

Case Study 1: Morphogen Gradients in Development of Elliptical Embryos

Transport in Biological Systems

Fall 2015

Overview

In this Case Study, you will further develop your ability to manipulate and understand key approaches to diffusive processes. We do this by considering a paper that looks at concentration profiles in *Drosophila* embryos. You will reproduce the figures in the paper and extend or explore the model. We will split work on the following items between in-class time and out-of-class time.

Reading Assignment

The paper, *Diffusion and scaling during early embryonic pattern formation*, by Gregor *et al.* presents biological and modeling data on Bicoid gradient formation during *Drosophila* development. Skim the other Gregor paper and the paper by Castle *et al.* provided as well. For class on Thursday, September 17th, read these articles and be prepared to discuss them. To do so, you may wish to prepare a written document which contains:

1. a one sentence summary of every paragraph in the paper.
2. a one paragraph written description of the model used in this paper.
3. the relevant equations, initial conditions, and boundary conditions.

Objectives and Deliverables

The objective of this course is for you to apply concepts and skills in modeling and simulation to problems in biological transport. I therefore recommend that, as an individual, you develop your knowledge and abilities in all aspects of the course. Towards this objective, I believe that there is tremendous benefit in working with other people and highly recommend that you perform this work in groups of 2-3. I do not, however, want you to develop a divide and conquer strategy - ideally all members of your team will be committed to and engaged in developing integrated skills in modeling and simulation of problems in biological transport. This means that during working times, I should be able to ask any member of your group about any aspect of the work. For this case study, you should work with 1 or 2 other people.

This paper does not provide exhaustive details of their modeling. However, they do lay out their governing equations, boundary conditions, and initial conditions. Your task for this case study is to start by writing a clear review of this paper, with a much greater focus on the concepts relevant to diffusion and implications of the results (e.g. scaling due to λ , explanations for changing τ). You should set up a model in COMSOL to reproduce the relevant graphs from the paper. An adequate paper will complete this minimum requirement, while a stellar paper will perform some additional analysis, such investigation into alternate hypotheses

and how they would be manifested in the experimental and/or modeling results. Note that they reduce their system to 1D, which may be fine. However, some extensions of the model may require you to investigate 2D or 3D systems (which is where COMSOL becomes very handy). You could also choose to explore the system further by incorporating information from the newer, Castle *et al.* paper, *Assessment of Transport Mechanisms Underlying the Bicoid Morphogen Gradient*. Prepare your written review in the style of IEEE in which you present your results. Your document should be 3-4 pages and should include the following:

- title
- authors
- brief abstract
- introduction (includes background and significance)
- methods
- results and discussion, including relevant figures (no more than 4)
- references cited

The draft of this report is due electronically by midnight on September 24th. You will receive a review of the manuscript within a few days. The final report is due on October 1st.