Acknowledgment:

UBC's Point Grey Campus is located on the traditional, ancestral, and unceded territory of the **xʷməθkʷəy̓əm (Musqueam)** (https://www.musqueam.bc.ca) people. This site has always been a place of learning for the Musqueam people to pass on culture, history, and traditions from one generation to the next.
For more information on the joint history of UBC and the Musqueam, visit UBC's **aboriginal portal** (https://aboriginal.ubc.ca/community-youth/musqueam-and-ubc/).

Course information

Instructor:	Christoph Hauert
Office:	Math 234
Hours:	by appointment
Lectures:	Tuesday & Thursday 10:30am - 12pm
First class:	September 10, 2020
End of term:	December 3, 2020

Outline

Evolution is the unifying theme in biology. Evolutionary processes are responsible for the emergence of the rich variety of species across the planet. Cooperation represents one of the key organizing principles in evolution, and the history of life and of societies could not have unfolded without the repeated cooperative integration of lower level units into higher level entities. Evolutionary theories have attracted increasing attention from other behavioural disciplines including sociology and economics. This has led to the notion of cultural evolution aiming at a better understanding of human cooperation including the emergence of social norms. Cultural evolution follows the same basic selection principle as biological evolution but the lack of the genetic constraints of mutation, recombination and inheritance results in a largely unexplored dynamics governed by the more flexible mechanisms of innovation, learning and imitation.

Goals

This course provides a sound introduction into mathematical models of evolution and the theory of games. Modelling techniques that are covered include: stochastic dynamics of invasion and fixation of mutants in a finite population; evolutionary game theory and frequency dependent selection -- each agents' performance is affected by everyone else; adaptive dynamics and the process of diversification and speciation through evolutionary branching; modelling spatially structured populations. In all cases the link to current challenges in research is emphasized by student presentations and discussions of the literature as well as by identifying potential research questions. Each student develops his/her own research project in consultation with the instructor. At the end of the term, all students hand in a written report, present their project to the class and participate in a peer review process assessing the projects of their fellow students.

Prerequisites

This course combines various topics covered in undergraduate mathematics courses - including differential equations, dynamical systems, stochastic processes, probability, Markov chains, etc. However, committed graduate students from other disciplines that are willing to catch up on mathematical theories they might not be familiar with are encouraged to attend and stimulate discussions with problems from their fields. Knowledge of computer programming and mathematics software such as Maple, Mathematica or MATLAB might be helpful for the project work but are not required.

Grading guidelines

Your grade for the course is based on the following components:

Component	Description	Weight
Assignments	4-5 problem sets on material discussed in class	25%
Presentation	Oral presentation of research article to the class	10%
Term Project, Paper	Report of term research project (includes peer grading component)	30%
Term Project, Presentation	Oral presentation of research project to the class (includes peer grading component)	20%
Term Project, Peer Review	Review the term project papers of your peers	10%
Participation	Contributions to discussions in class	5%

Tentative Timeline

Week	Lecture Topic	Notes
Week 1, Sept. 10	Introduction	
Week 2, Sept. 14	Constant selection (deterministic dynamics in infinite populations; stochastic dynamics in finite populations)	

Week 3, Sept. 21	Frequency dependent selection (introduction to evolutionary game theory)	
Week 4, Sept. 28	From finite to infinite populations, replicator dynamics	Discussions of presentations
Week 5, Oct. 5	Evolutionary graph theory	
Week 6, Oct. 12	Games on graphs	Presentations
Week 7, Oct. 19	Repeated interactions	Discussions of projects
Week 8, Oct. 26	Structured populations, pair approximation	
Week 9, Nov. 2	Classical versus evolutionary game theory	
Week 10, Nov. 9	Ecological dynamics & evolutionary games	
Week 11, Nov. 16	Public goods games and applications	
Week 12, Nov. 23	Continuous games (origin of cooperation; adaptive dynamics)	
Week 13, Nov. 30	Project presentations	

Textbook

Currently I am working on an interactive introductory textbook to modelling evolutionary dynamics. There are two editions available:

EvoLudo (pdf)
traditional (hyperlinked) pdf with links to external interactive online simulations

EvoLudo (eBook)
interactive eBook that includes interactive simulations
(no connection to the Internet necessary but a JavaScript enabled eBook-reader is required, for example Apple Books or Adobe Digital Editions)

This is truly work in progress but nevertheless at least sections of the project have matured enough to be hopefully of some use in this course. **Personal use of the book now and in the future is encouraged but please do not share the material in any form**. Eventually a more polished, complete and corrected version will be available. Your feedback is most welcome. Please add **errata (https://canvas.ubc.ca/courses/55356/discussion_topics/586045)** and suggestions for the **textbook (https://canvas.ubc.ca/courses/55356/discussion_topics/586046)** or the **interactive simulations (https://canvas.ubc.ca/courses/55356/discussion_topics/586148)** to the corresponding discussions.

Assignments (https://canvas.ubc.ca/courses/55356/assignments)

See assignments section for homework assignments. Late homework is not accepted.

Presentations & Project (https://canvas.ubc.ca/courses/55356/pages/presentations-and-project)

Suggestions for presentations and projects based on recent research results. For some of these topics ideas for manageable term projects exist. If you are interested please contact me for more specific information. However, you are free (and encouraged) to choose any other research paper that catches your interest. Ideally, pick a topic that fits with your graduate studies and adds an evolutionary perspective to your research interests.

Useful Resources

- Martin Nowak, *Evolutionary Dynamics*, Belknap Press, 2006.
- Karl Sigmund, *The Calculus of Selfishness*, Princeton University Press, 2010.
- Michael Doebeli, *Adaptive Diversification*, Princeton University Press, 2011.
- Josef Hofbauer & Karl Sigmund, *Evolutionary Games and Population Dynamics*, Cambridge University Press, 1998.
- Nicholas Christakis & James Fowler, *Connected*, Little, Brown & Co., 2009.
- John Maynard Smith & Eörs Szathmary, *The Major Transitions in Evolution*, W. H. Freeman & Co., 1995.
- ***EvoLudo*** **(http://www.evoludo.org/)** online: Collections of interactive tutorials on the fascinating dynamical world of evolutionary processes.