

# Complex Adaptive Systems in Molecular Ecology

BIOL 692 Seminar in Biology

EVPP 692/EVPP 991 Advanced Seminar in Environmental Science

BIOS 710 - Current Topics in Bioscience

Ecosystems are the prototypical examples of complex adaptive systems where phase transitions emerge from localized interactions and selection processes acting at lower levels. Essential aspects of such nonlinearity systems are sensitivity to initial conditions, self organization, and emergent behavior. In Molecular Ecology, we refer the analysis of such complex adaptive systems as Systems Biology and they can be used to simulate multiscale multicellular systems such as gene regulation, metabolic oscillations, neural signaling pathways, morphogenesis, microbial ecology, and social behavior. We will explore the basic theoretical principles of Complex Adaptive Systems by focusing on models specific to Molecular Ecology and we will elucidate these principles using simple computer simulations.

- Microbial Communities are dynamic non-linear systems
- Put in context of microbiome analysis.
- Models not restricted to bacterial ecosystems
- Example of non-linear oscillator
- Refrain from differential equations – data is not available for microbiome.
- Intro to Individual/Agent Based modeling
- Intro to NetLogo

12 sessions

Present papers

Modeling examples

Final Netlogo model

## TEXTBOOKS

**Individual-based Modeling and Ecology (Princeton Series in Theoretical and Computational Biology)** 1st Edition  
Kindle Edition  
by Volker Grimm (Author), Steven F. Railsback (Author)  
★★★★☆ 5 customer reviews  
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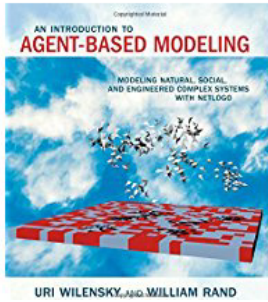
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Individual-based models are an exciting and widely used new tool for ecology. These computational models allow scientists to explore the mechanisms through which population and ecosystem ecology arises from how individuals interact with each other and their environment. This book provides the first in-depth treatment of individual-based modeling and its use to develop theoretical understanding of how ecological systems work, an approach the authors call "individual-based ecology?"

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**An Introduction to Agent-Based Modeling: Modeling Natural, Social, and Engineered Complex Systems with NetLogo (MIT Press)** Apr 3, 2015

by Uri Wilensky and William Rand

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Papers presented in lecture.

## High-Fat Diet Disrupts Behavioral and Molecular Circadian Rhythms in Mice

Akira Kohsaka,<sup>1,4</sup> Aaron D. Laposky,<sup>1,2</sup> Kathryn Moynihan Ramsey,<sup>1,3,4</sup> Carmela Estrada,<sup>1</sup> Corinne Joshu,<sup>1</sup> Yumiko Kobayashi,<sup>4</sup> Fred W. Turek,<sup>1,2</sup> and Joseph Bass<sup>1,2,3,4,\*</sup>

## Effects of Diurnal Variation of Gut Microbes and High-Fat Feeding on Host Circadian Clock Function and Metabolism

Vanessa Leone,<sup>1</sup> Sean M. Gibbons,<sup>2,3</sup> Kristina Martinez,<sup>1</sup> Alan L. Hutchison,<sup>3,4</sup> Edmond Y. Huang,<sup>1</sup> Candace M. Cham,<sup>1</sup> Joseph F. Pierre,<sup>1</sup> Aaron F. Heneghan,<sup>5</sup> Anuradha Nadimpalli,<sup>1</sup> Nathaniel Hubert,<sup>1</sup> Elizabeth Zale,<sup>1</sup> Yunwei Wang,<sup>1</sup> Yong Huang,<sup>1</sup> Betty Theriault,<sup>6</sup> Aaron R. Dinner,<sup>3,7,8</sup> Mark W. Musch,<sup>1</sup> Kenneth A. Kudsk,<sup>5</sup> Brian J. Prendergast,<sup>9</sup> Jack A. Gilbert,<sup>2,10</sup> and Eugene B. Chang<sup>1,\*</sup>

## Synthetic microbial ecology and the dynamic interplay between microbial genotypes

Jan Dolinšek<sup>1,2,\*</sup>, Felix Goldschmidt<sup>1,2,†</sup> and David R. Johnson<sup>1,§</sup>