

MATH 259: Mathematical and Computational Modeling in Biology and Medicine

M/W 12:30 PM - 1:50 PM, FALL, 2025

Skye 284

Instructor: Mark Alber, malber@ucr.edu, <https://profiles.ucr.edu/app/home/profile/malber>

Course description: This self-contained course introduces students to mathematical and computational multiscale predictive modeling approaches, model calibration and sensitivity analysis using AI/Machine learning approaches, with applications to biology and medicine. Examples include bacterial swarming, early development, and cancer growth. The course first describes models of chemotactic cellular responses, cellular growth and motion with applications to morphogenesis and cancer. This is followed by a description and a discussion of the coupling of signaling sub models with mechanistic cellular sub models based on particle systems approach. Course expectations include students collaborating in small groups on first providing review of a paper and on a small project to be presented in class on specific applications of multiscale modeling in biology and medicine. The course also includes two guest lectures by biomedical researchers from the City of Hope, one of the largest hospitals in Southern California.

References:

Leah Edelstein-Keshet, *Mathematical Models in Biology*, SIAM: Society for Industrial and Applied Mathematics; 1st edition (February 1, 2005).

Gerda de Vries, Thomas Hillen, Mark Lewis, Birgitt Schönfisch, Johannes Muller, *A Course in Mathematical Biology: Quantitative Modeling with Mathematical and Computational Methods*, SIAM: Society for Industrial and Applied Mathematics (July 1, 2006).

Vittorio Cristini and John Lowengrub, *Multiscale Modeling of Cancer: An Integrated Experimental and Mathematical Modeling Approach*, Cambridge University Press 2010.

Alber, M., Buganza Tepole, A., Cannon, W.R. *et al.* Integrating machine learning and multiscale modeling—perspectives, challenges, and opportunities in the biological, biomedical, and behavioral sciences. *npj Digit. Med.* **2**, 115 (2019).

Lopatkin, A.J., Collins, J.J. Predictive biology: modelling, understanding and harnessing microbial complexity. *Nat Rev Microbiol* **18**, 507–520 (2020).

Harkos, C., Hadjigeorgiou, A.G., Voutouri, C. *et al.* Using mathematical modelling and AI to improve delivery and efficacy of therapies in cancer. *Nat Rev Cancer* **25**, 324–340 (2025).