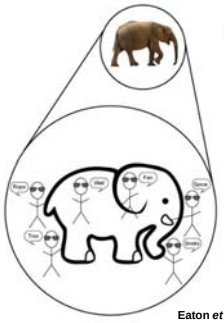
Think – Write – Pair – Share

- **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

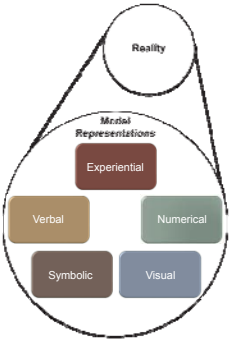


Models can serve several purposes:

- **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)

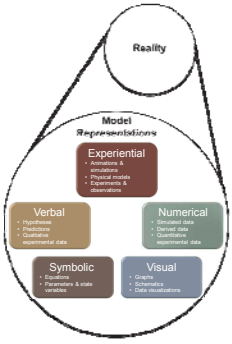
We aim to be both more expansive and more inclusive of what counts as models



What's the big deal?

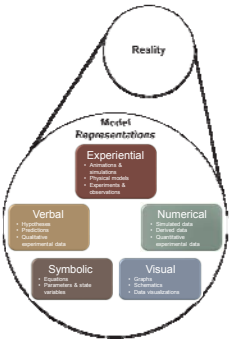
- **Models are not *only* formulas.**
- **Understanding is strengthened when you can make connections between different representations.**
- **You may prefer working with certain representations, but you will benefit the most from seeing and using multiple representations and from moving between them.**

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.

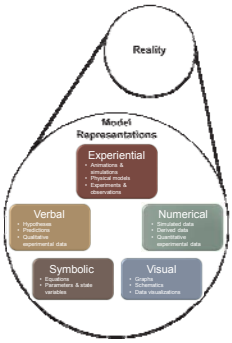
Visual Representation



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

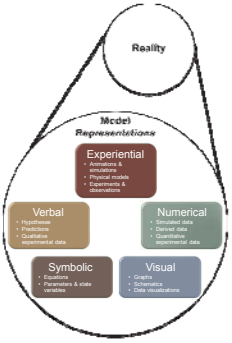
Symbolic Representation

a.k.a. mathematical model



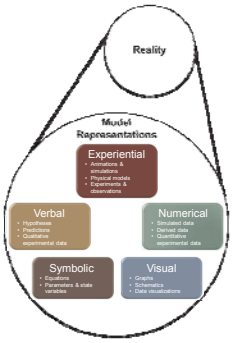
- **Equations**: Discrete difference equation for geometric growth $x_{n+1} = \lambda x_n$ and continuous differential equation for exponential growth $dP/dt = rP$
- **Parameters**: If in HWE, p = frequency of one allele, p^2 = frequency of homozygotes for that allele
- **State variable**: P(t) = population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

Numerical Representation

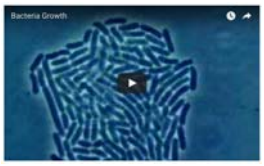


- **Simulated data**: Numbers of infected individuals calculated from a Symbolic epidemic model
- **Derived data**: low density growth rate and carrying capacity calculated from plotting relative growth rate versus population for logistic growth
- **Quantitative Experimental Data**: Measured population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

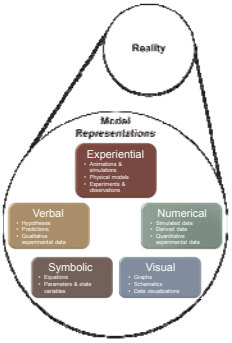
Experiential Representation



- **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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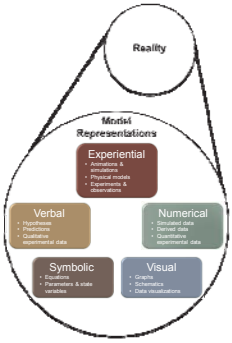
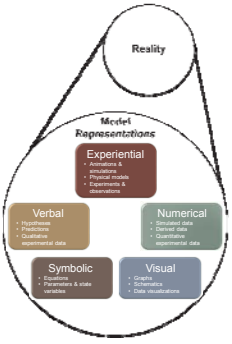
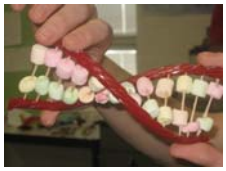


- **Experiments & observations**: measure bacterial growth in the laboratory

Experiential Representation



- **Physical model**: structure of DNA



The Process of Modeling Is the Process of Science