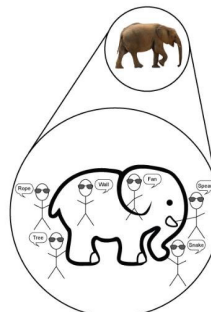


Think – Write – Pair – Share

- What is a model?
- What is modeling?

A model is a simplified, abstract or concrete representation of relationships and/or processes in the real world, constructed for some purpose

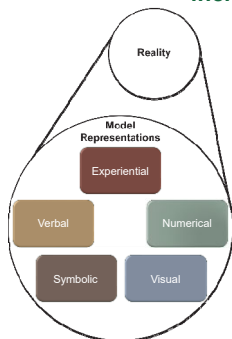


Models can serve several purposes:

- Models are used to communicate ideas between scientists.
- Simple, unrealistic models help scientists explore complex systems.
- Models can lead to the development of conceptual frameworks and causal explanations (i.e., understanding)
- Models can make accurate predictions.

Eaton et al. (2016) <https://arxiv.org/abs/1607.02165v2>; Odenbaugh (2005)

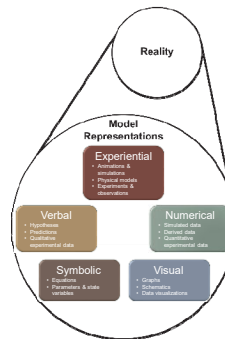
We aim to be both more expansive and more inclusive of what counts as models



What's the big deal?

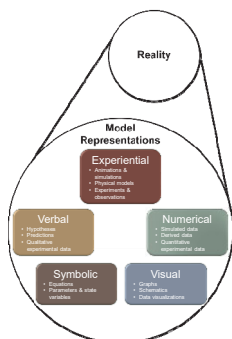
- Models are not *only* formulas.
- Understanding is strengthened when you can make connections between different representations.
- You may prefer working with certain representations, but you will benefit the most from seeing and using multiple representations and from moving between them.

Verbal Representation



- **Hypothesis:** A mutation in a particular gene will reduce the rate of bacterial growth because the mutation impairs DNA replication.
- **Prediction:** On average global temperature will increase.
- **Assumption:** We assume that the population is well mixed.
- **Simple descriptions of observations:** The rate of increase is decreasing; we observe far more of the blue flower type than the purple flower type.
- **Qualitative data:** Spiciness ratings by tasters of chili peppers.

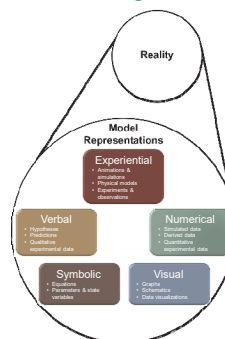
Visual Representation



- **Graph:** relative growth rate versus population
- **Schematic:** SIR epidemic model; stock-and-flow diagrams
- **Data visualizations:** histograms, scatter plots, infographics, etc.

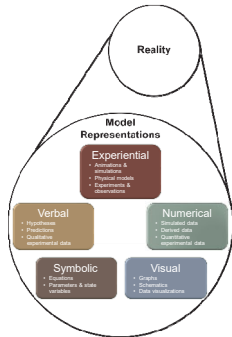
Symbolic Representation

a.k.a. mathematical model



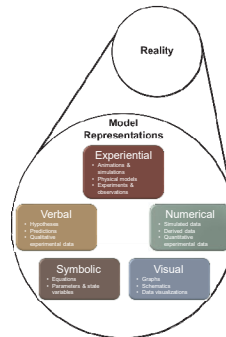
- **Equations:** Discrete difference equation for geometric growth $x_{n+1} = \lambda x_n$ and continuous differential equation for exponential growth $dP/dt = rP$
- **Parameters:** If in HWE, p = frequency of one allele, p^2 = frequency of homozygotes for that allele
- **State variable:** $P(t)$ = population at time t (in years)
- **Equation (stats):** linear regression
- **Equation (stats):** probability distribution

Numerical Representation

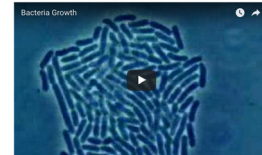


- **Simulated data:** Numbers of infected individuals calculated from a Symbolic epidemic model
- **Derived data:** low density growth rate and carrying capacity calculated from plotting relative growth rate versus population for logistic growth
- **Quantitative Experimental Data:** Measured population counts from experiments

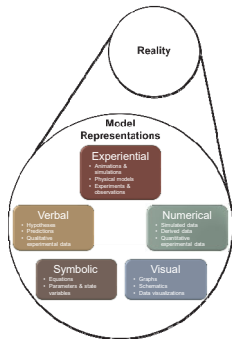
Experiential Representation



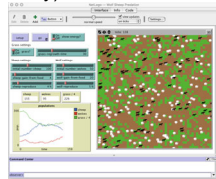
- **Animations & simulations:** A video of bacterial growth; beanbag biology; virtual laboratories (e.g, SimBio, the BUGBOX-predator virtual laboratory)



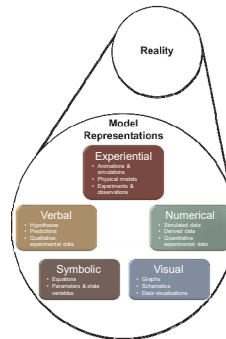
Experiential Representation



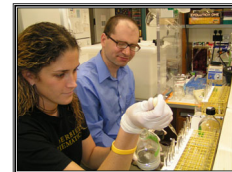
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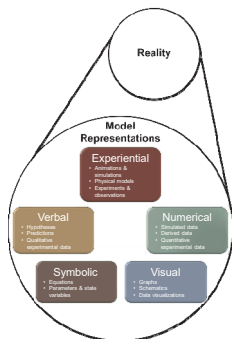
Experiential Representation



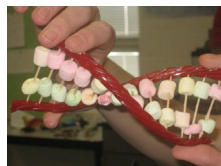
- **Experiments & observations:** measure bacterial growth in the laboratory



Experiential Representation



- **Physical model:** structure of DNA



The Process of Modeling Is the Process of Science

