KTH SOLID MECHANICS SEMINAR; Thursday, August 9th, 13.45; KTH Solid Mechanics Seminar room

David M. Umulis
"Delineating mechanisms of gradient formation by BMPs in zebrafish embryo development"

Mixing qualitative measurements, such as phenotype, with more quantitative measurements, such as measured biophysical rates or quantitative images, into "logical models" has driven discovery in experimental biology for decades. However, as the systems we are studying become more complex, there is a greater need for mathematical models to integrate the ensembles of data into mathematical models at multiple scales. We have developed methods that serve the back and forth between modeling and experiments and applied them to discern the mechanism of Bone Morphogenetic Protein (BMP) signaling along the dorsal/ventral axis in zebrafish embryos. During early development. a gradient of BMP signaling forms with a ventral peak and a dorsal minimum through the interplay of BMP ligands interacts with other secreted factors that shape the gradient. To inform models, we developed methods to quantify BMP signaling activity IN TOTO, and used the data to constrain mathematical models that test different hypotheses of gradient formation including counter-gradient, source-sink, transcriptional, and shuttling. We found that a source-sink mechanism provided the greatest correspondence between the simulation results and measurements for BMP gradient formation, however it required a relatively freely diffusing BMP ligand. We measured the diffusion of BMP-2b –Venus fusion protein and found it is diffusible with a diffusion coefficient of 4.4 micron2/sec, supporting the source-sink mechanism.

Dr. David Umulis works at the interface between developmental biology and engineering where he studies early embryonic development and spatial patterning using mathematical models, imaging, and tight model/data integration. These analyses enable society to understand the earliest stages of life and predict outcomes in quantitative detail and understand the regulation of molecules of significant clinical significance. Dr. Umulis' primary focus is on unraveling the mechanisms of Bone Morphogenetic Protein (BMP)-mediated regulation during development. Dr. Umulis has published over 40 items including journal articles, refereed conference proceedings, and five book chapters; graduated 9 Ph.D. students and 3 M.S. students; and assembled interdisciplinary research teams and acquired grant funding from the NIH, NSF, Showalter Trust, Mathworks®, and Purdue Research Foundation. Dr. Umulis joined the faculty of Purdue University in 2008 after completing a BSE from the University of Michigan and a PhD from the University of Minnesota- both in Chemical Engineering. Dr. Umulis' work is internationally recognized and he was awarded the Richard L. Kohls early Career Award in 2012.