

Research Paper Template

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Abstract

A 150–200 word summary of your work goes here. Here is an example of an abstract:

Insulin resistance, characterized by a reduced cellular response to insulin, is a major factor in type 2 diabetes pathogenesis, with a complex etiology consisting of a combination of environmental and genetic factors. Oxidative stress, which develops through an accumulation of toxic reactive oxygen species generated by mitochondria, is believed to contribute to insulin resistance in certain tissues. We develop mathematical models of feedback between reactive oxygen species production and dysfunction in mitochondria to provide insight into the role of oxidative stress in insulin resistance. Our models indicate that oxidative stress generated by glucose overload accelerates irreversible mitochondrial dysfunction. These models provide a foundation for understanding the long-term progression of insulin resistance and type 2 diabetes.

1 Introduction

This section should include an analysis of the main problem. You should make the assumption that the audience is intelligent, but not knowledgeable about the current topic. You therefore need to introduce the circumstances in which the particular problem arises, giving sufficient description. Give sufficient background information that will help the reader as you build the model later. In addition, clearly explain the problem and the purpose of the study undertaken.

1.1 Basic Scientific Writing Tips

As you write your report, please consider the following tips for success.

- Grammar matters! Not only is it important to write with correct grammar, but it is also important to pay attention to mathematical grammar. This means that you need to be aware of how your English phrases connect to your mathematical phrases. The result should be a series of complete sentences. Consider the following example.

Example 1: To solve the quadratic equation $x^2 + 4x - 5 = 0$:

$$x^2 + 4x - 5 = 0$$

$$(x + 5)(x - 1) = 0$$

$$x = -5, 1$$

Compare this to the alternative, Example 2.

Example 2: To solve the quadratic equation $x^2 + 4x - 5 = 0$, we first wish to factor the left-hand side of the equation. This gives

$$(x + 5)(x - 1) = 0.$$

Setting each individual factor equal to 0, we obtain the two linear equations

$$x + 5 = 0 \text{ and } x - 1 = 0.$$

Finally, solving for x gives two solutions, $x = -5$ and $x = 1$.

Between these two examples, it is clear that Example 2 illustrates how mathematical writing and English need to combine to create complete, grammatically correct, sentences. Otherwise, the reader is left to guess the meaning, which is not what you want. Note also that is common practice to avoid starting a sentence with a mathematical symbol. For example, you would avoid the following sentence structure.

Example 3: x is the state variable of the equation.

- Scientific writing is formal writing. You should avoid the use of slang and contractions.
- Your L^AT_EX document should not be your first attempt at compiling the work for your scientific report. In other words, you should have completed the analysis and obtained results for the model you're working with *prior to* writing up the report.
- Be thorough, yet succinct. Include all necessary details to construct a cohesive picture of the work you've done, but avoid focusing on tiny details that distract from the big picture.
- Understand your work! Hopefully, this is self-explanatory, but the explanations you provide (or lack) will give a very good idea of how much of your work you actually understand. If there are any lingering questions as you compile your report, please be sure to have them answered, rather than glossing over important details.

- All graphs and tables should have captions. Graphs should have **legible** axes, axis labels, and other text. Your graphs should also be an appropriate size for the report (i.e., not take up a full page unless absolutely necessary). You can use scaling options in L^AT_EX to ensure this. Tables should have appropriate column/row labels, where applicable.
- Proofread, proofread, proofread! Everything. Always.

2 Model Design

Here is where you explain the details of the model. Depending on the model, this section may be relatively short. In other cases, it may require a great deal more detail. It depends. In any case, you will want to state the simplifying assumptions for the model and explain why the decision for such simplifications were made. In addition, you may wish to add diagrams that illustrate visually the relationships between variables. This will help the reader understand the model.

When you generate a system of equations, you may want to be able to refer to the entire set of equations simultaneously. To do this, you can use the `subequations` environment.

$$S'_L(t) = \Omega - \frac{\beta_1^L I + \beta_2^L D + \beta_3 R_I}{N} S_L - \varepsilon \rho_L S_L + \sigma_L S_H - \sigma_H \frac{I + \hat{I} + D + \hat{D}}{N} S_L - \mu S_L \quad (1a)$$

$$S'_H(t) = -\frac{\beta_1^H I + \beta_2^H D}{N} S_H - \varepsilon \rho_H S_H + \sigma_H \frac{I + \hat{I} + D + \hat{D}}{N} S_L - \sigma_L S_H - \mu S_H \quad (1b)$$

$$S'_W(t) = \psi(\phi + I + \hat{I} + D + \hat{D}) - \frac{\beta_1^W \hat{I} + \beta_2^W \hat{D}}{N} S_W - \varepsilon \hat{\rho} S_W - \mu S_W \quad (1c)$$

$$\begin{aligned} & \vdots \\ V'_W(t) &= \varepsilon \hat{\rho} S_W - \mu V_W \end{aligned} \quad (1d)$$

To generate a flow diagram of your model, use drawing capability of the Tikz package. Figure 1 (copied from [3] with permission of the authors) shows an example of a flow diagram generated with Tikz. The example in Figure 1 shows how to make use of color coding and non-straight arrows, if needed. Note that figure captions always appear below the figure.

If your model has several parameters, it may be helpful to include a parameter table. The `booktabs`, `siunitx`, and `array` packages provide commands for creating an aesthetically pleasing, publication ready table. Note that table captions always appear above the table. Table 1 is copied from [2] with permission of the authors.

Lastly, you should note that L^AT_EX will not always place the figures or table in the same relative location that they appear in the L^AT_EX code. Do not worry about fiddling with figure and table placement within the document until you have all of the text of the manuscript written.

3 Methods

In this section, you should describe the methods and techniques you used to solve the model/problem. You should also describe the solution itself. Sometimes, this section will contain the detailed mathematical analysis of a model. (Be sure you can identify the difference between model solutions and model analysis). Along with Section 2, this is typically the most mathematics-intensive component of the scientific report. You also want to be careful to give enough detail without spelling out every single step (e.g., omitting

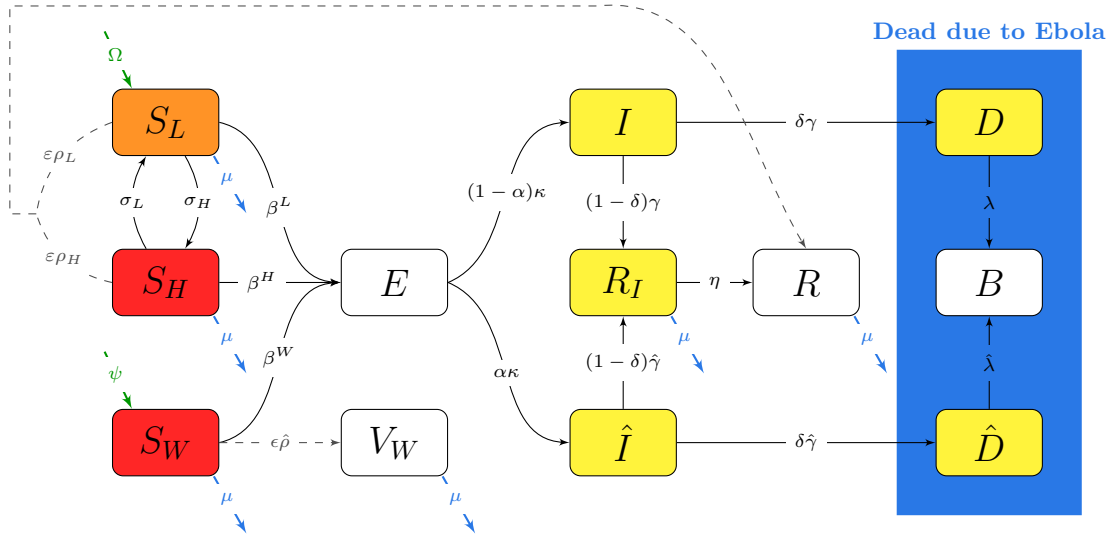


Figure 1: Flow diagram of the model given in System (1). Shaded compartments indicate high risk of exposure (red), low risk of exposure (orange), and ability to transmit EVD (yellow). Green arrows indicate movement into the population, blue arrows indicate background death, and dashed line arrows indicate vaccination.

Table 1: Values of parameters used in simulations of the model described in Section 2.

Parameter		Value
k_A	Cancer cell growth rate (hours ⁻¹)	0.008 165
k_H	Healthy cell growth rate (hours ⁻¹)	2.108 703
M_A	Relative carrying capacity of A cells in 1 mm layer of tissue	0.225
M_B	Relative carrying capacity of B cells in 1 mm layer of tissue	0.675
μ_A	Effective diffusion rate for A cells	0.133 642
μ_H	Effective diffusion rate for H cells	0.131 166
α	Maximum cell death rate at depth i from a single treatment	0.02
β	Determines range over which the majority of cell death occurs	0.0075
δ	Hours after treatment at which cell death rate is maximized	47

extensive algebra, even if the process took you a while). This is also the section that often contains the most errors, so be sure to proofread this section carefully!

4 Results

Results usually contain data in tables or graphs that illustrate the behavior of the model/mathematical work. You can describe the overall details of the tables/figures, but you can save your interpretation of the results for the discussion in Section 5. It's okay if this distinction is unclear at first; there is a fine line between results and discussion. But perhaps the best way to think about it is a result describes *what happened*, whereas the discussion explains *why* it happened and interprets the meaning of the result itself, often to connect the math back to the original problem.

Depending on your results, it may be beneficial to use subfigures within a single figure. Figure 2, shows an example of how to use the `subfloat` command (using the `subfig` package) to generate subfigures. Note that each subfigure has a short caption and the entire figure has a longer caption which applies to the entire set of figures. Figure 2 is reproduced from [2] with permission from the authors.

5 Discussion

As mentioned in Section 4, this section pulls all of the work you have done together. It presents an explanation and interpretation of model results, while also outlining the potential implications of the current work (for future work/modifications). You can also use this section to generate recommendations and conclusions from the model solution. When applicable, it may also be appropriate to identify any shortcomings of the model and discuss how additional modifications might affect the results.

A Further Calculations

You may include an appendix that contains extended calculations that are not suitable to display in the Model Designs or Methods sections. You can also use an appendix to provide supplementary information.

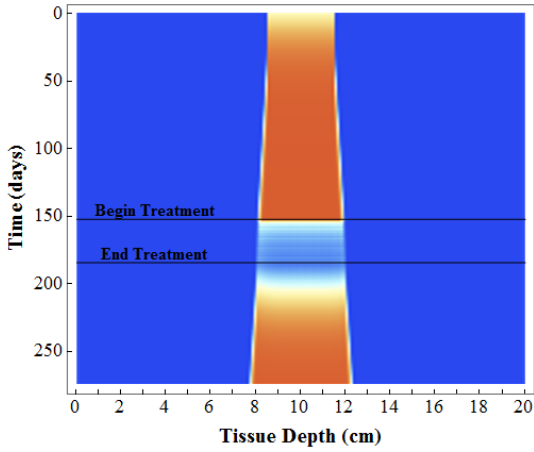
B Source Code

B.1 Code written for xxxx

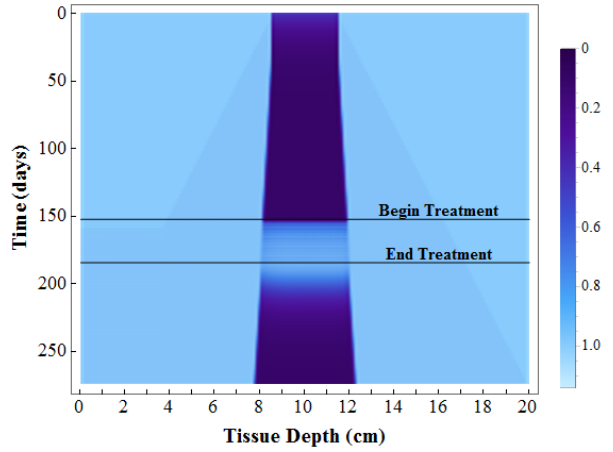
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% insert code here, verbatim
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References

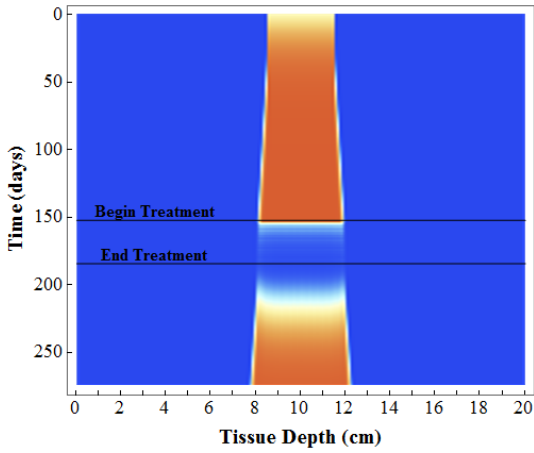
- [1] Binney, J.J., Dowrick, N.J., Fisher, A.J. and Newman, M.E.J. (1992), The Theory of critical phenomena: An introduction to the renormalization group. Clarendon Press, Oxford, UK.



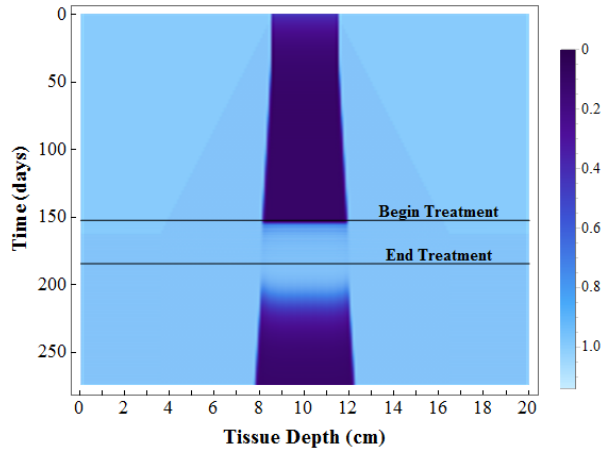
(a) Cancer cells ($A + B$); Non-conformal treatment



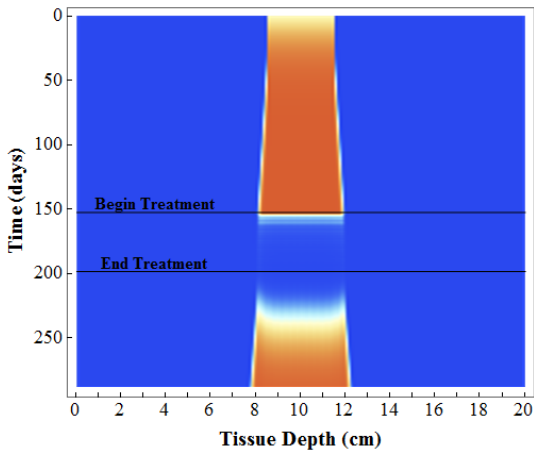
(b) Cancer cells (H); Non-conformal treatment



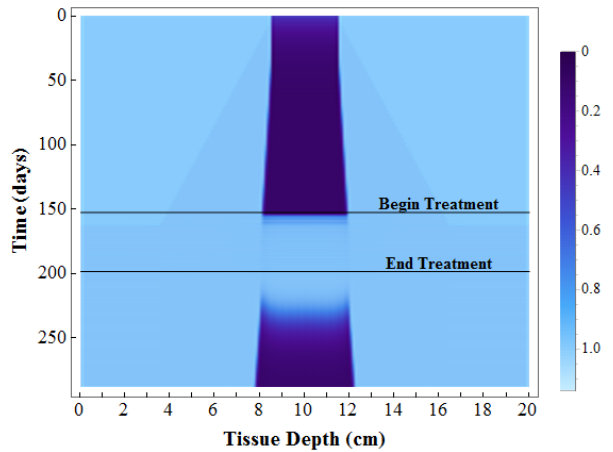
(c) Cancer cells ($A + B$); Conformal treatment A



(d) Cancer cells (H); Conformal treatment A



(e) Cancer cells ($A + B$); Conformal treatment B



(f) Cancer cells (H); Conformal treatment B

Figure 2: Simulation of the growth and treatment of a hepatocellular carcinoma for each of the treatment courses: non-conformal (top row), conformal A (middle row), conformal B (bottom row). The color bars on the right show the value of $A_t^i + B_t^i$ (left column) and H_t^i (right column) for a given tissue depth i and time step t .



Figure 3: If you send your paper off for publication, you will first need to go through the peer-review process. Reproduced from [4].

- [2] Bodine, E.N., and Monia, K.L. (2017). A Proton Therapy Model using Discrete Difference Equations with an Example of Treating Hepatocellular Carcinoma. *Mathematical Biosciences & Engineering*, 14 (4), 881–899; doi:10.3934/mbe.2017047.
- [3] Bodine, E.N., Cook, C., and Shorten, K. (2018). The Potential Impact of a Prophylactic Vaccine for Ebola in Sierra Leone. *Mathematical Biosciences & Engineering*, 15 (2), doi:10.3934/mbe.2018015.
- [4] Cham, J. (2016). PhD Comics. <http://phdcomics.com/comics.php?f=1900>.