
Georgia Tech

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EMORY UNIVERSITY

# BMED 2110: CONSERVATION PRINCIPLES IN BIOMEDICAL ENG

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## INTRODUCTION TO MODELS

SPRING 2021

CREATING THE NEXT®

# OUTLINE

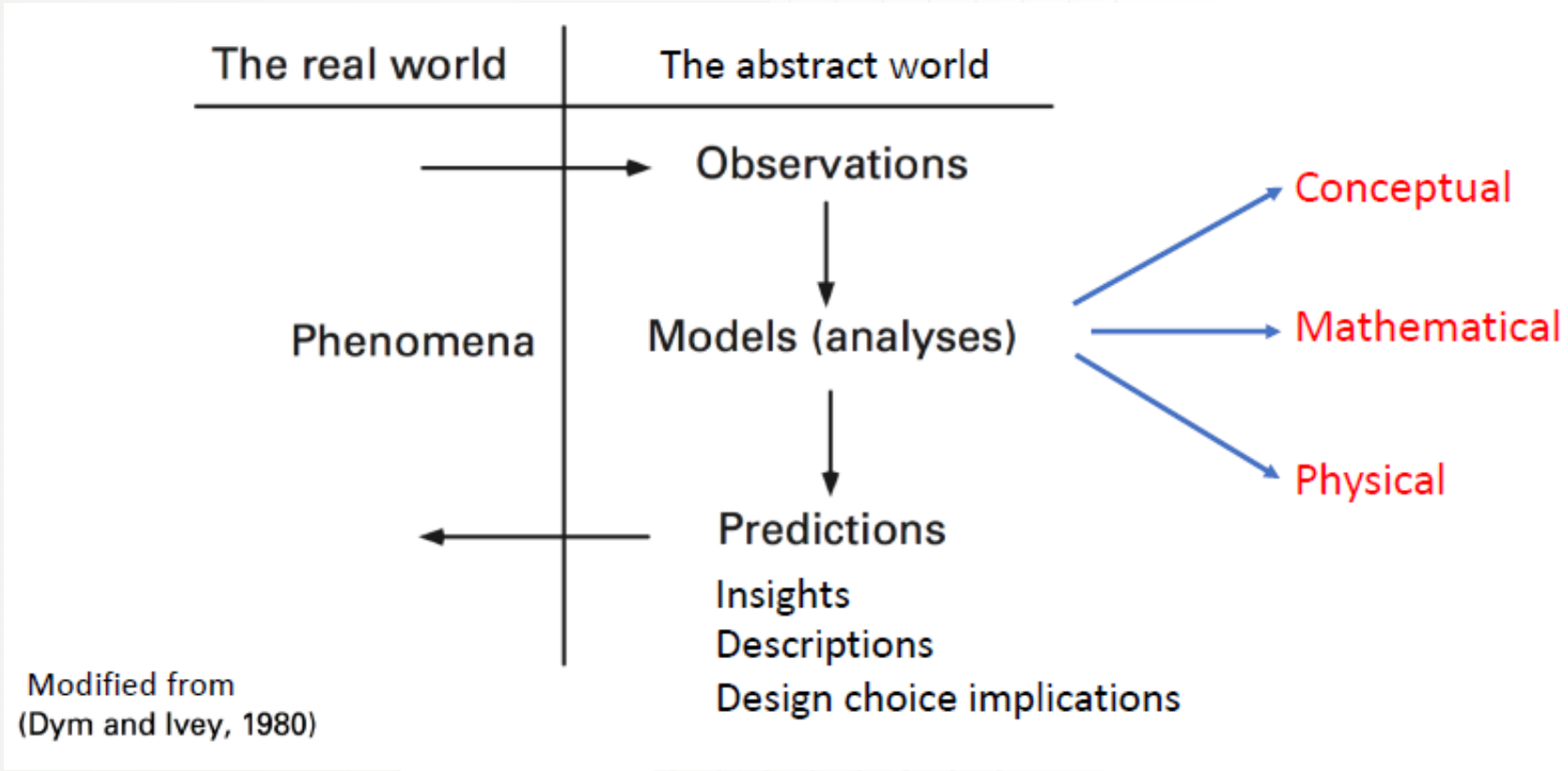
- Project Rationale
- Models: Conceptual vs Mathematical
- Where are we in our project status
- Important note about specification grading
- Project's Rubric (see Video B)
- Notes about citation

# DESCRIBE YOUR SEMESTER SO FAR IN A WORD

# ENGINEERS AND MODELS

- Engineers DESIGN devices, processes and systems.
- To design these, engineers use MODELS to describe, explain and predict the behavior of these devices, processes and system.
- These are two distinguishing features of engineering: Design and Model-based reasoning.

# HOW ENGINEERS KNOW WHAT THEY KNOW



# YOU WILL SEE MODELING MULTIPLE TIMES

| Conceptual | Mathematical | Physical/ for experiments | Physical for design |
|---|---|---|---|
| BMED 3100 | BMED 2110 | BMED 3110 | BMED 2250 |
| BMED 3600 | BMED 2400 | BMED 3610 | BMED 2310 |
| BMED 2250 | BMED 3310 | | BMED 4602 |
| | BMED 3400 | | |
| | BMED 3520 | | |

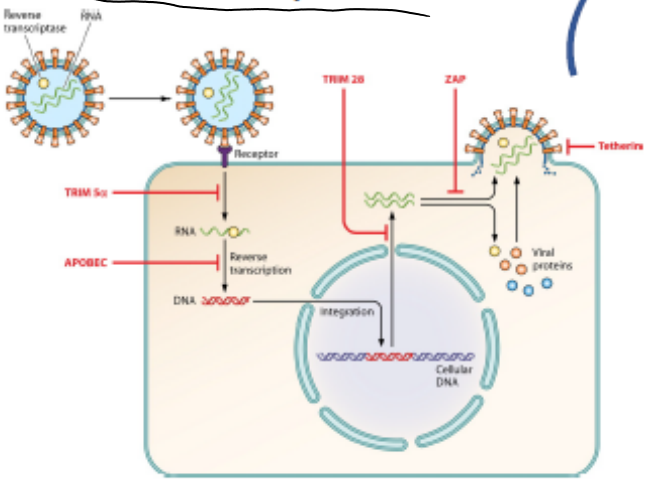
# WHAT IS A MODEL?

- A simplified representation of a real-world situation used to help answer a simplified question.

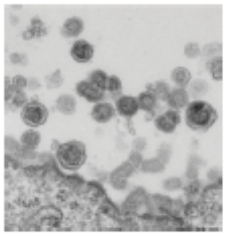
- Simplifying: It is important to preserve the properties of the system that are relevant to the question.

- Detail vs complexity: A good model has as low complexity as possible while retaining the relevant details needed to answer the specific question the model is designed to examine.

# Conceptual

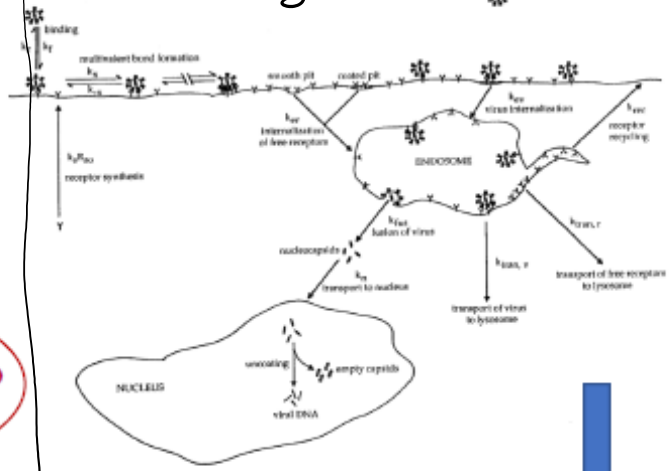



REAL WORLD?



PHYSICAL MODELS

DATA / OBSERVATIONS




# Mathematical

$$\frac{dV_1}{dt} = (\alpha k_f C)V_{ex}R_{sf} - k_r V_1 - (j-1)k_x V_1 R_{sf} + 2k_{-x}V_2 - k_{ev}V_1$$

# THE FULL MODEL AND AN EXAMPLE OF ITS USE

**Table I.** Analytical solutions of trafficking model when receptors are excess.

$$V_{cc} = V_{exo}e^{-k_a C t}$$

$$V_s = \frac{k_a C V_{exo}}{k_{ev} - k_a C}\left(e^{-k_a C t} - e^{-k_{ev} t}\right)$$

$$V_{int} = \frac{V_{exo}}{k_{ev} - k_a C}\left[k_a C\left(e^{-k_{ev} t} - 1\right) - k_{ev}\left(e^{-k_a C t} - 1\right)\right]$$

$$V_{endosome} = \delta V_{exo}\left[\frac{1}{\alpha}\left(e^{-k_a C t} - e^{-\phi t}\right) - \frac{1}{\theta}\left(e^{-k_{ev} t} - e^{-\phi t}\right)\right]$$

$$V_{cytosol} = \delta k_{fus} V_{exo}\left\{\frac{1}{\alpha}\left[\frac{1}{k_n - k_a C}\left(e^{-k_a C t} - e^{-k_{ev} t}\right) - \frac{1}{k_n - \phi}\left(e^{\phi t} - e^{-k_{ev} t}\right)\right] - \frac{1}{\theta}\left[\frac{1}{k_n - k_{ev}}\left(e^{-k_{ev} t} - e^{-k_{ev} t}\right) - \frac{1}{k_n - \phi}\left(e^{-\phi t} - e^{-k_{ev} t}\right)\right]\right\}$$

$$V_{nuclear} = \delta k_n k_{fus} V_{exo}\left\{\frac{1}{\alpha(k_n - k_a C)}\left[\frac{1}{k_a C}\left(1 - e^{-k_a C t}\right) + \frac{1}{k_n}\left(e^{-k_{ev} t} - 1\right)\right] - \frac{1}{\alpha(k_n - \phi)}\left[\frac{1}{\phi}\left(1 - e^{-\phi t}\right) + \frac{1}{k_n}\left(e^{-k_{ev} t} - 1\right)\right] - \frac{1}{\theta(k_n - k_{ev})}\right.$$
$$\left.\left[\frac{1}{k_{ev}}\left(1 - e^{-k_{ev} t}\right) + \frac{1}{k_n}\left(e^{-k_{ev} t} - 1\right)\right] + \frac{1}{\theta(k_n - \phi)}\left[\frac{1}{\phi}\left(1 - e^{-\phi t}\right) + \frac{1}{k_n}\left(e^{-k_{ev} t} - 1\right)\right]\right\}$$

$$\delta = \frac{k_{ev} k_a C}{k_{ev} - k_a C};\ \alpha = k_{fus} + k_{tran,r} - k_a C;\ \phi = k_{fus} + k_{tran,r};\ \theta = k_{fus} + k_{tran,r} - k_{ev}$$

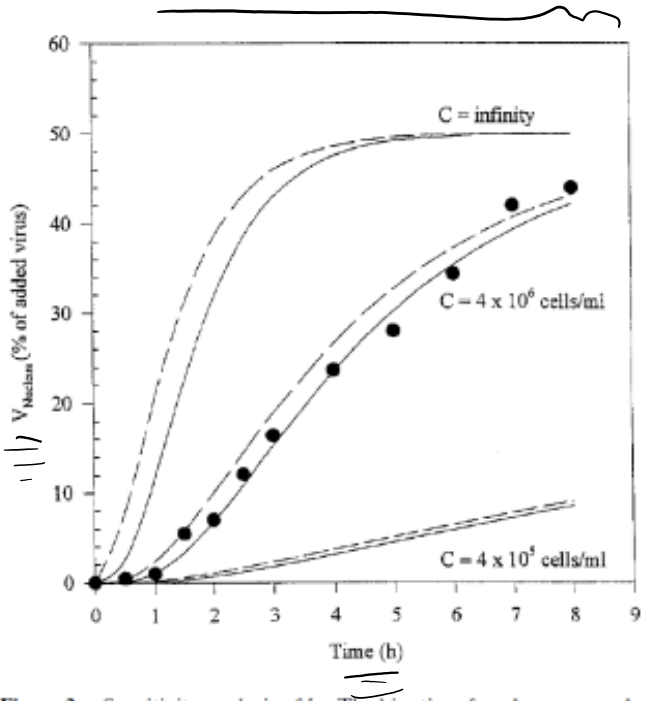
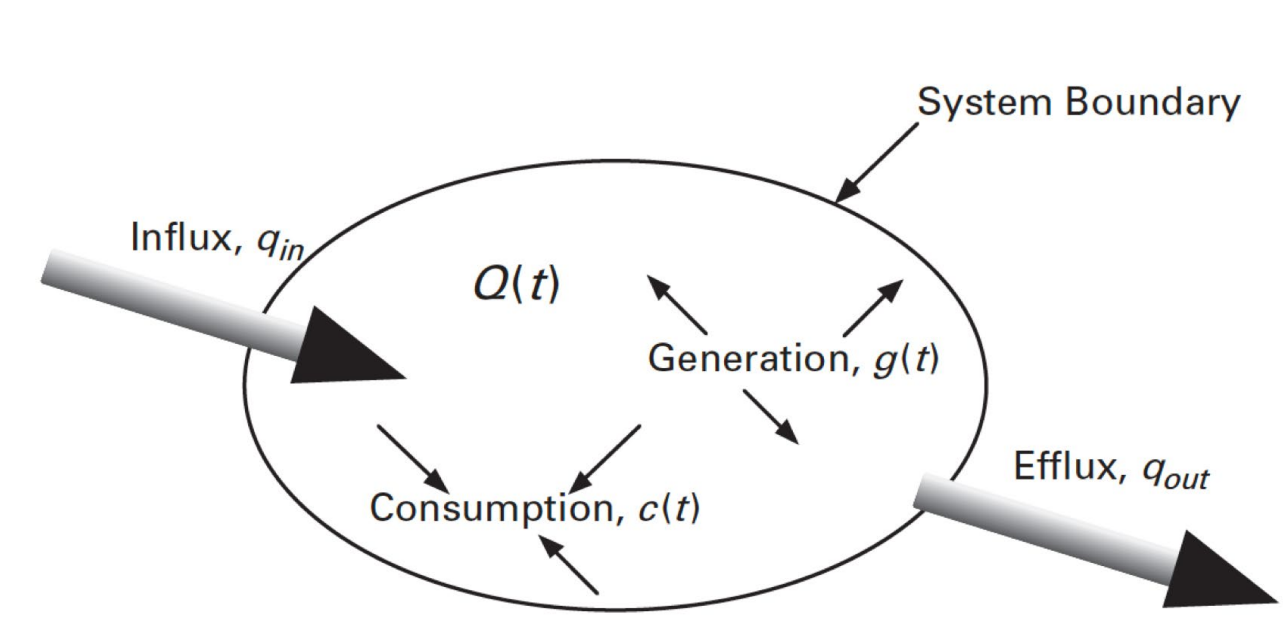



**Figure 3.** Sensitivity analysis of $k_n$. The kinetics of nuclear accumulation was simulated with Eq. 17 using $k_a = 1.3 \times 10^{-9}$ cm$^3$/cell·min, $k_{ev} = 0.023$ min$^{-1}$, $k_{fus} = 0.01$ min$^{-1}$, and different $k_n$ and cell densities. (——) $k_n = 0.04$ min$^{-1}$; (---) $k_n \to \infty$; (●) experimental data at $4 \times 10^6$ cells/mL.

# WHERE DO WE USUALLY BEGIN?

- When we develop mathematical models, we often begin with statements that indicate that some property of an object or system is being conserved.

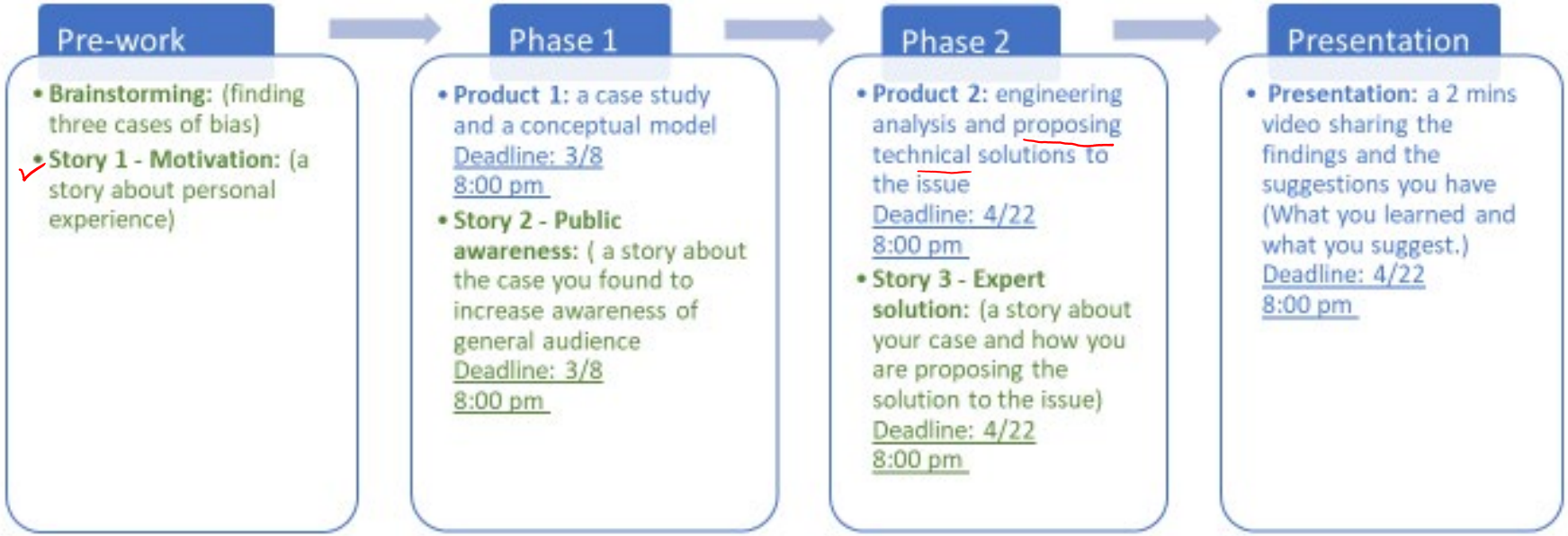


- Conceptual models
  - Theoretical constructs that visually represent the processes, relationships, and variables considered important to the question at hand
  - Provide insight into why a given situation exists and/or what its driving factors are
  - Do not provide specific numerical results – they can't be run or used to test hypotheses

- Mathematical models

  diagram + equation

  - Uses the language and tools of mathematics to describe our theoretical understanding – our model – of how a system works
  - Describes the system with a set of variables and equations that establish quantitative relationships between these variables
  - Are executable: they can be "run" and therefore used to study the implications of our theoretical understandings on the systems' behavior


Pre-work
• Brainstorming: (finding three cases of bias)
• Story 1 - Motivation: (a story about personal experience)
Phase 1
• Product 1: a case study and a conceptual model
Deadline: 3/8
8:00 pm
• Story 2 - Public awareness: ( a story about the case you found to increase awareness of general audience
Deadline: 3/8
8:00 pm
Phase 2
• Product 2: engineering analysis and proposing technical solutions to the issue
Deadline: 4/22
8:00 pm
• Story 3 - Expert solution: (a story about your case and how you are proposing the solution to the issue)
Deadline: 4/22
8:00 pm
Presentation
• Presentation: a 2 mins video sharing the findings and the suggestions you have (What you learned and what you suggest.)
Deadline: 4/22
8:00 pm

# SPECIFICATION GRADING

- Each assignment's rubric consists of sections (level 1) and criterion (level 2).
- You will be graded based on level 2, specifications (criteria).
- You should have a satisfactory level of contents to get passing grade for each specification.
- The grade for specifications is pass/fail, there is no partial credit within specifications.
- Prepare your draft by Next Monday so you can check it on Monday and Tuesday.

# ACCEPTANCE LEVEL (SATISFACTORY LEVEL)

1. Ready as is to be presented in a student based, research conference such BMES student section or PURA research symposium
2. With minor modification it will be presentable to a student symposium
3. With changing of some features it can be presented

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4. It can not be presented unless a significant portion of it should be changed or re done.
5. fundamental scientific and technical issues exists in the analogy which requires re doing of project.

# HOW TO USE AND CITE A PAPER

- In text mentioning of the paper:
  You should cite the paper you used in your manuscript, by by mentioning name of the author and the year of publication.
  Example: (Collino, 2013).

- Bibliography (or list of references)

Collino, M., Benetti, E., Rogazzo, M., Mastrocola, R., Yaqoob, M. M., Aragno, M., & ... Fantozzi, R. (2013). Reversal of the deleterious effects of chronic dietary HFCS-55 intake by PPAR-δ agonism correlates with impaired NLRP3 inflammasome activation. *Biochemical Pharmacology*, *85*(2), 257-264. doi:10.1016/j.bcp.2012.10.014

# TAKE THE FOLLOWING ASSESSMENT

- To confirm that you have fully understood these concepts we want you to participate in the following self assessment:

https://gatech.co1.qualtrics.com/jfe/form/SV_erqqQwxEg8YSyii