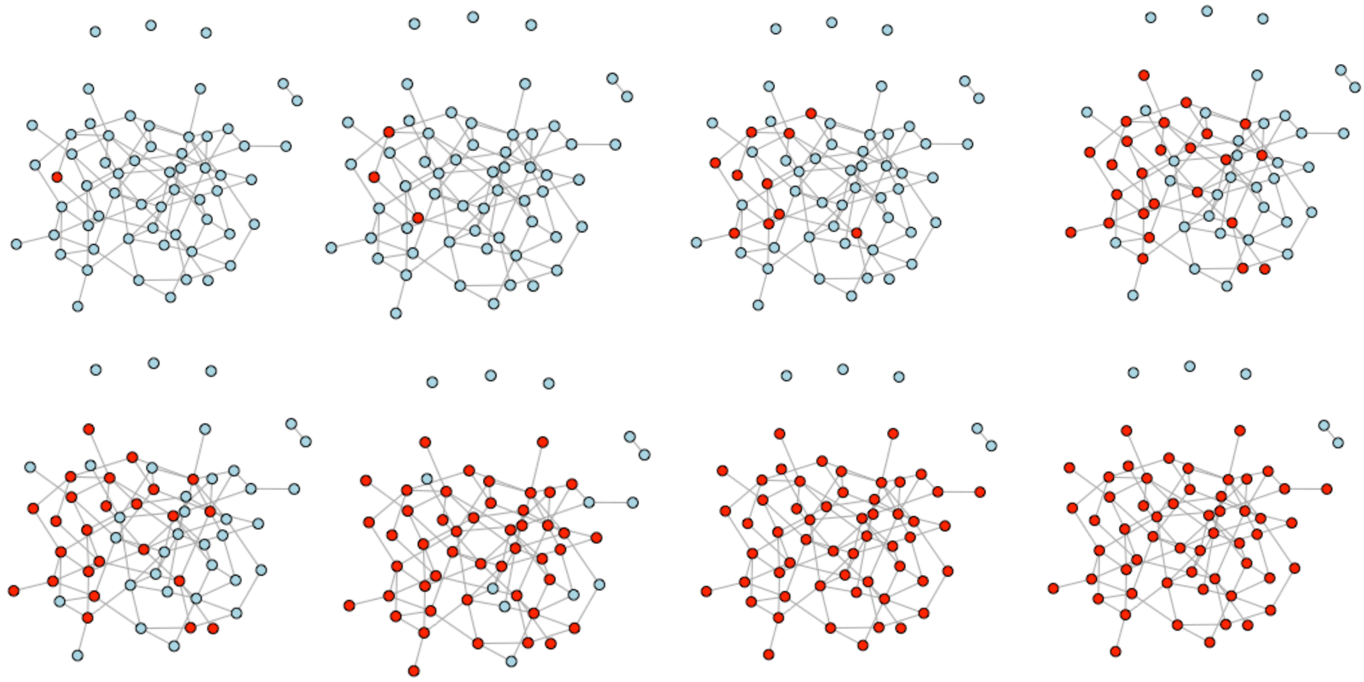
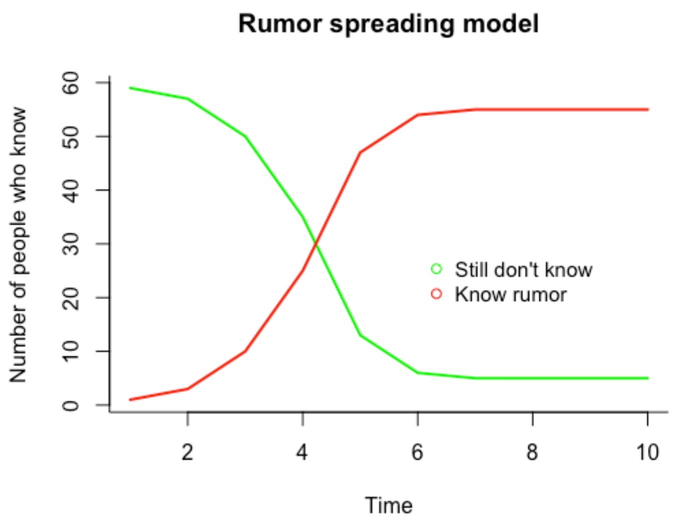
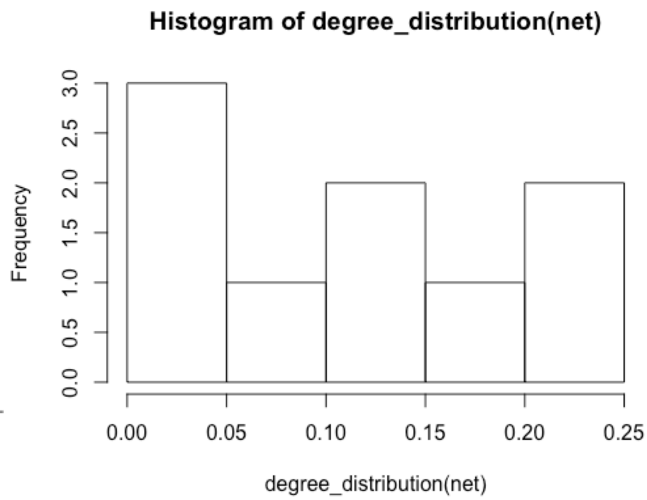
EXTENDED BIOLOGICAL PROCESSES: NETWORKS

Carry out a numerical simulation of a rumor propagation process that starts with a single individual carrying a hot new. Follow the numbers of informed individuals at each (time discrete) generation and compare with the mean-field solution. (Hint: the mean-field in this case corresponds to the propagation at a constant speed given by the average number of contacts.)

> Imagine this situation: in an office of 60 employees, someone finds out a confidential information. How many days will it take for the information to reach everyone at the office. If we suppose that each person trusts an average of 3 other people in the company, the transmission rate will be 3/60 = 0.05.
>
> The evolution of the network will be:



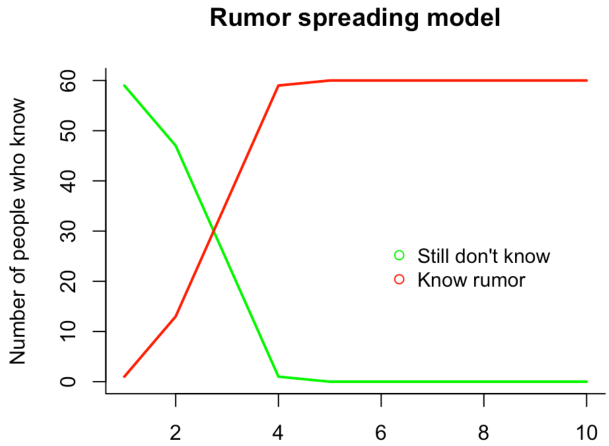


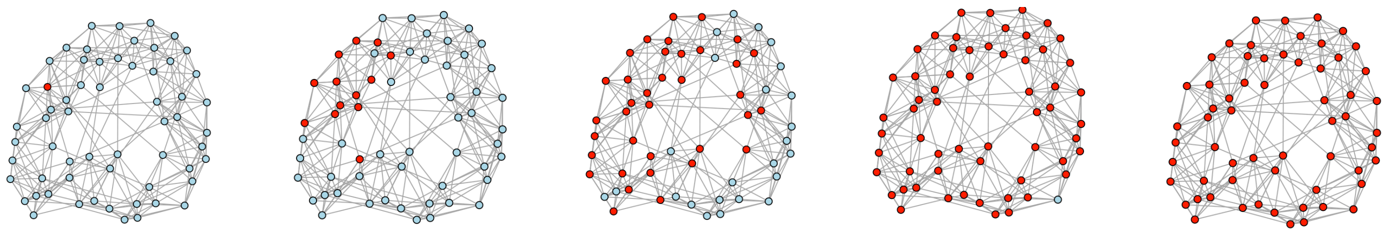


Compare Erdös-Rényi network, small-world network and preferential attachment network.

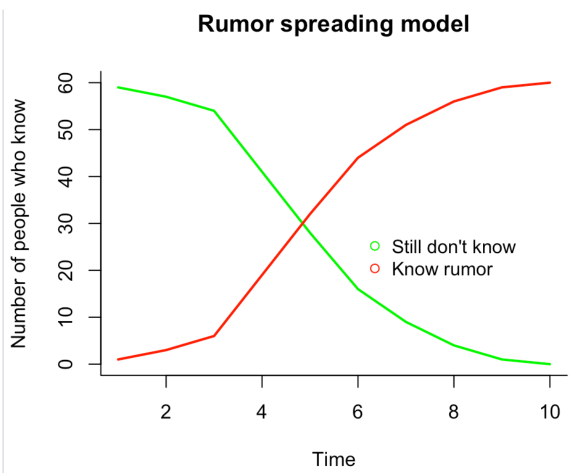
This network shows a **Erdös-Rényi network**, where each vertex is liked with every other with a probability *p* (in this case p= 0.05). The problem with this network is that, since the vertex connections depend on probability, there are almost always some vertex with no connections, which in the real world is very rare. For this situation, the fixed point where all individuals of the network find out about the secret, is not reached but that is an artifact of the program.

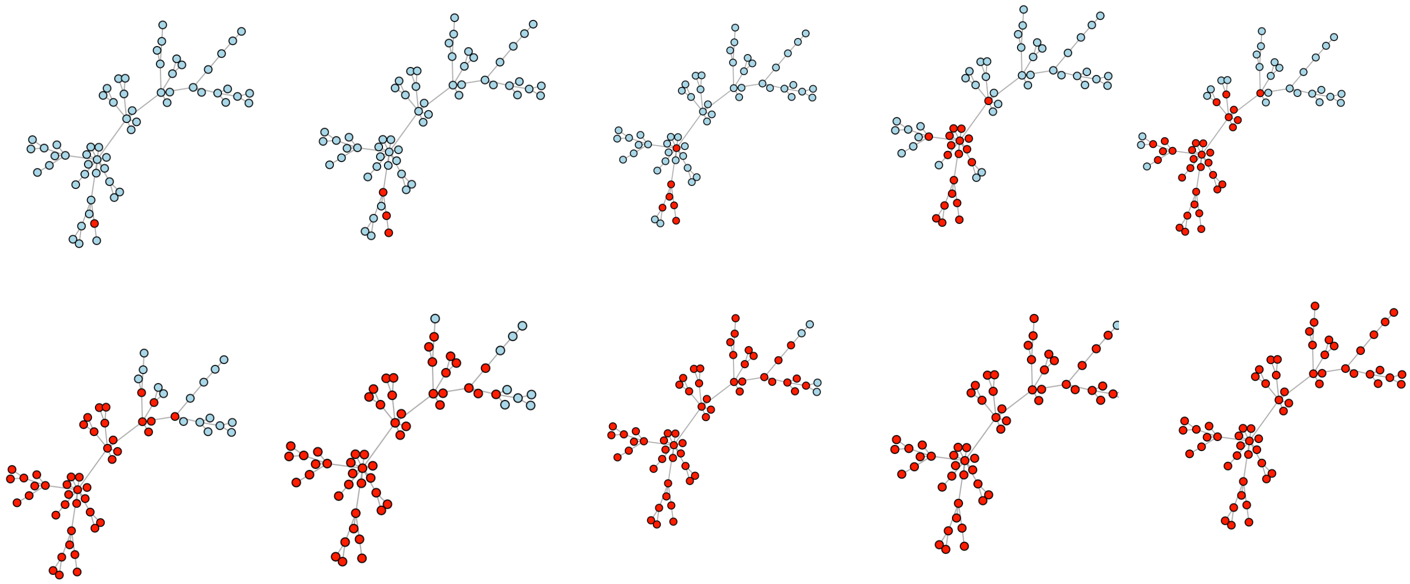
When we use the **small-world network**, where we start with a lattice of n vertex and the connections are updated each time step (there are more connections), the rumor spreads much faster:





The **preferential attachment network**, as the small-world network, has a more realistic approach to real social networks than Erdös-Rényi network in the way that all vertices are connected to the network. However, in this case there are 'clusters', very few people that connect subgroups of connected people. This makes the transmission of the rumor slower than with the small world network approach. Still, with this model the fixed point (all population knows the rumor) is reached:





Do the results depend on the initial individual? **Can you find some general principle explaining when the rumor spreads to the whole population and when it dies out, leading to just a locally "informed" group**

Yes, because not all members of the net have the same number of connections. If the rumor starts with someone very connected, the rumor will spread faster.

Repeat the simulation a large number of times. Record the time at which the rumor stops propagating (if it does at all). Plot the distribution of rumor extinction times.

The experiment was repeated 100 times and 20 generations, for each network model using the same parameters defined before (60 people, interaction probability of 5%). At each iteration the network had a different topology and the individual initiating the rumor was also different.

The plot shows how in most iterations with the Small-World network, the rumor reaches everyone between days 4 and 5. With the Preferential Attachment network, there is more variability; the rumor reaches everyone between the days 6-11 (some at 13). Finally, the Erdös-Rényi network shows that most of the times the rumor does not reach everyone; that happens because the network is not really connected.