



Networks

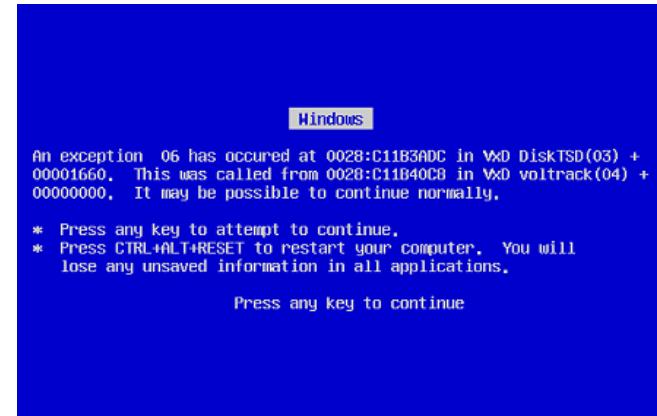
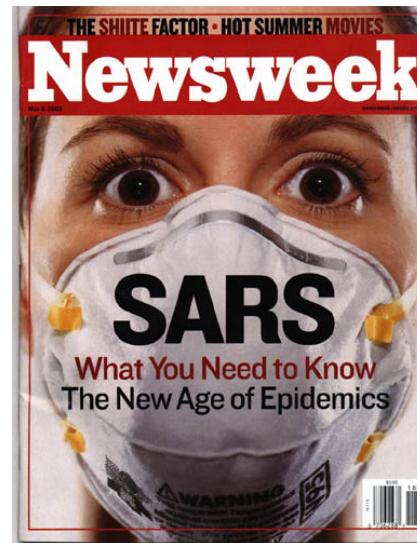
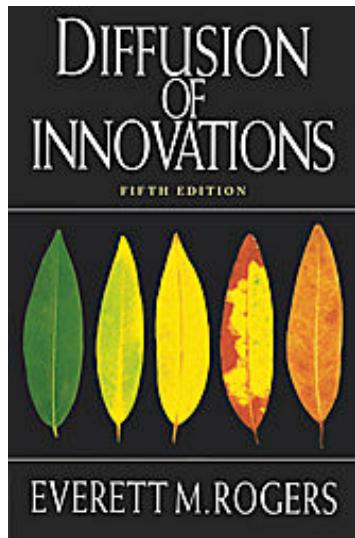
Spreading Phenomena

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Slides adapted from László Barabási
<http://www.barabasilab.com/>

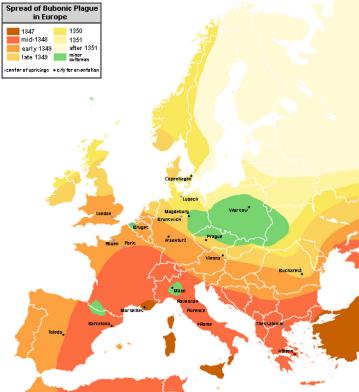
Epidemic spreading – Why?

Why is the spreading process important?

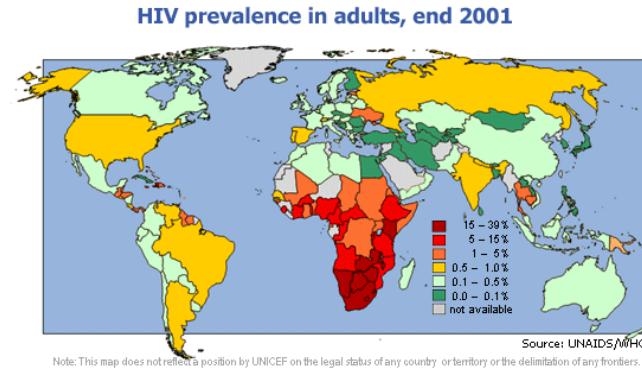


Biological: Notable Epidemic Outbreaks

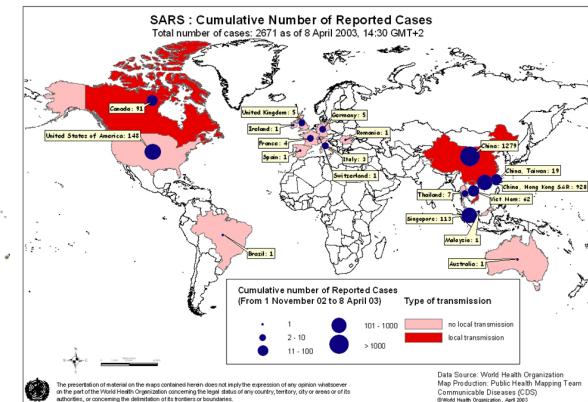
The Great Plague



HIV



SARS

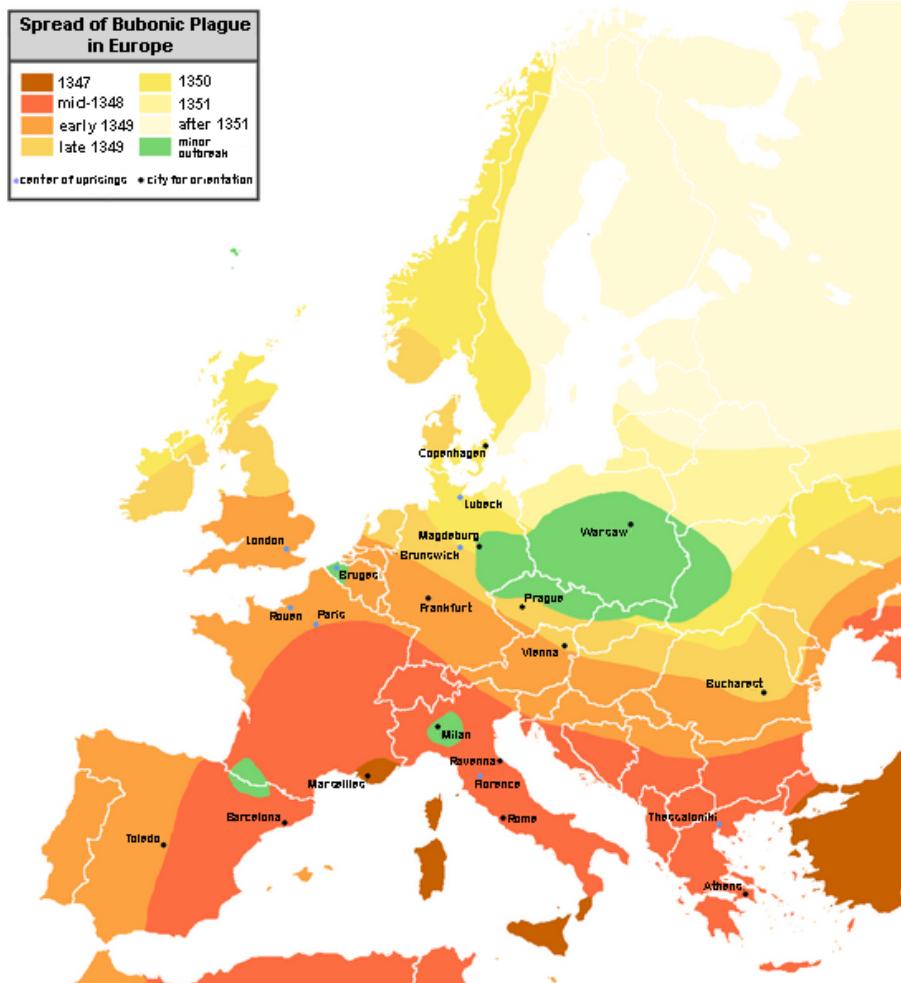


1918 Spanish flu



H1N1 flu

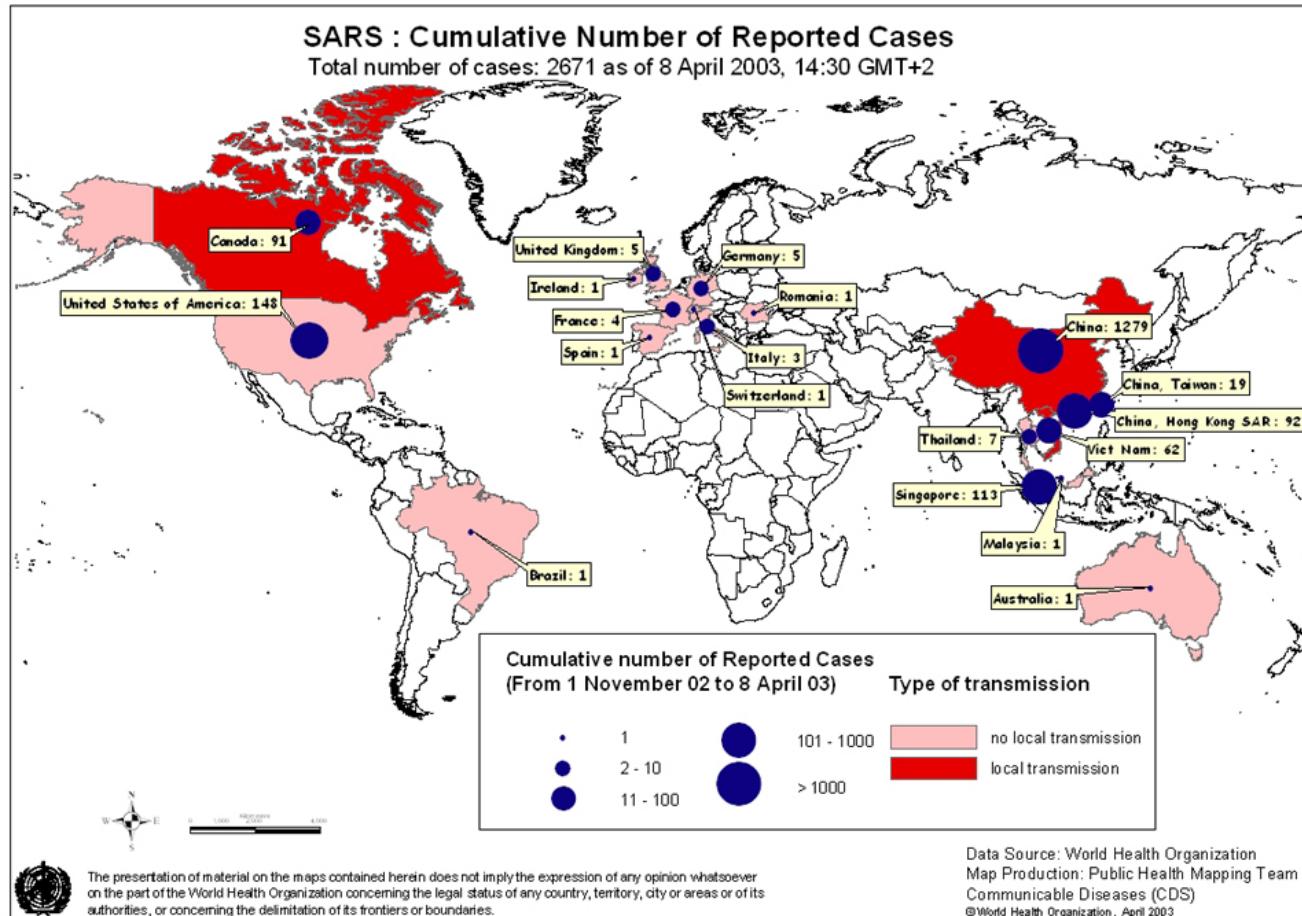
14th Century – The Great Plague



4 years from France to Sweden

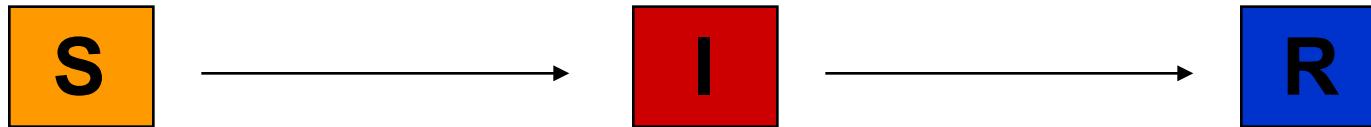
Limited by the speed of human travel

21st Century – SARS



Source: World Health Organization

SIR Model



S number of susceptible individuals

I number of infectious individuals

R number of removed individuals

N total population

$$N = S + I + R$$

- age
- gender
- health
- job
- severity of disease
- environment
- social status
- latency
-

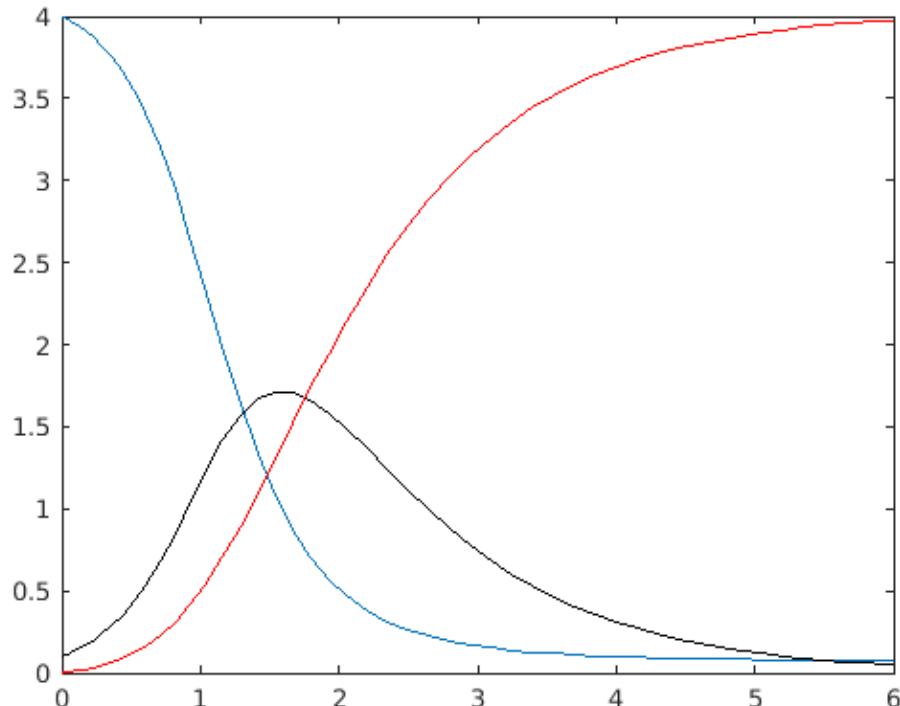
Compartmental Models

Assume a well mixed population, then:

S $\frac{dS}{dt} = -\beta i(t)S(t)$

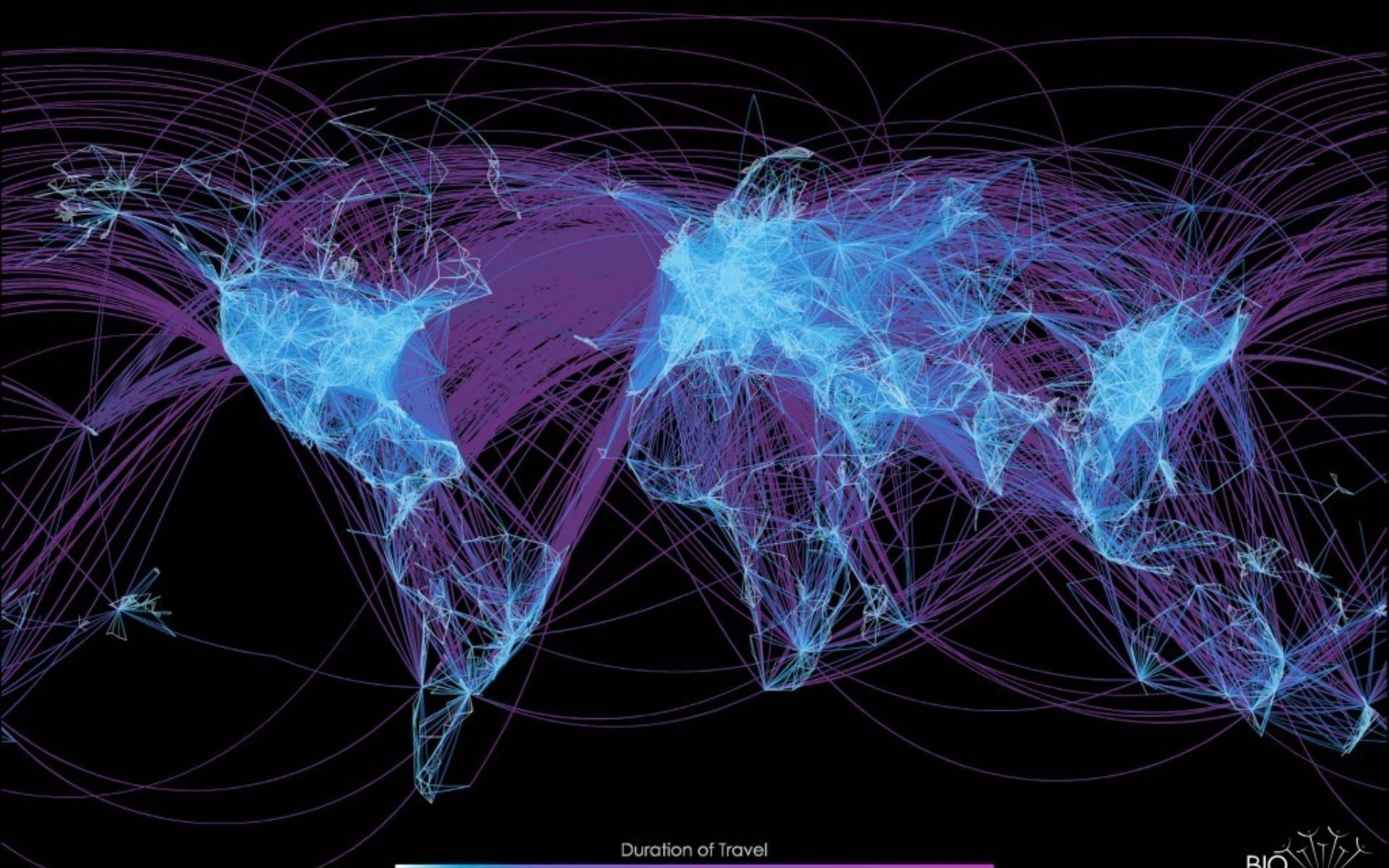
I $\frac{di}{dt} = \beta i(t)S(t) - \alpha i(t)$

R $\frac{dr}{dt} = \alpha i(t)$



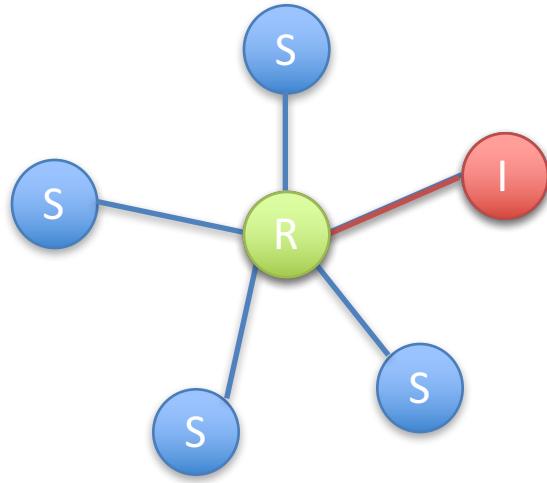
β covers probability of infection (disease and interaction)

α covers probability of recovery/removal



Duration of Travel

Network SIR Model



Each time step, infected nodes have chance to infect susceptible neighbors with probability β

Each time step, infected nodes have chance be removed (recover/die), with probability α

Importance of Networks

How does network topology impact disease spread?

Will an epidemic spread faster or slower in a scale-free network?

How important are the starting nodes of the disease?

....

Immunization?

Transmission-reducing interventions: face masks, gloves, washing hands – may reduce the transmission rate below the epidemic-causing critical rate

Contact-reducing interventions: quarantining a patient, closing schools – make the network sparser, may increase the critical transmission rate

Simulated Vaccinations: remove nodes from the network

Q. Which nodes should we vaccinate if we have a limited number of vaccines?

Q. What if we don't have information about the network structure or node statistics?