An Introduction to Agent-Based Modeling

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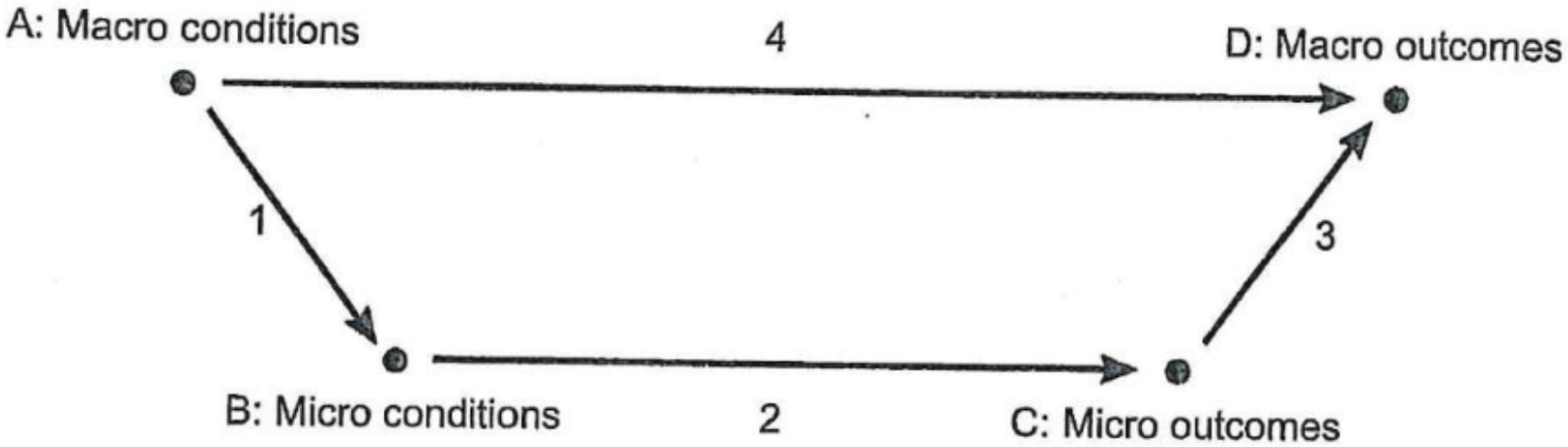
Explanation in the social sciences



Coleman's boat

In order to explain macro phenomena
we need to dig into the micro level.

Explanation in the social sciences

Most statistical or mathematical models are models of the *data*, not of the *mechanism*. The mechanism determining the phenomenon is in the *interpretation* of the model.

E.g.: linear regression of income on education, age and gender does not give us the *mechanism*.

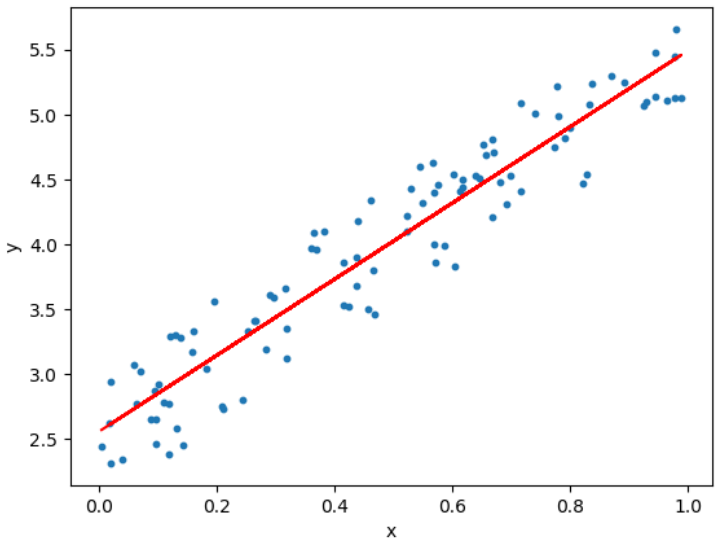
Agent-Based Modeling

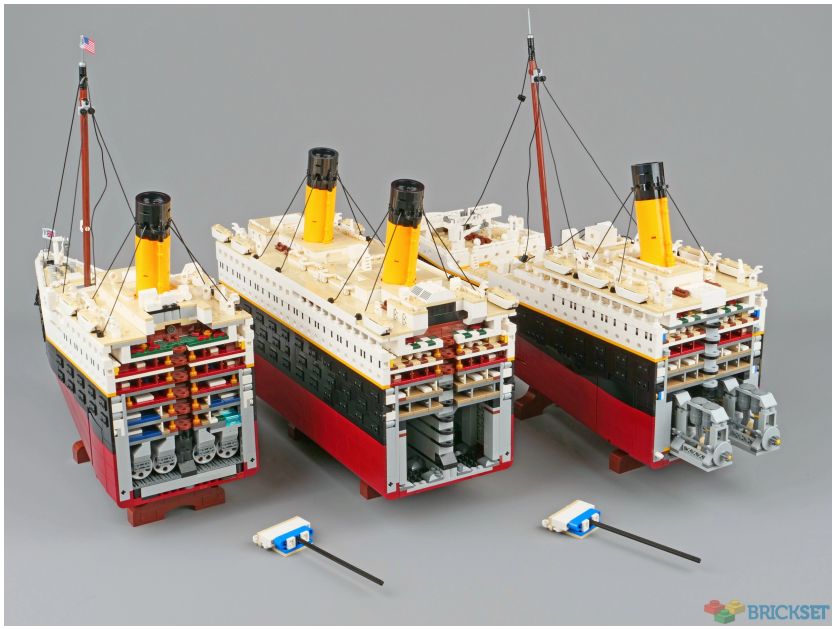
Agent-Based Modeling is a *computational* method to explicitly represent groups of *agents*, their *behaviour* and their *interaction*.

Unlike statistical models, which explain social aggregates as caused by other social aggregates, or mathematical models, which assume population homogeneity, here social aggregates are emerging processes from nonlinear interaction between heterogeneous agents.

Computational model (coding required!) – **Agents** (whatever)

Agent-Based Modeling





NB: this is not to say that a certain kind of model is *superior*, just that they are good at doing different things... But what kind of things exactly? **Complex** phenomena!

An app contest

WhatsApp vs Snapchat

- Non independent observations
- Diffusion process
- Tipping point
- Local dynamic
- Endogenous dynamic / feedback loop

Now, let's move to the most classical ABM...

Patterns of segregation

Suppose we are discussing a theory about the factors affecting spatial segregation. The role of individual preferences is disputed.

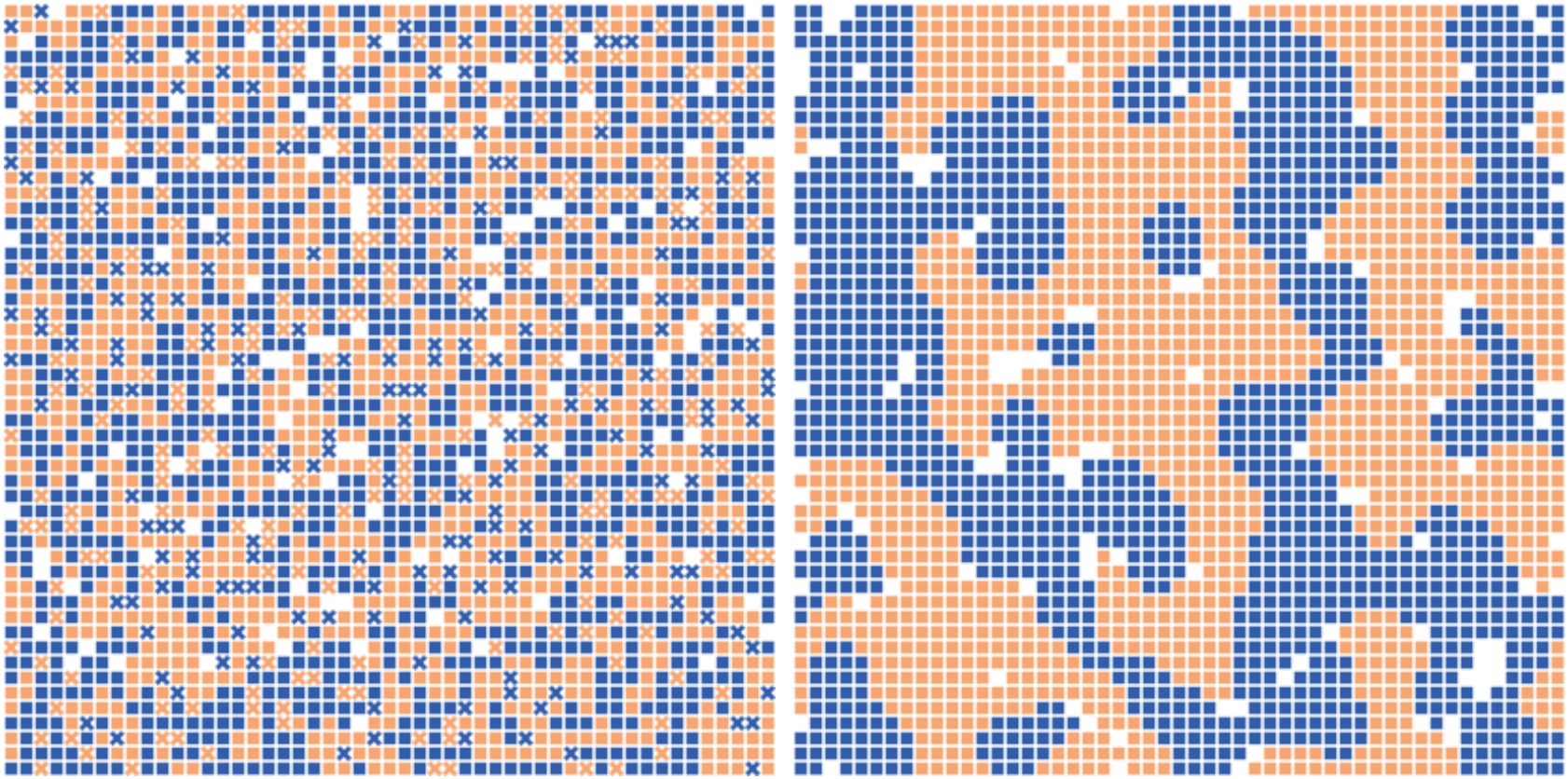
In an ideal society in which housing is uniformly distributed and other factors (like prices etc) are irrelevant, how strong individual preferences are required to be to observe segregation?

I.e.: If we observe segragation in this idealized society, should we assume that the people there *want* to be segregated (are racist)?

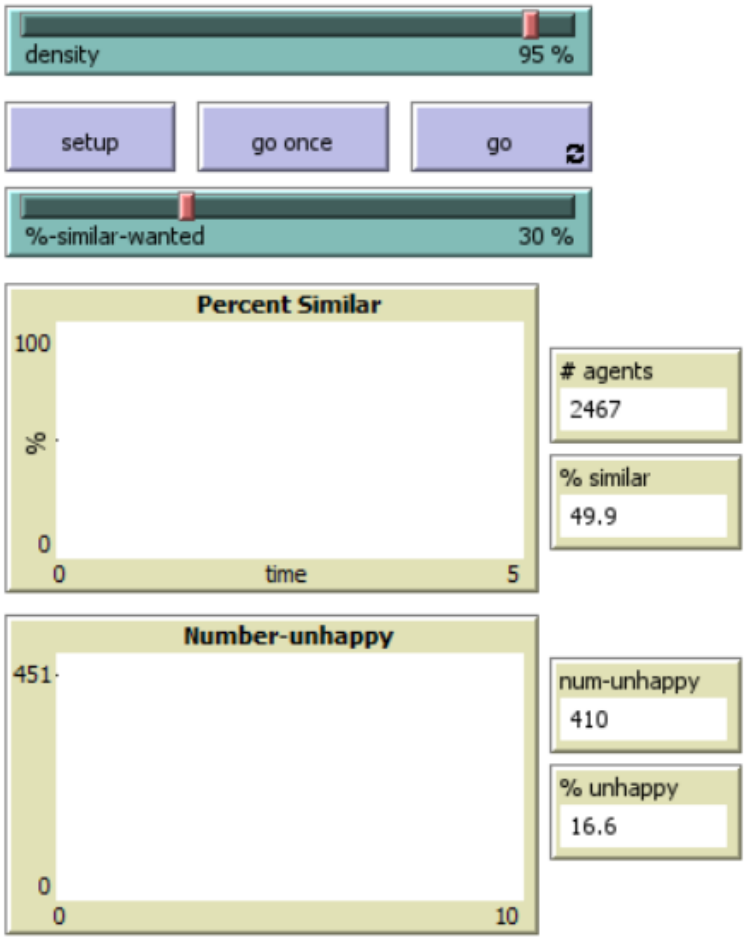
Unfortunately there are no data available and experiments are impossible. So. . . ?

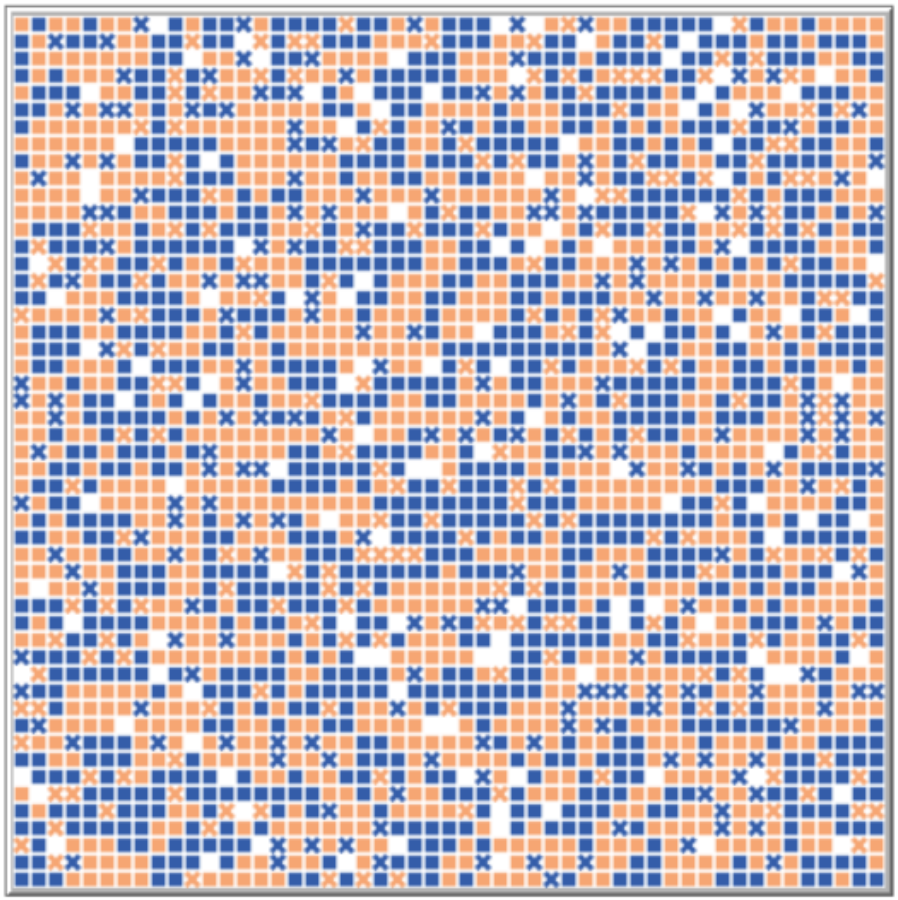
Schelling's model of segregation

Schelling (1971) is a very abstract model. Space is a grid partially filled. Two kind of agents. They prefer a certain proportion of similar neighbors, if unhappy they move.



Models Library > Social Science > Segregation





Netlogo interface with sliders for the two parameters

Kinds of explanation

So, relatively low levels of preference for similar neighbors can determine relatively high levels of segregation.

What does this imply? Alternatively, what kind of explanation this model provides?

Kinds of explanation

- *How possibly* explanations: the same outcome can be generated by several different mechanisms
- Demonstration of **existence**
- We found it by exploring *counterfactual scenarios*

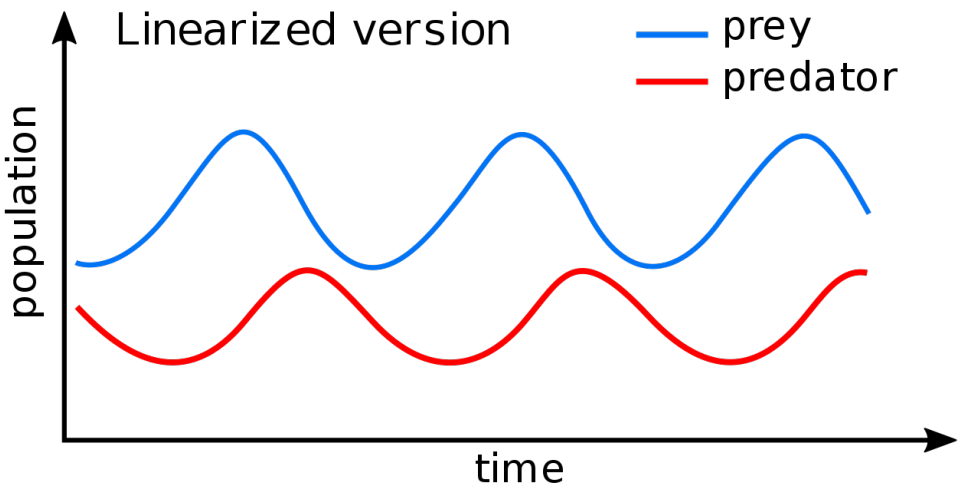
Along the way we also geined: Formalisation of the assumptions and formal demonstration of conclusions, to go beyond simple intuition

In the following we'll see other two ABMs compared with their dynamical system counterpart and look at the differences...

Lotka-Volterra model

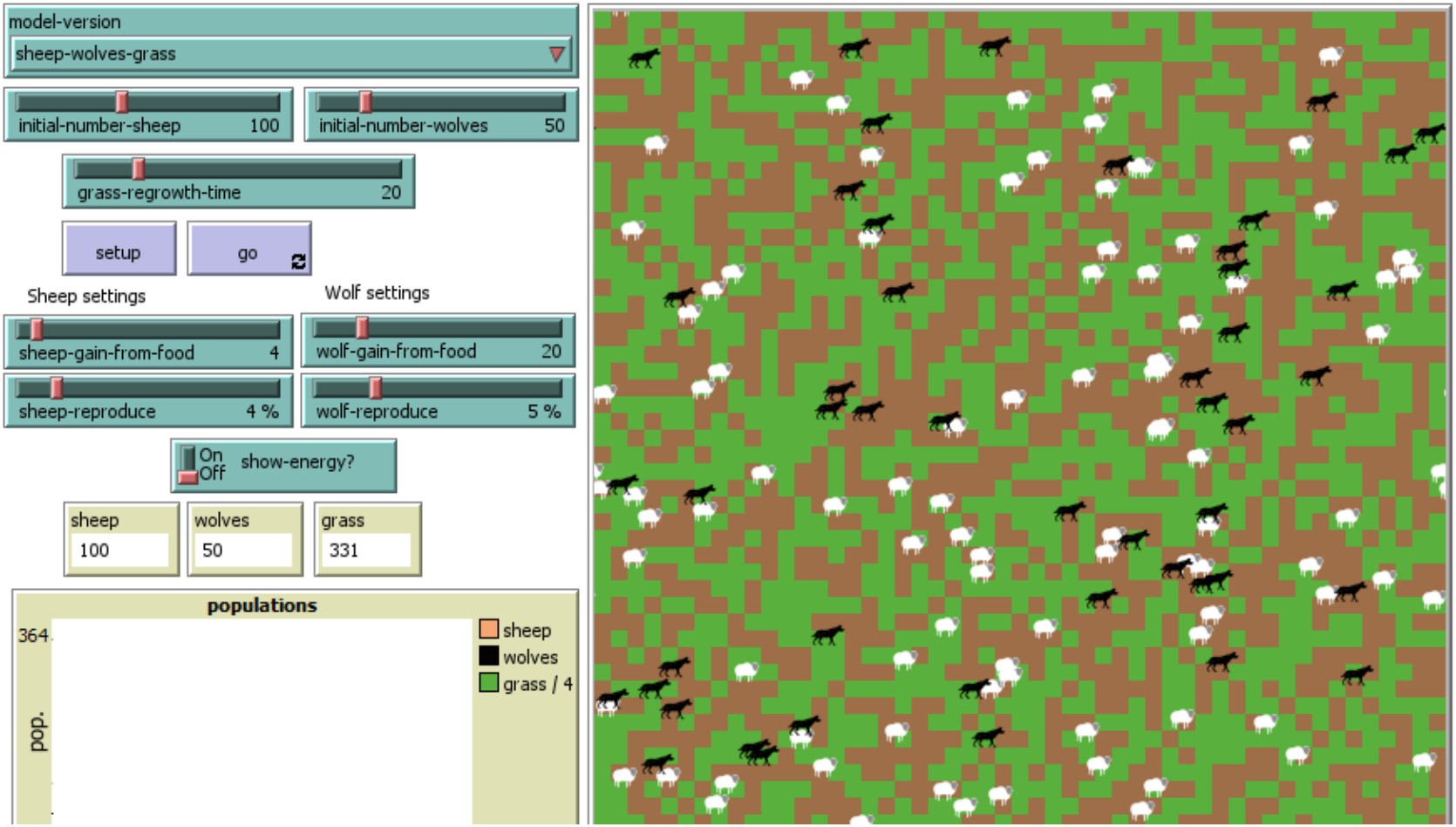
The Lotka-Volterra model is a traditional model in population biology for predator-prey interaction.

$$\frac{dx}{dt} = \alpha x - \beta xy,$$
$$\frac{dy}{dt} = \delta xy - \gamma y,$$



It's an endless cycle? What about extinction?

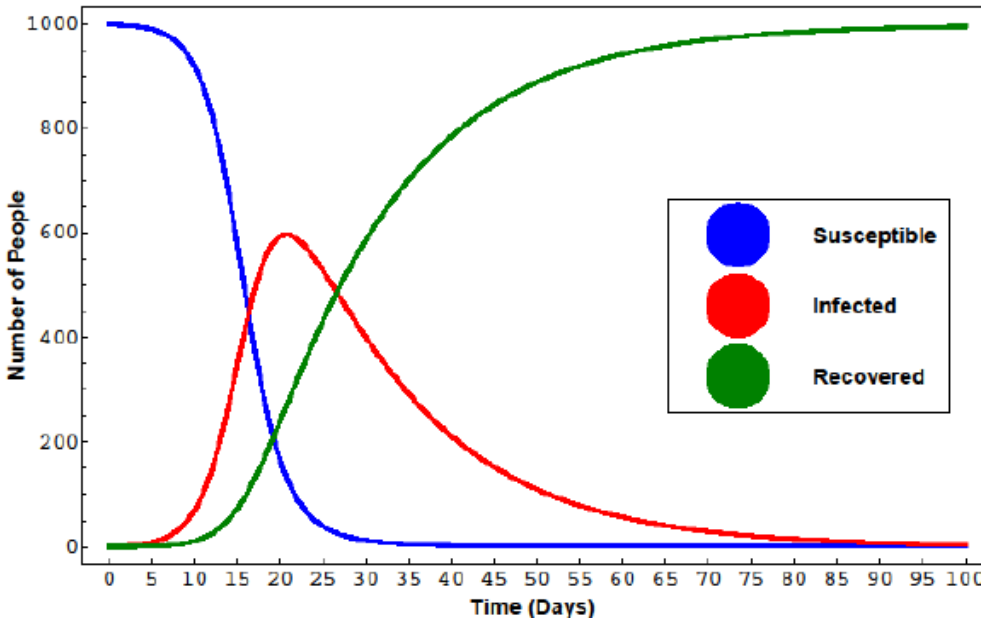
Models Library > Biology > Wolf Sheep Predation



SIR model

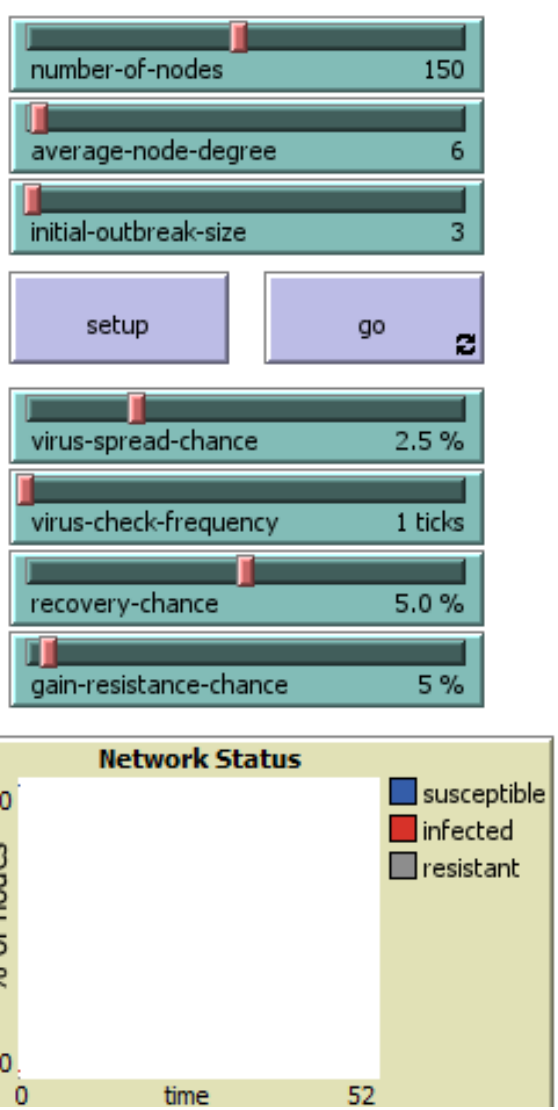
The SIR is the most famous epidemiological model.

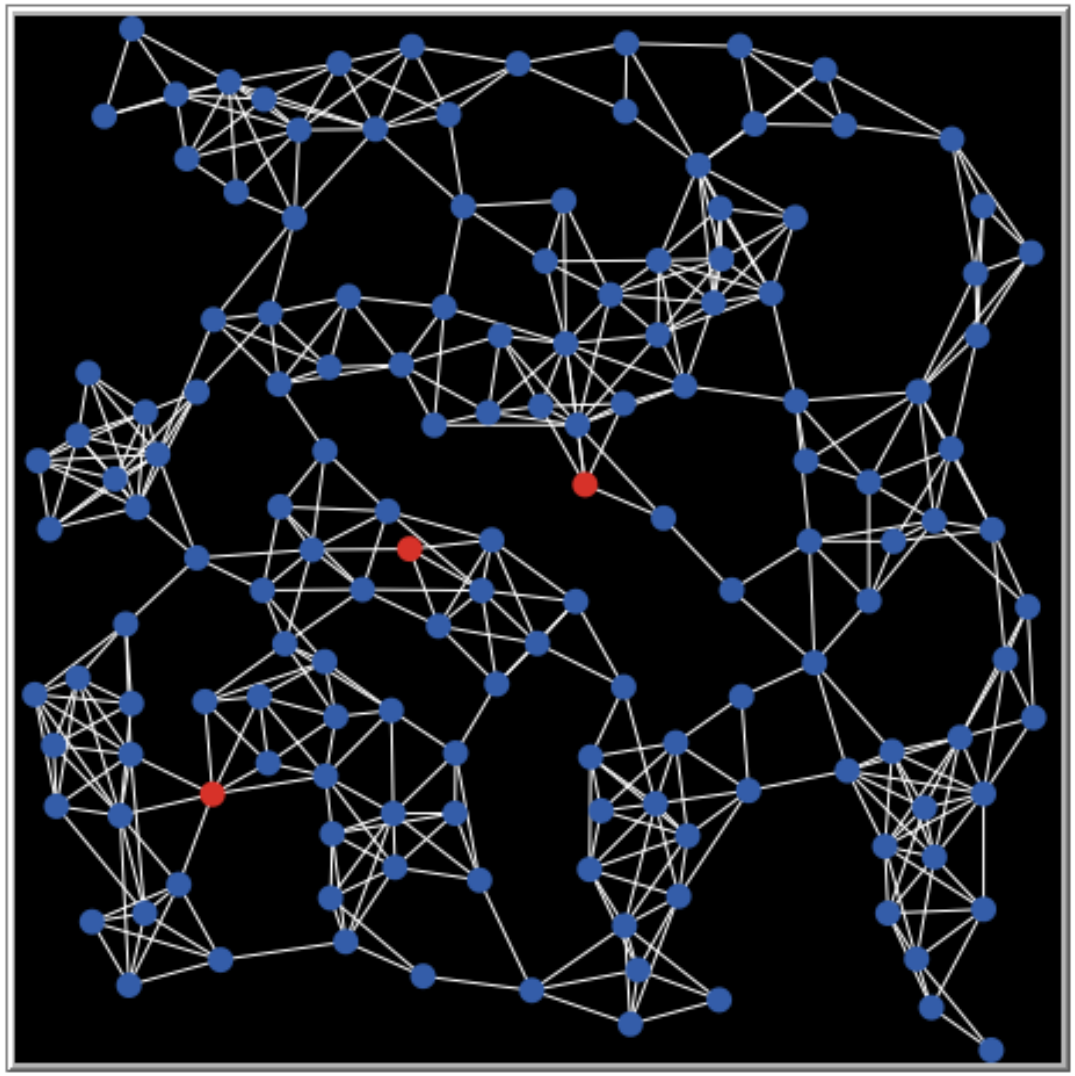
$$\begin{cases} \dfrac{dS}{dt} = -\dfrac{\beta I S}{N}, \\ \dfrac{dI}{dt} = \dfrac{\beta I S}{N} - \gamma I, \\ \dfrac{dR}{dt} = \gamma I, \end{cases}$$



What about different rate of contacts?

Models Library > Networks > Virus on a Network





Modeling philosophy and data integration

Why don't we add this and that?

- The KISS principle (Keep It Simple Stupid)
- Gradual process of development
- "All models are wrong, but some are useful" - Box (1987)

What about data?

- Calibration
- Validation

The end

Any questions?