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.

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
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.

Numerical Representation

- Simulated data
- Derived data
- Quantitative experimental data

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