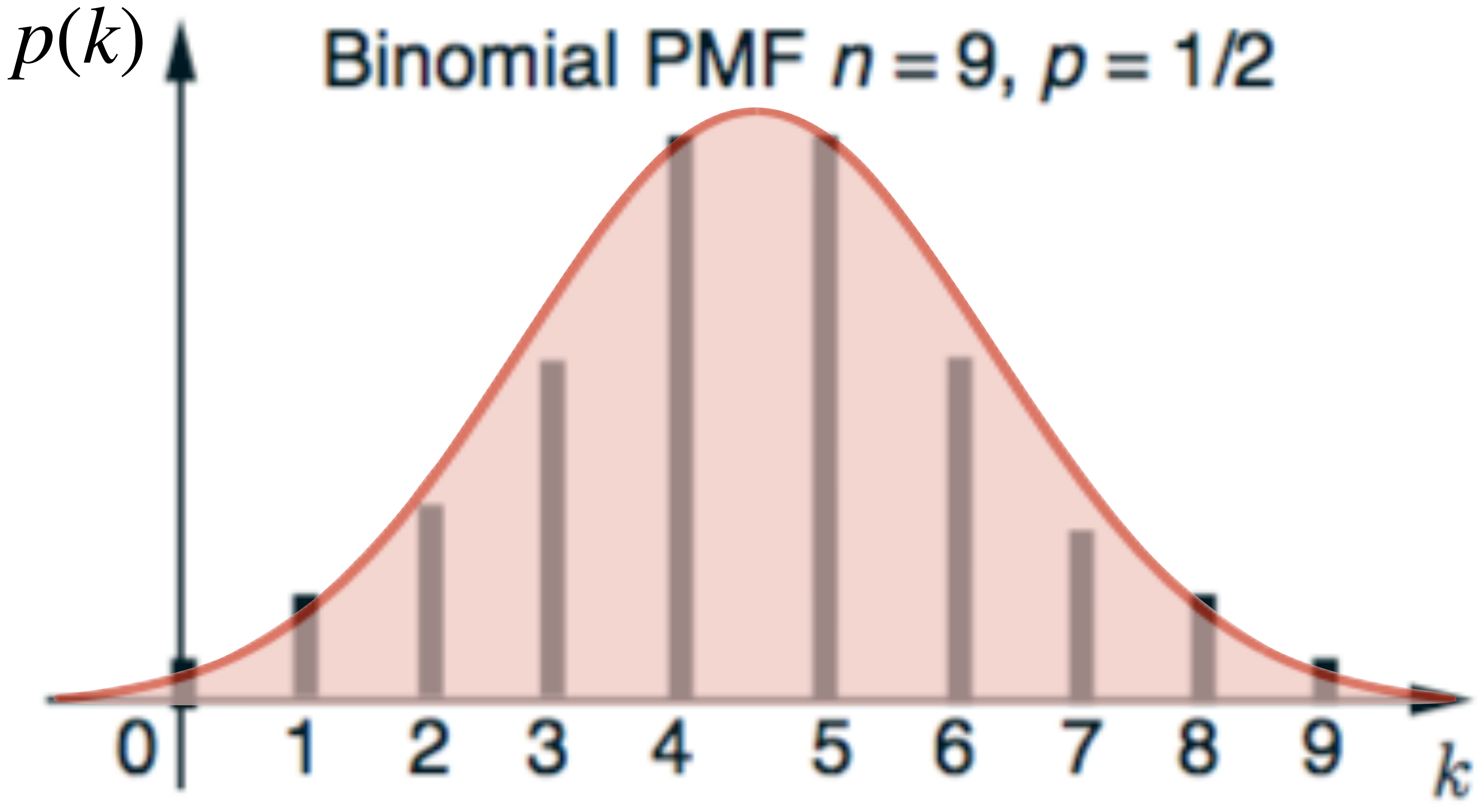
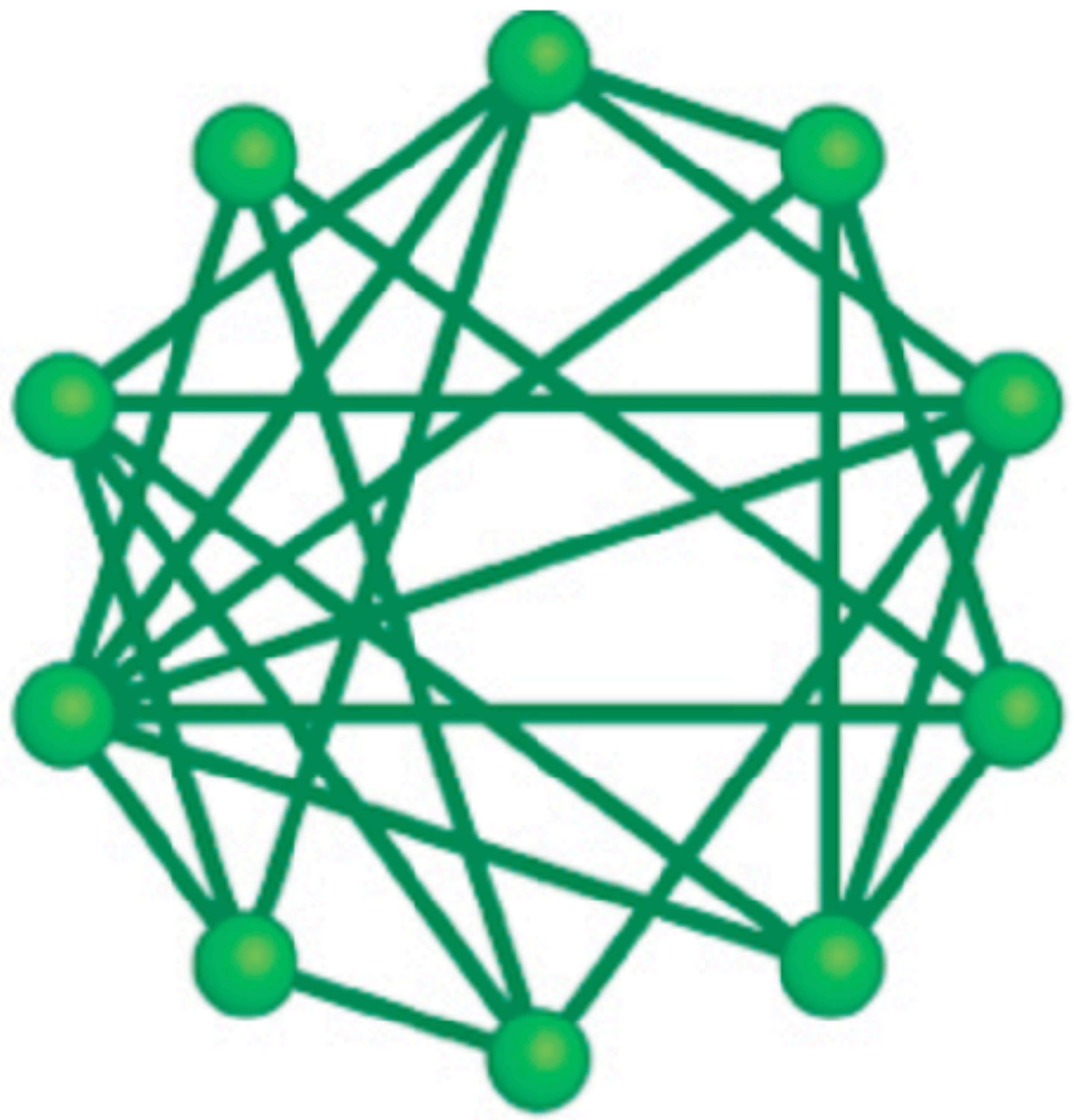
The normal distribution is an approximation to a binomial

ER networks are from Mediocristan.





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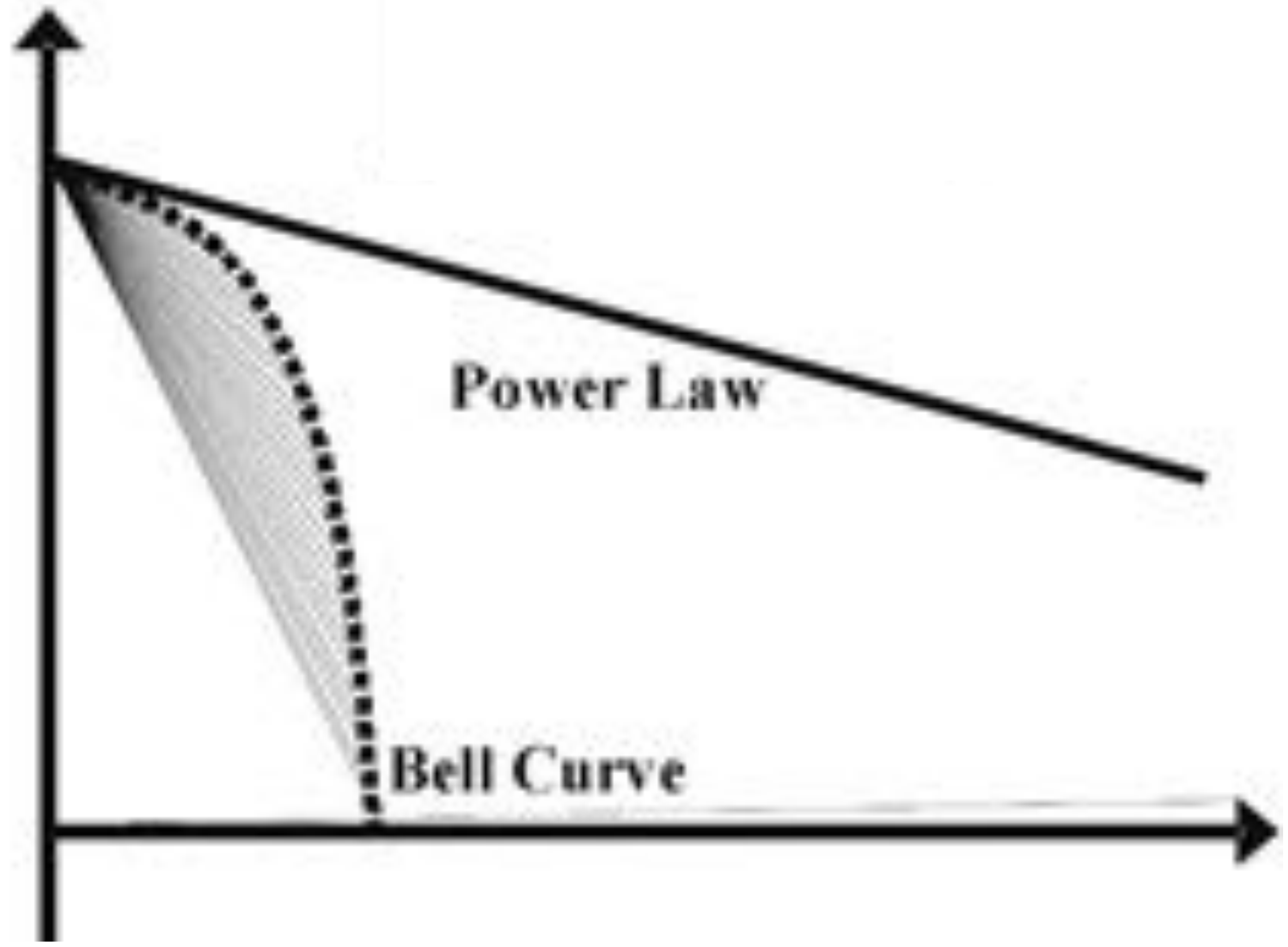
20th century statistics

21th century statistics add:



Mediocristan

Extremistan

20th century statistics

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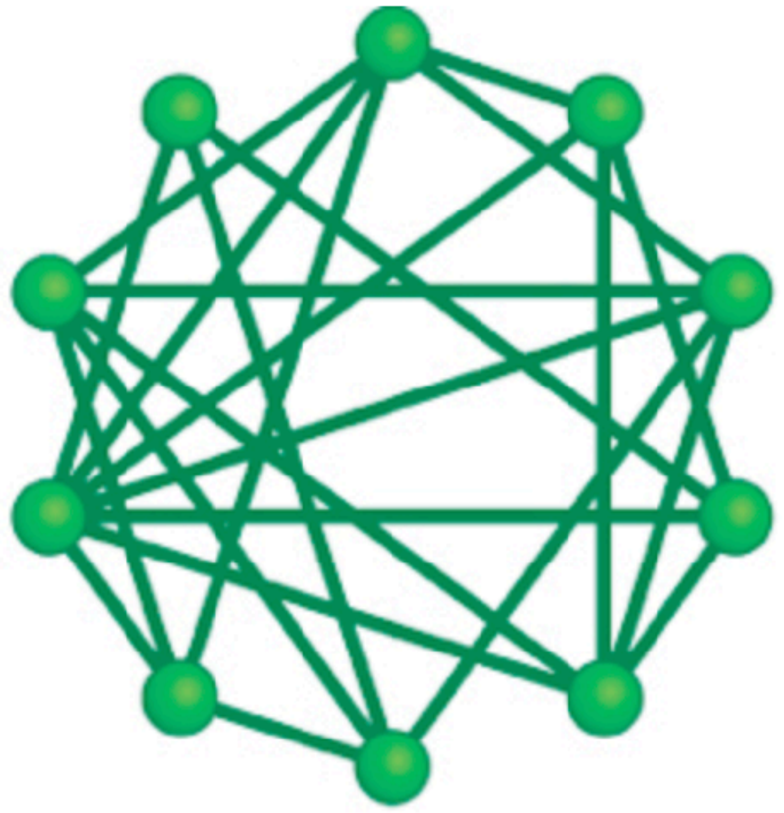

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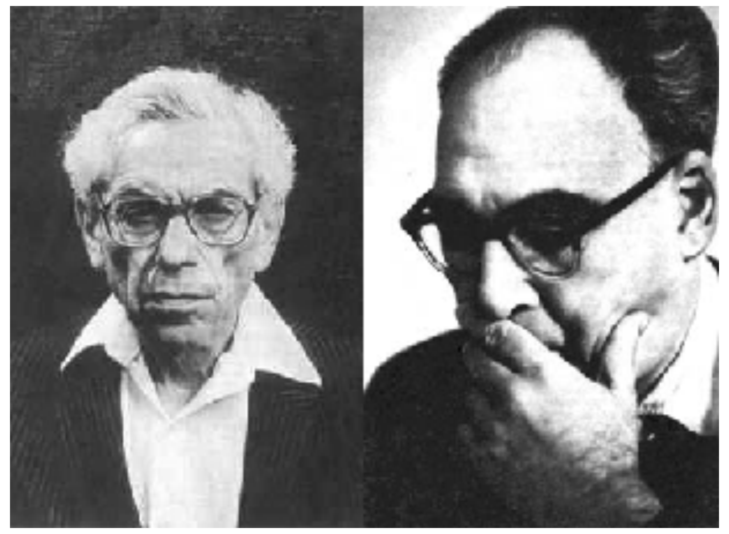
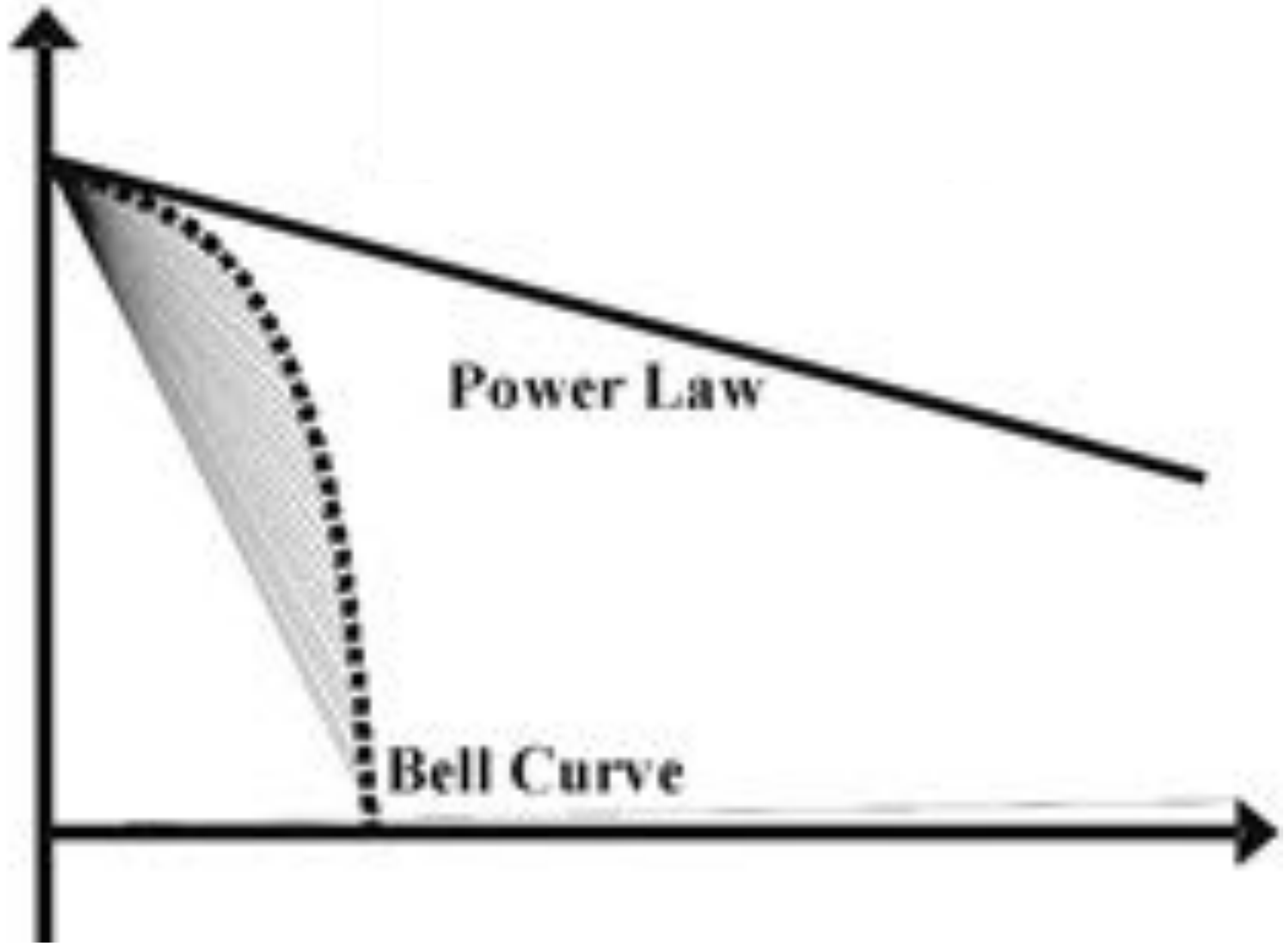


Mediocristan

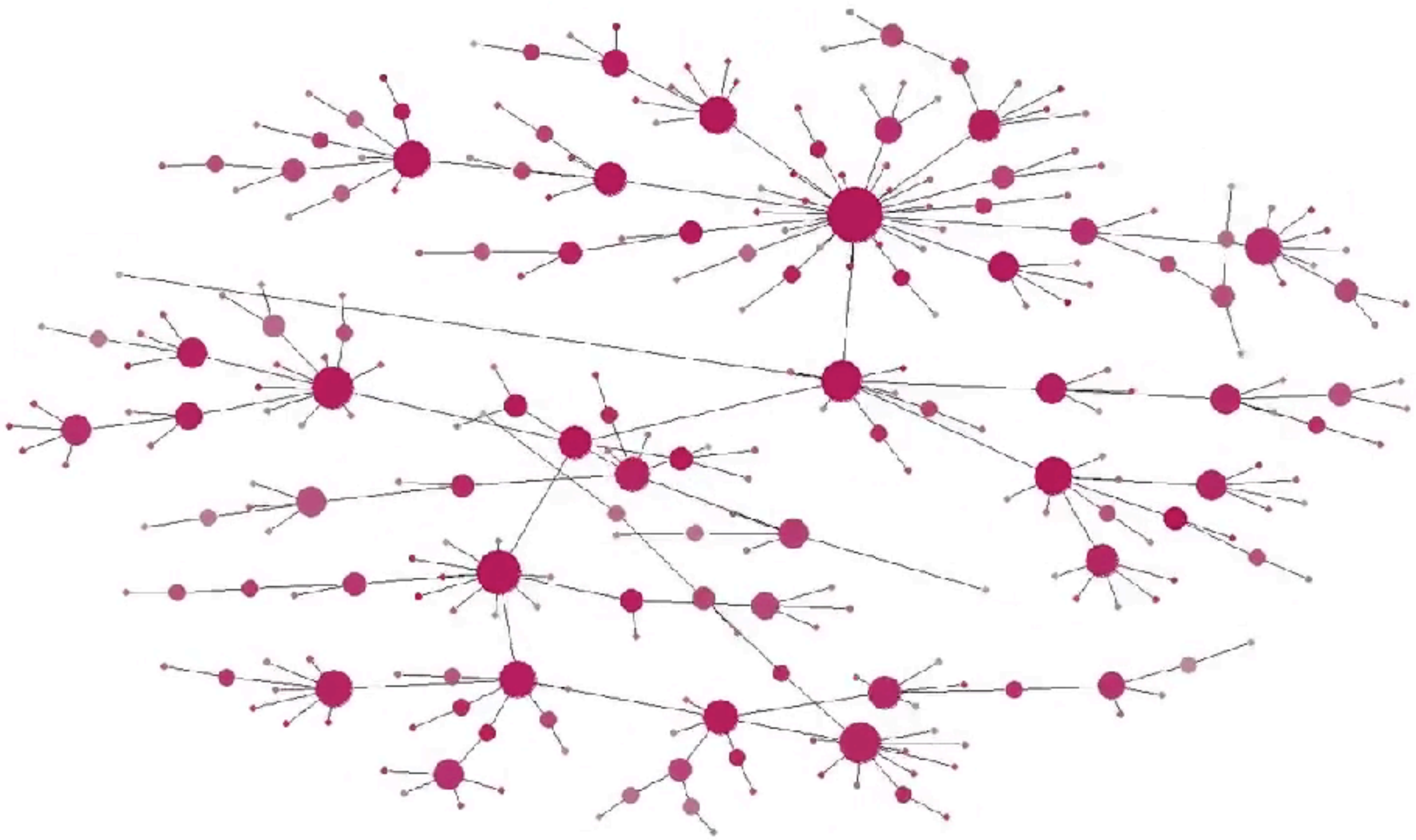


?

Extremistan

The Barabási-Albert (BA) network models "rich getting richer"

Start with a single node.
New nodes arrive and link randomly to an old node.
They prefer to link to a high-degree node.



https://www.youtube.com/watch?v=4GDqJVtPEGg

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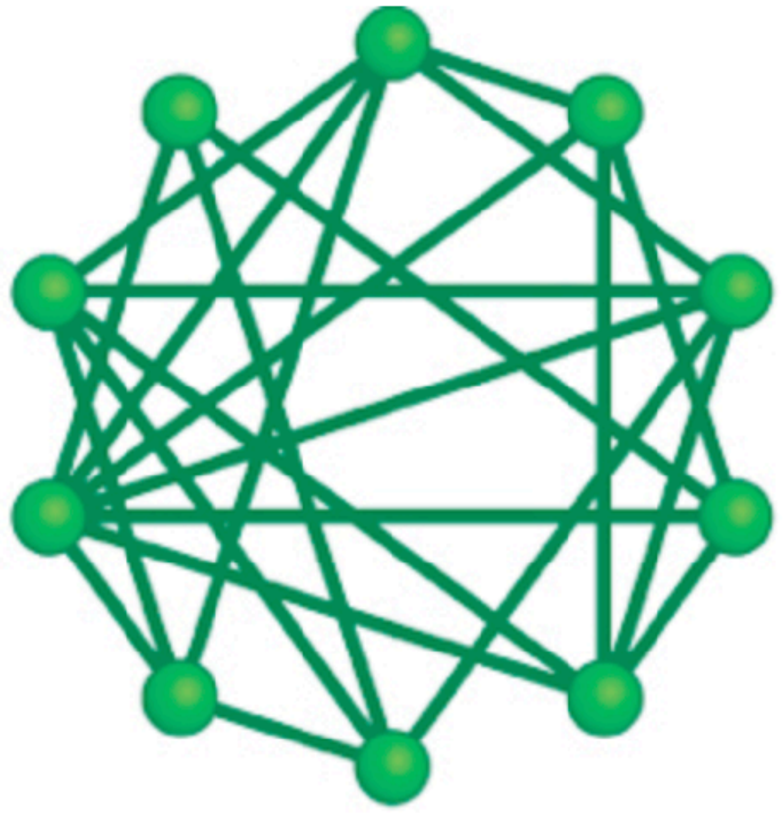
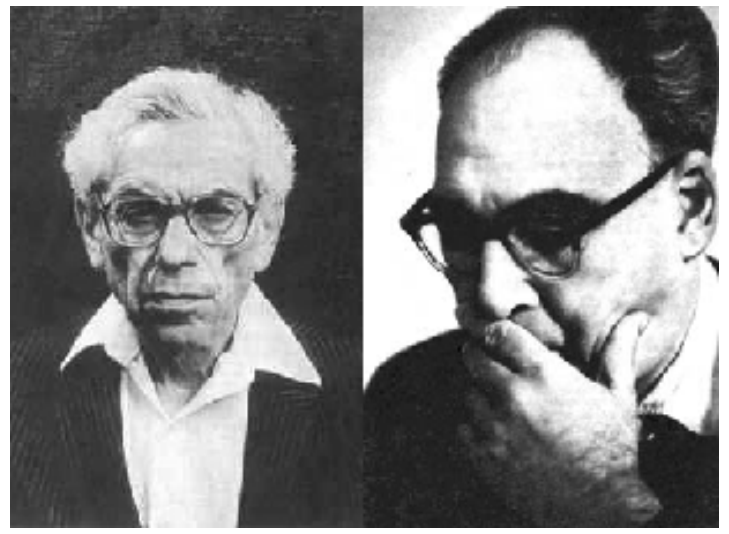
Also called scale-free

20th century statistics





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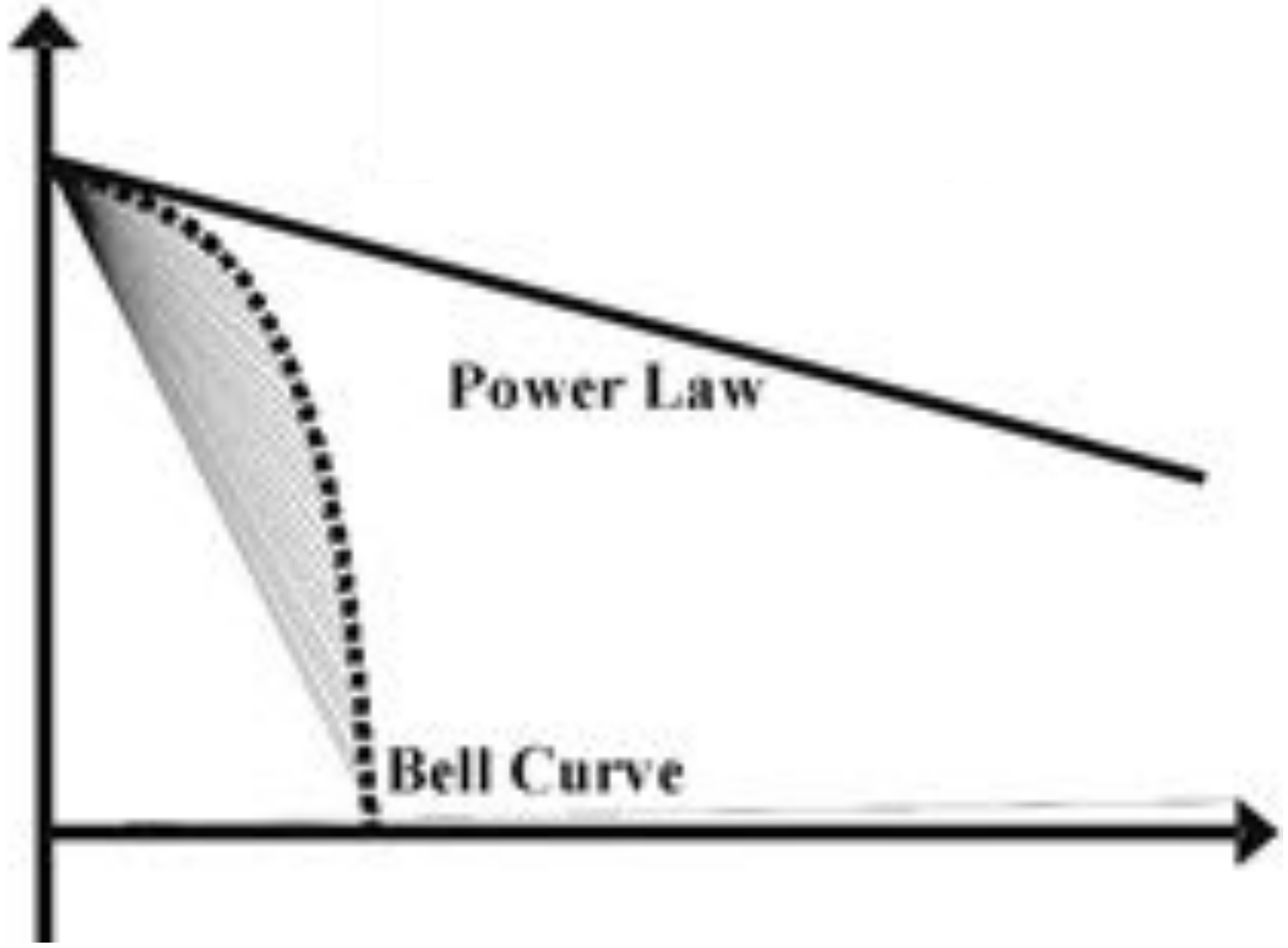
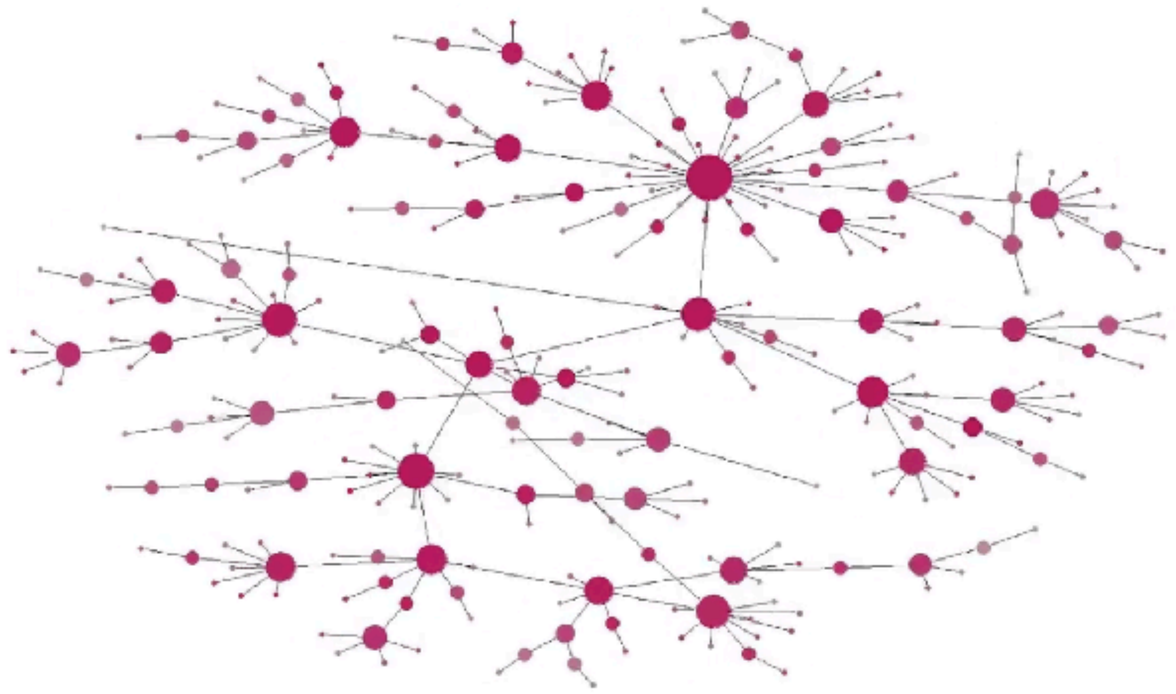
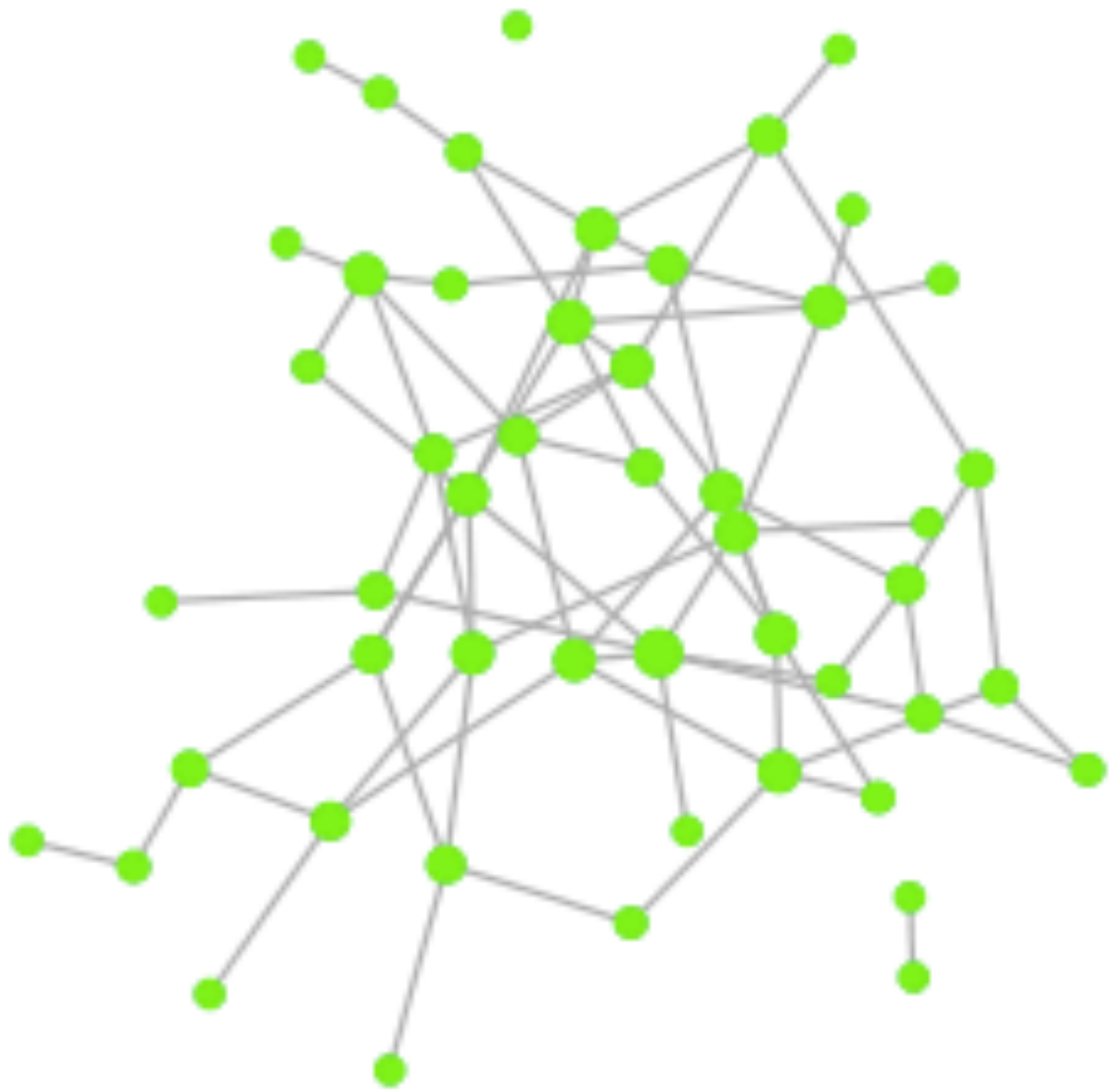
Mediocristan

21th century statistics add:



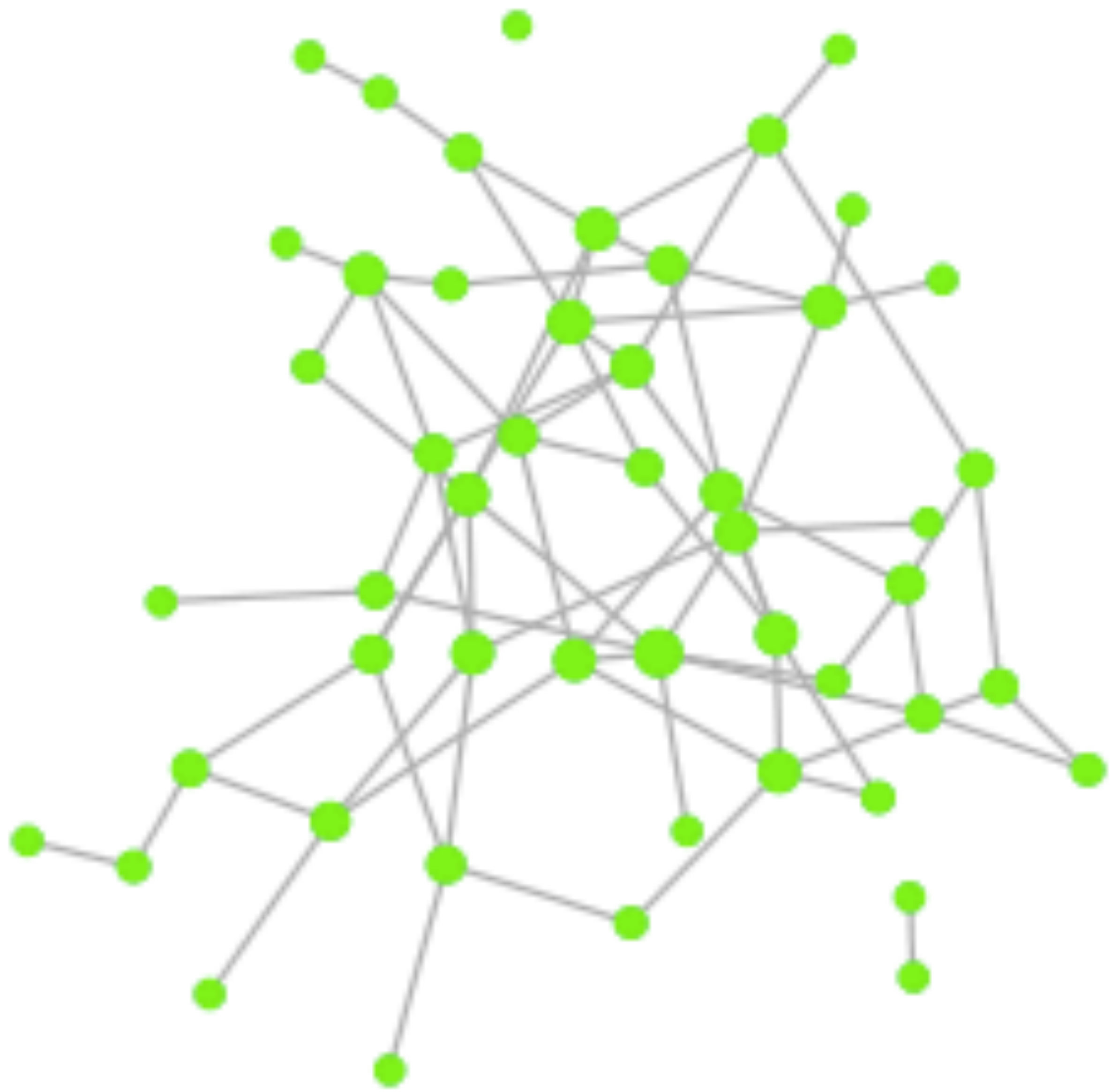


Extremistan



ER network

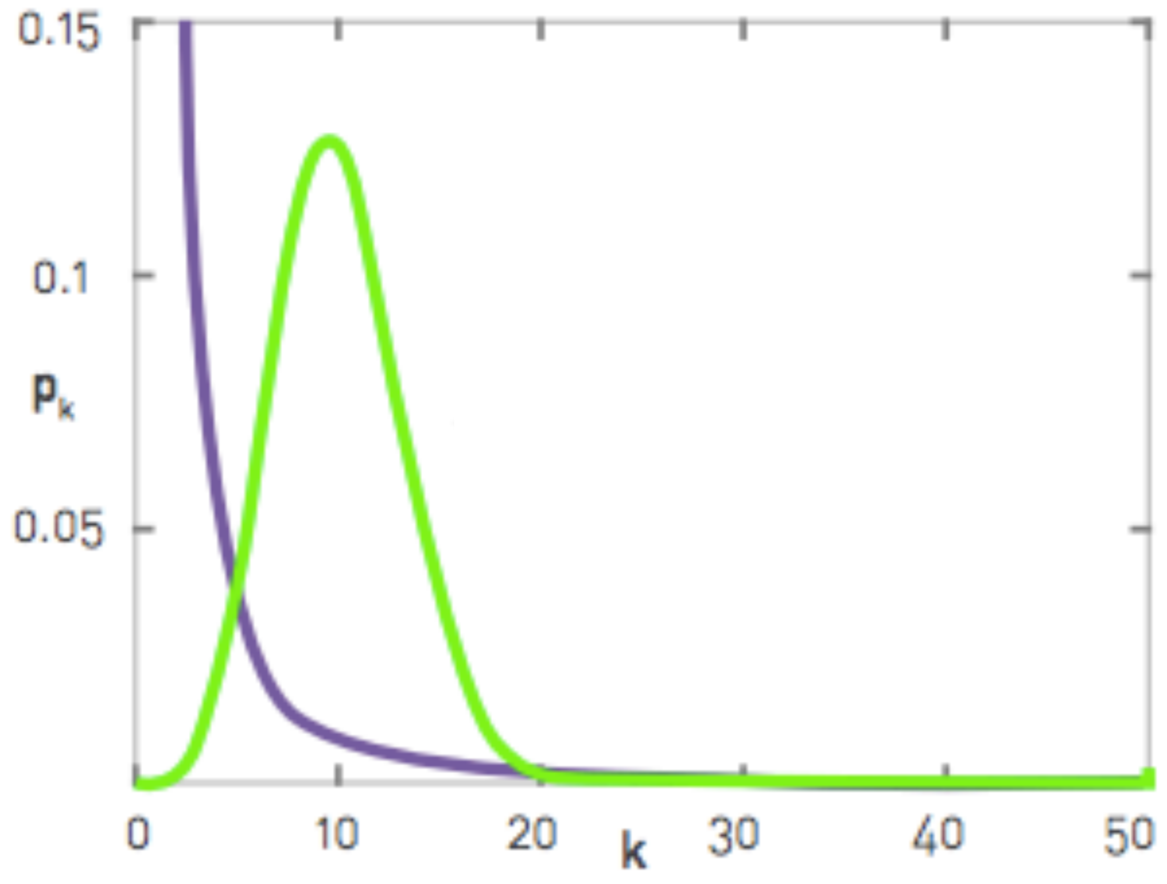
Scale-free network



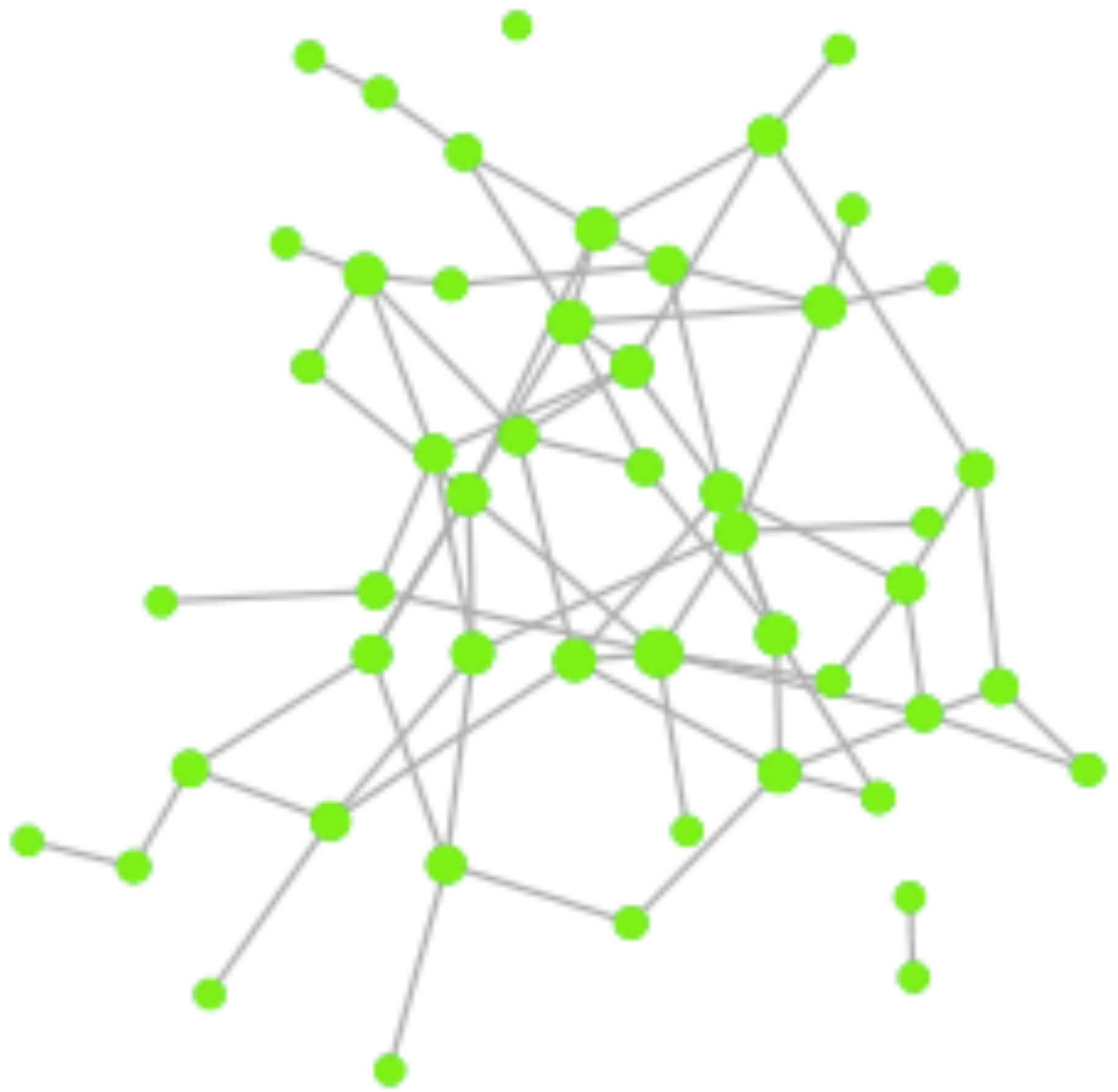
ER network

Scale-free network

Their degree distributions



linear scale



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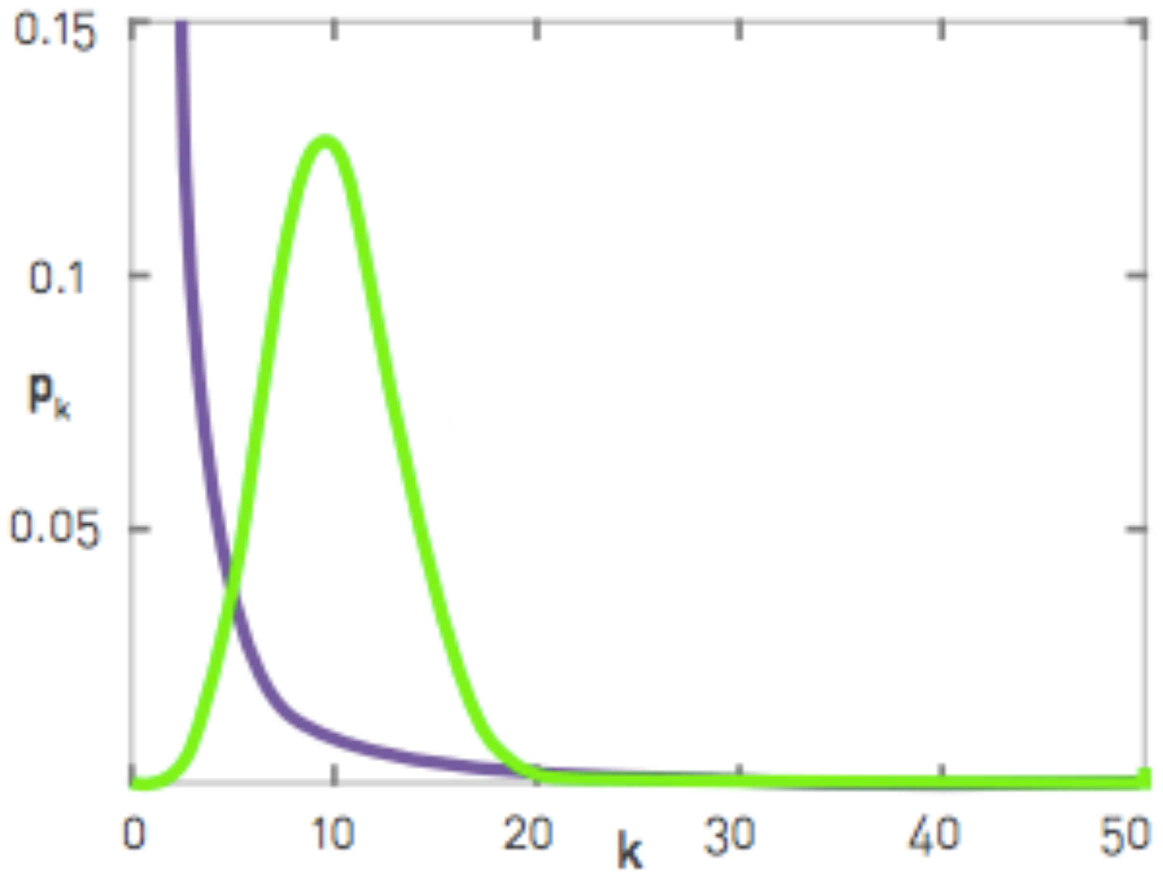

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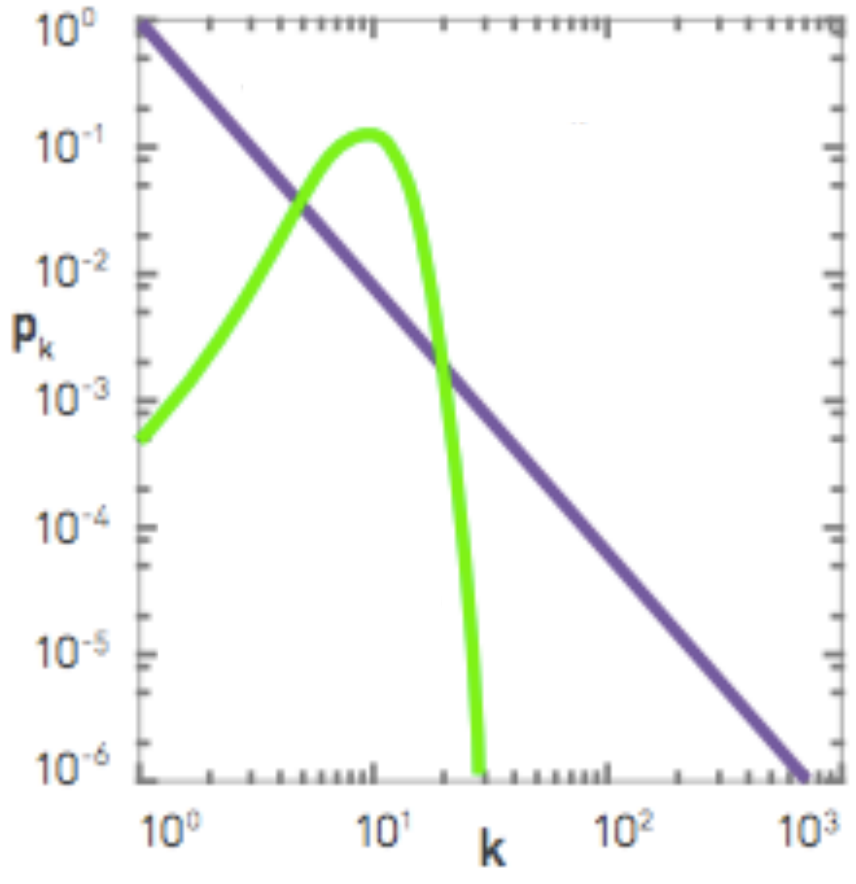
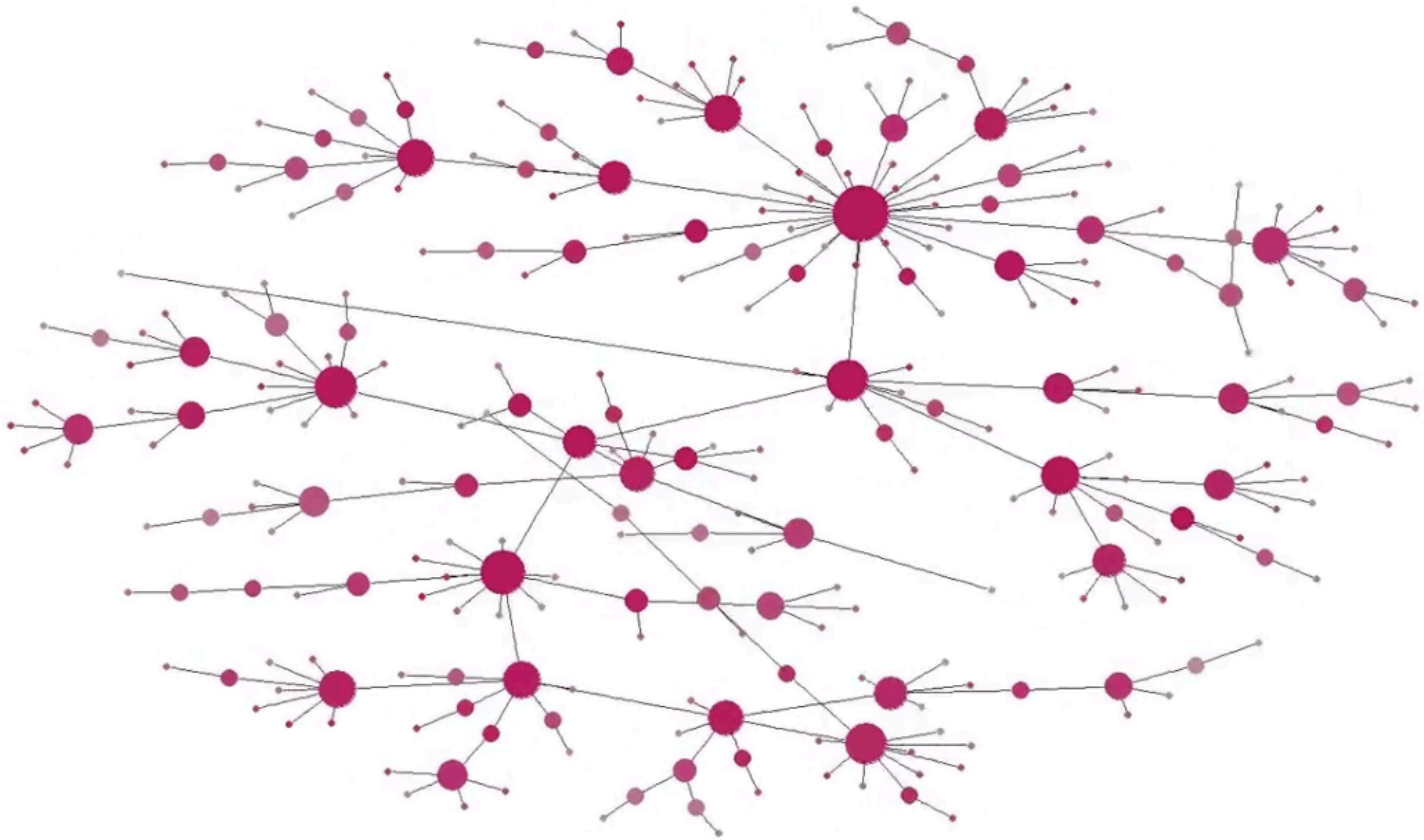
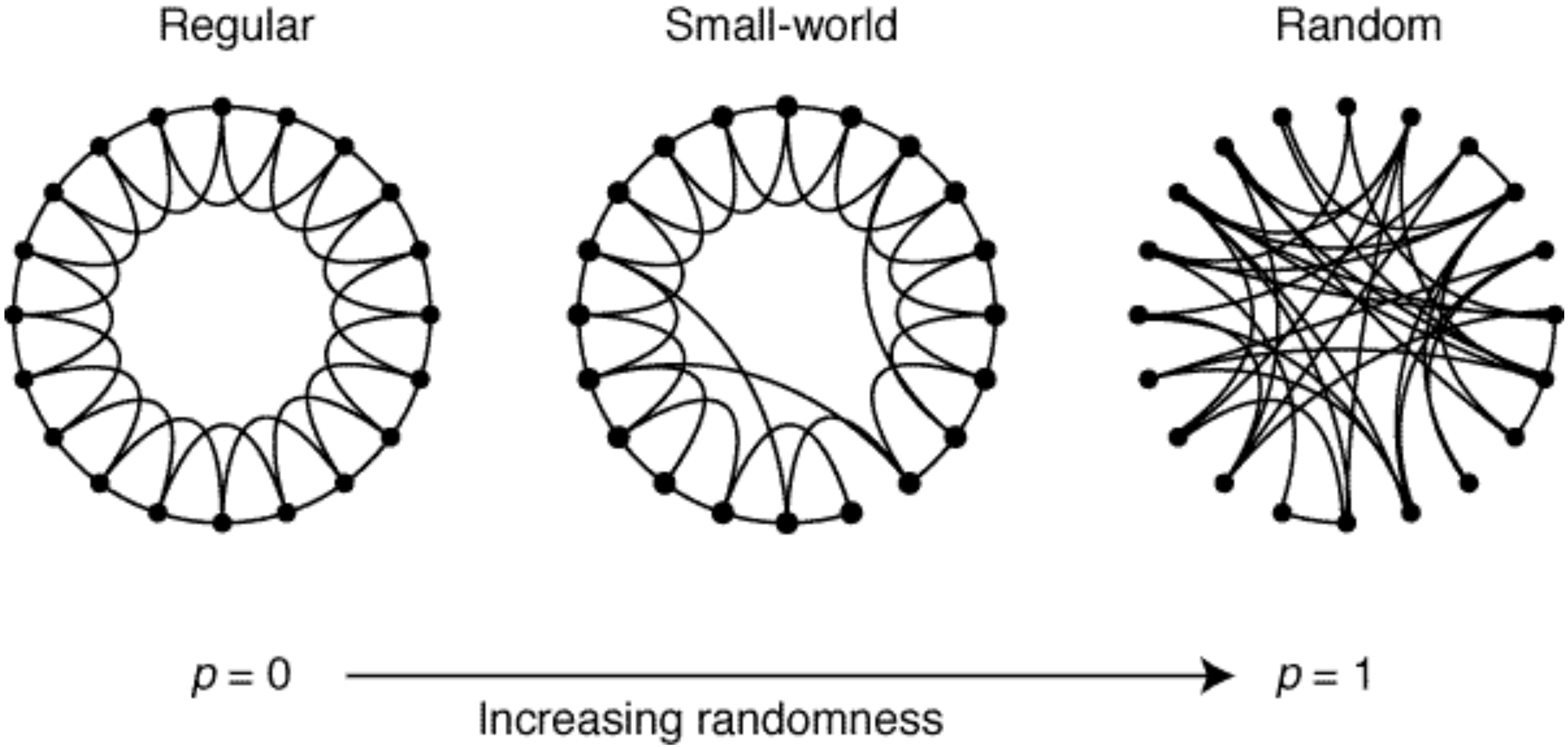


loglog scale

The BA model is not realistic for social networks.
What is missing?

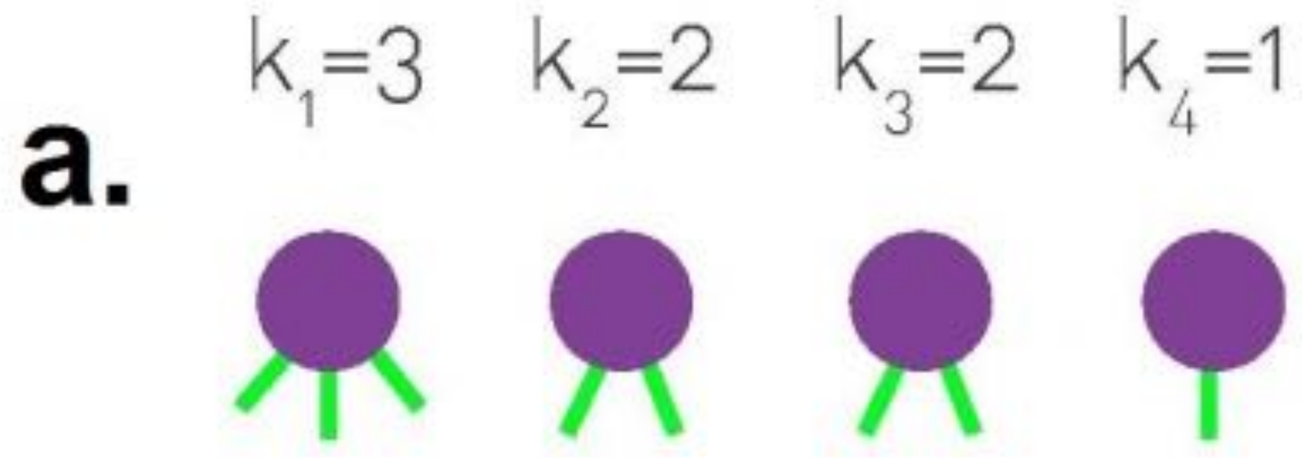


The Watts-Strogatz model implements a small world network with high clustering



http://worrydream.com/ScientificCommunicationAsSequentialArt/

The configuration model is another way of building random networks



Start with a degree sequence

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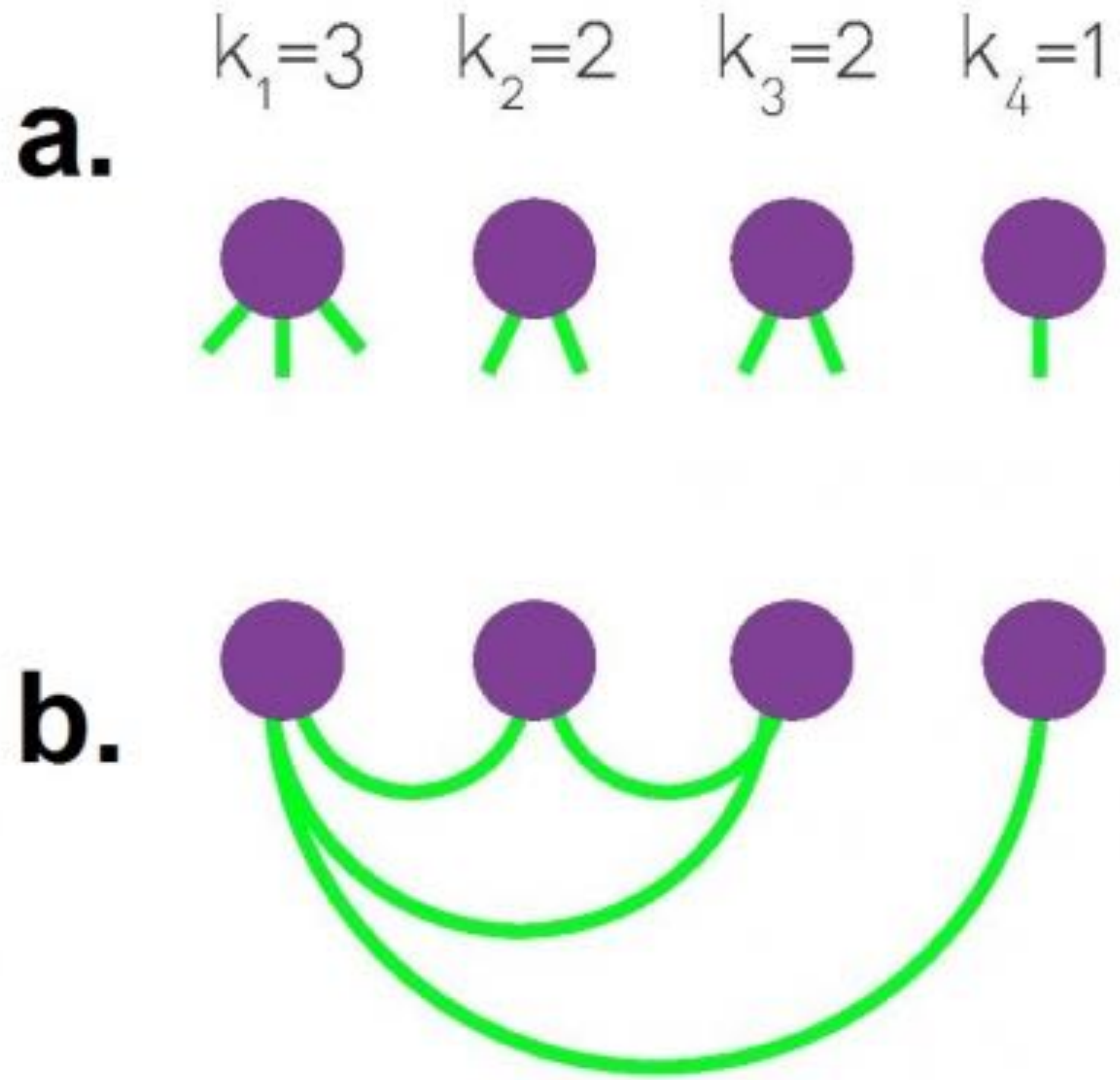

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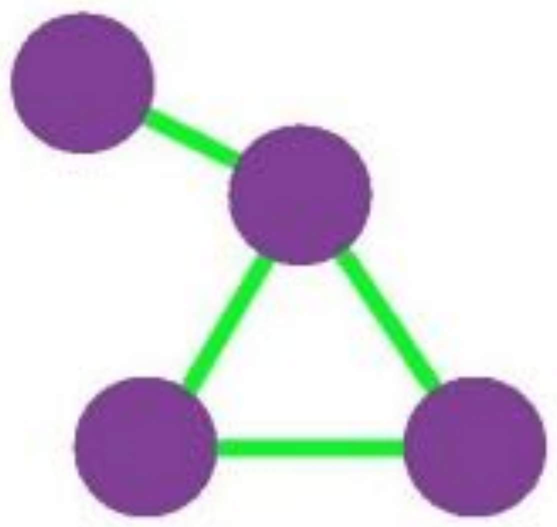

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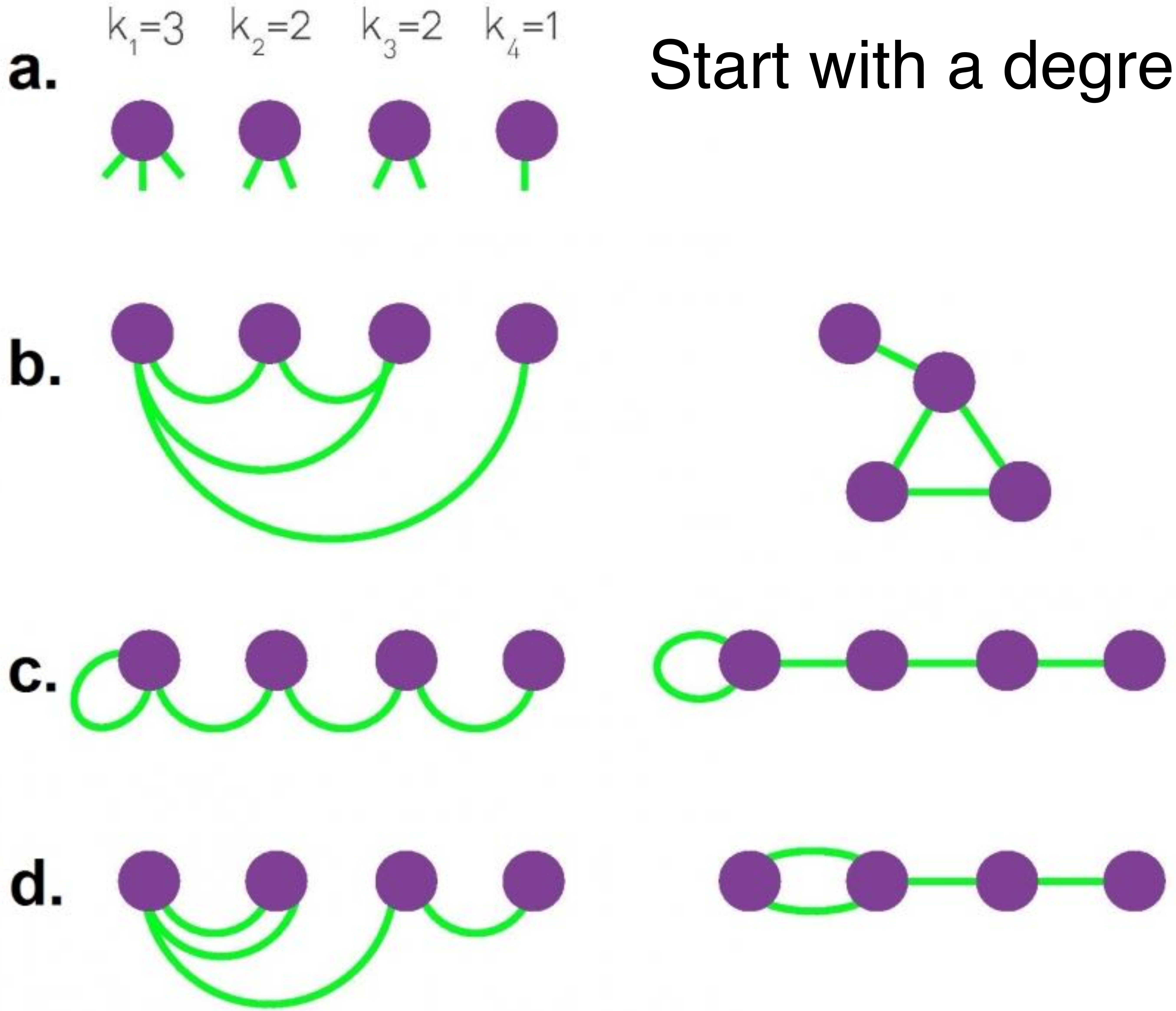


Start with a degree sequence

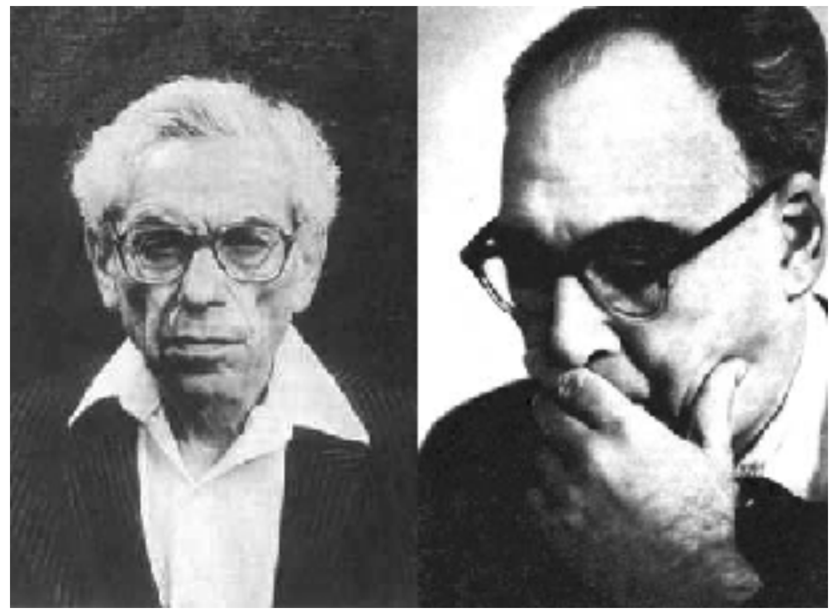
Jupyter

For next class, install:

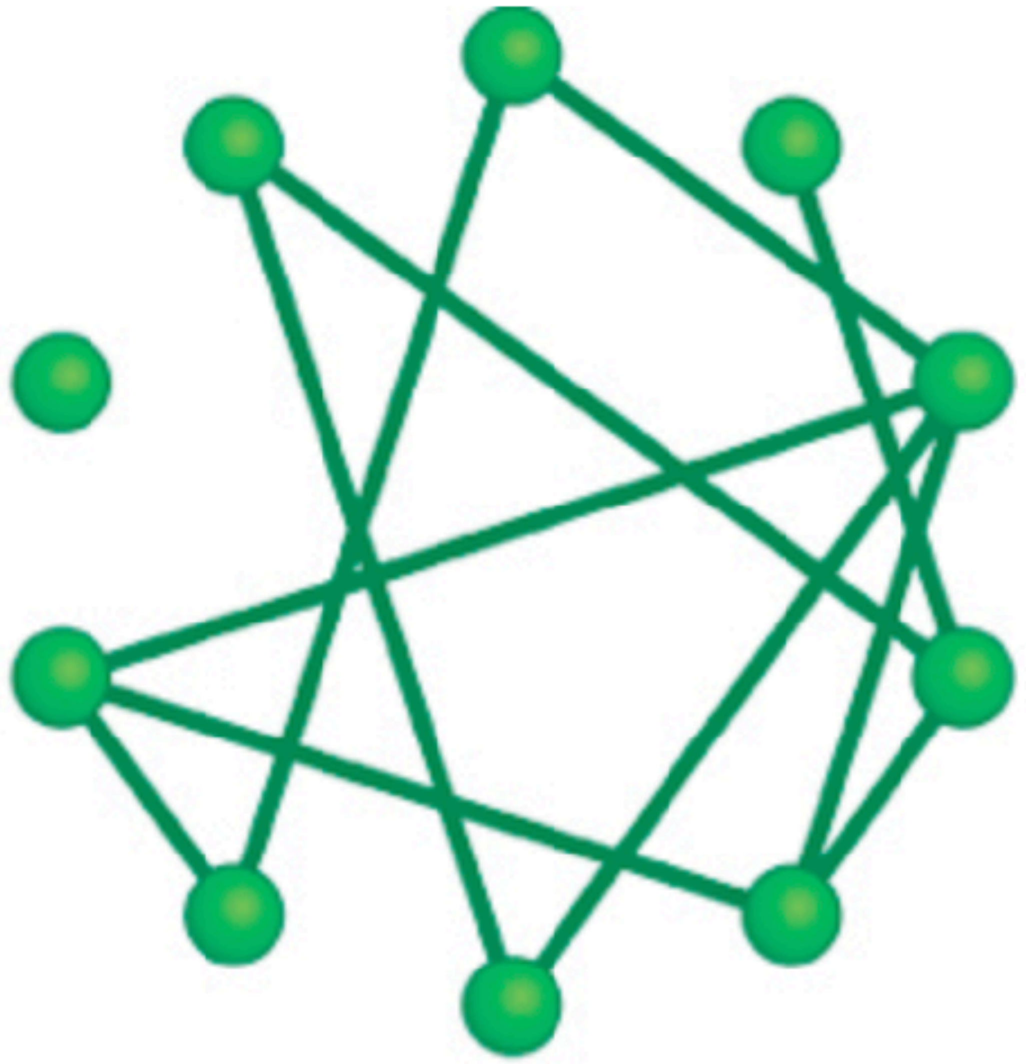
Gephi

gephi.org

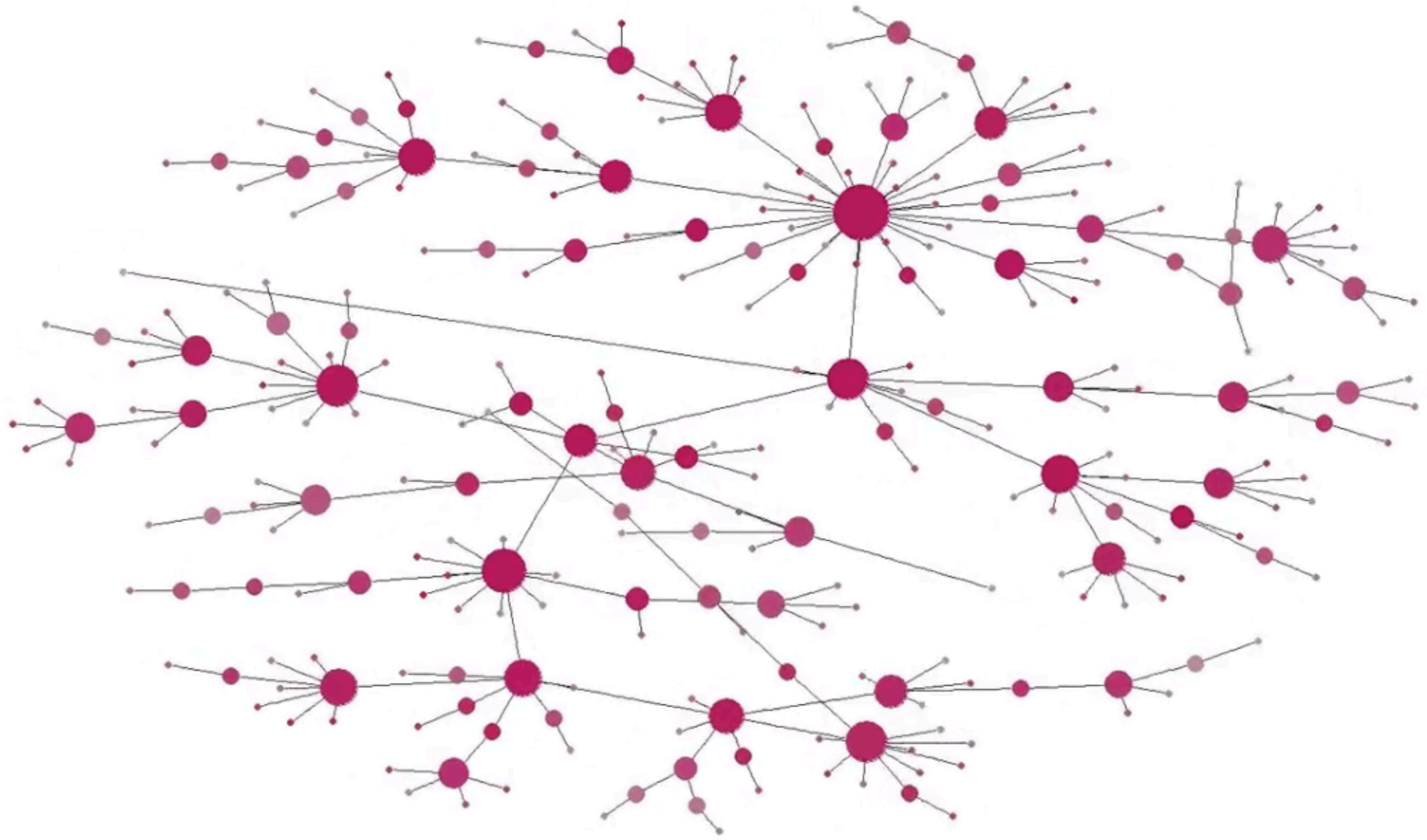
Today you learned the 3 most important network models



Erdős-Rényi
networks



Barabási-Albert
networks



Watts-Strogatz
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