Lecture 1
Overview of Modeling

Lesson Outcomes

At the end of this lesson, you should be able to

1. discuss what a model is;
2. describe the mathematical modeling process;
3. identify the components of an optimization model; and
4. formulate a basic optimization model.

Introduction to Modelling

What comes to mind when you think of a model?

Do not edit
How to change the design

ⓘ The Slido app must be installed on every computer you're presenting from

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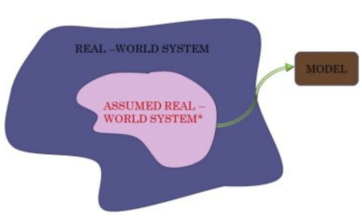
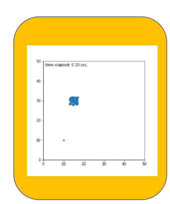
How do we understand biological and physical phenomena through mathematics?



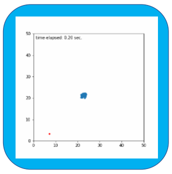
A **Model** is a simplified **representation** of some real-world entity or phenomenon intended to **mimic essential features** while leaving out inessentials.

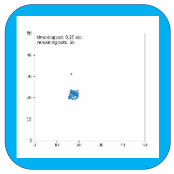




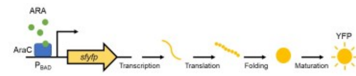
Mathematical model as equation: Exponential Growth: $P(t) = P_0 e^{kt}$

Mathematical model as computer simulation:

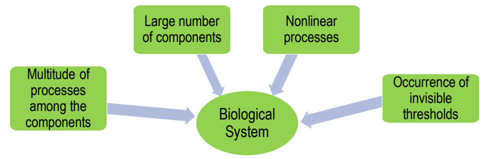




Characteristics of Physical and Biological Systems



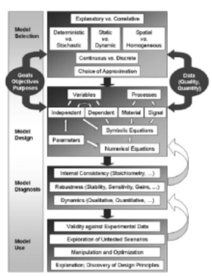
YFP production in *E. coli*



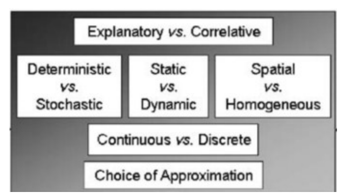
The modeling cycle

Steps of modeling complex biological systems (Voit et al., 2008)

4-Phase Representation
- ***Model selection***
- ***Model design***
- ***Model diagnosis***
- ***Model use***



The modeling cycle - Model Selection



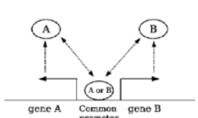
Example

PHYSICAL REVIEW E 75, 021904 (2007)

Stochastic simulations of genetic switch systems

Adiel Loinger,[1] Azi Lipshtat,[2] Nathalie Q. Balaban,[1] and Ofer Biham[1]

In this challenge, we will analyze a genetic toggle switch using stochastic methods. In this simple genetic circuit, two proteins, A and B, negatively regulate each other's synthesis. The regulation is performed at the transcription level, namely the production of protein A is negatively regulated by protein B, through binding of copies of B to the A promoter, and vice versa. Suppose that there is an overlap between the promoters of A and B. As a result, there is no room for both A and B proteins to be bound simultaneously (see Figure below).



Example

Network Modeling Analysis in Health Informatics and Bioinformatics (2021) 10:17
https://doi.org/10.1007/s13721-021-00295-6

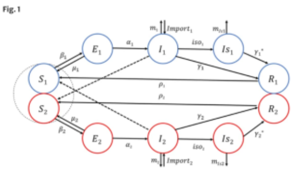
ORIGINAL ARTICLE

A mathematical model of COVID-19 transmission between frontliners and the general public

Christian Alvin H. Buhat[1,2] · Monica C. Torres[1,2] · Yancee H. Olave[1,2] · Maica Krizna A. Gavina[1,2] · Edd Francis O. Felix[1,2] · Gimelle B. Gamilla[1,2] · Kyrell Vann B. Verano[1,2] · Ariel L. Babierra[1,2] · Jomar F. Rabajante[1,2,3]

In this study, a conceptual mathematical model on the transmission dynamics of COVID-19 between the frontliners and the general public was formulated

Fig. 1



What is simulation modeling?

Simulation is the complete process of the forecasting or replication of a certain scenario. Nowadays, usually referred to as *computer simulation*.

In a tight sense, what simulation refers to is just the actual computation.

Simulation involves replicating the actual behavior to collect data (indirectly) and to test effects of various alternatives.

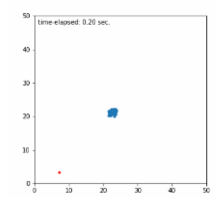
Consider a group of communicating individuals whose goal is to get to a food source.

1. One of them knows where the food source is.
2. Individuals follow where its neighbors are going.

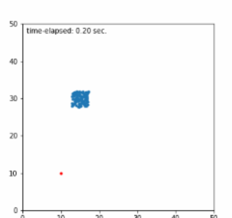
Q1: What will happen when the strength of social interaction is high?

Q2: What will happen when the strength of social interaction is low?

Q1: What will happen when the strength of social interaction is high?



Q2: What will happen when the strength of social interaction is low?



Advantages of Simulation Modeling in Science

a) Ease of use compared to "real" experiments
b) Time-saving
c) Cost-effective
d) Versatile, and many more…

End