Biology 497: Behavioral Ecology (Evolutionary Game Theory)  
– Fall 2022

Instructor: Marco Archetti, W210 MSC; mua972@psu.edu; 814-863-4383  
Classes: MWF 10:10 - 11:00, HDD 355  
Student Hours: Online, anytime by appointment

Course Content: This is a course on the logic of strategic decision making in biology. We will discuss a wide range of examples from natural history (from the evolution of autumn leaf colors in trees to the laws that prescribe marriage rules in human societies, from auction theory to interactions between coronaviruses) using a common framework: mathematical models of strategic interactions. That is, Game Theory, the study of strategic behavior: situations in which one’s best decision depends on someone else’s best decision. We could rename the course “Evolutionary Game Theory”. Strategic problems arise at all levels of biological complexity, from interactions between genes to social behavior in humans. While game theory in economics implies rational decision making, in biology mutations produce strategies (phenotypes) and natural selection, rather than conscious decisions, leads to optimal strategies. We will discuss how game theory applies to a variety of problems in biology and how it helps understand complex interactions and apparently paradoxical observations. We will keep Maths to a minimum and you will be guided through each problem step by step.

Learning Goals: After completing this course, you should be able to understand the logic of strategic interactions in different fields of biology and to build and analyse simple mathematical models of game theory. This is a hands-on course: you will learn by practicing the material discussed in class rather than by reading a book. But the books listed below will help.

Course Materials:  
# LECTURE SCHEDULE

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
</tr>
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<tbody>
<tr>
<td>M 22 August</td>
<td>Introduction</td>
</tr>
<tr>
<td>W 24 August</td>
<td>An example of optimization: coevolution and signaling</td>
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<tr>
<td>F 26 August</td>
<td>From models to experiments and back</td>
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<tr>
<td>M 29 August</td>
<td>Another example of optimization: optimal foraging</td>
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<tr>
<td>W 31 August</td>
<td>The replicator dynamics of natural selection</td>
</tr>
<tr>
<td>F 2 September</td>
<td>Recap: <strong>optimization and natural selection</strong></td>
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<tr>
<td>M 5 September</td>
<td>no class</td>
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<tr>
<td>W 7 September</td>
<td>Midterm 1: <strong>optimization and natural selection</strong></td>
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<tr>
<td>F 9 September</td>
<td>Discussion of Midterm 1</td>
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<tr>
<td>M 12 September</td>
<td>A simple two-player game: The prisoner’s dilemma</td>
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<tr>
<td>W 14 September</td>
<td>Evolutionarily Stable Strategies</td>
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<tr>
<td>F 16 September</td>
<td>Evolutionary dynamics using the replicator dynamics</td>
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<tr>
<td>M 19 September</td>
<td>Other two-player games</td>
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<td>W 21 September</td>
<td>Sequential games</td>
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<tr>
<td>F 23 September</td>
<td>Evolutionary duels</td>
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<tr>
<td>M 26 September</td>
<td>Repeated games</td>
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<tr>
<td>W 28 September</td>
<td>Recap: <strong>two-player games</strong></td>
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<tr>
<td>F 30 September</td>
<td>Midterm 2: <strong>two player games</strong></td>
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<tr>
<td>M 3 October</td>
<td>Discussion of Midterm 2</td>
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<tr>
<td>W 5 October</td>
<td>Signalling</td>
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<tr>
<td>F 7 October</td>
<td>Signalling and coevolution</td>
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<tr>
<td>M 10 October</td>
<td>Sexual Selection</td>
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<tr>
<td>W 12 October</td>
<td>Parental care and mating systems</td>
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<tr>
<td>F 14 October</td>
<td>Auction theory</td>
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<td>M 17 October</td>
<td>Mechanism design</td>
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<td>W 19 October</td>
<td>Screening theory</td>
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<tr>
<td>F 21 October</td>
<td>Recap: <strong>games with asymmetric information</strong></td>
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<tr>
<td>M 24 October</td>
<td>Midterm 3: <strong>games with asymmetric information</strong></td>
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<td>W 26 October</td>
<td>Discussion of Midterm 3</td>
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<td>F 28 October</td>
<td>Collective interactions</td>
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<tr>
<td>M 31 October</td>
<td>Public goods games</td>
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<td>W 2 November</td>
<td>Nonlinear public goods</td>
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<td>F 4 November</td>
<td>Measuring public goods</td>
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<tr>
<td>M 7 November</td>
<td>Applications to cancer biology</td>
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<td>W 9 November</td>
<td>Applications to coronavirus biology</td>
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<tr>
<td>F 11 November</td>
<td>Applications to human social behavior</td>
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<tr>
<td>M 14 November</td>
<td>Recap: <strong>games with collective interactions</strong></td>
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<tr>
<td>W 16 November</td>
<td>Midterm 4: <strong>games with collective interactions</strong></td>
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<tr>
<td>F 18 November</td>
<td>Discussion of Midterm 4</td>
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<tr>
<td>M 21 November</td>
<td>no class</td>
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<tr>
<td>W 23 November</td>
<td>no class</td>
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<td>F 25 November</td>
<td>no class</td>
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<td>M 28 November</td>
<td>Intragenomic conflict</td>
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<td>W 30 November</td>
<td>Kin selection</td>
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<td>F 2 December</td>
<td>Human marriage systems</td>
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<td>M 5 December</td>
<td>Complex human behavior</td>
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<tr>
<td>W 7 December</td>
<td>Recap: <strong>games and genetics</strong></td>
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<tr>
<td>F 9 December</td>
<td>Final recap</td>
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**Grades:** Midterms are done during normal class hours (see lecture schedule), but can then be revised and resubmitted by 11 December. The final scores for the midterms are based on these revision. The average of these scores makes 50% of the total score. The final exam makes the remaining 50%.

Final course grades will be assigned as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Total score</th>
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<tbody>
<tr>
<td>A</td>
<td>Above 93%</td>
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<tr>
<td>A-</td>
<td>90% - 93%</td>
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<tr>
<td>B+</td>
<td>87% - 90%</td>
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<tr>
<td>B</td>
<td>83% - 86%</td>
</tr>
<tr>
<td>B-</td>
<td>80% - 83%</td>
</tr>
<tr>
<td>C+</td>
<td>77% - 80%</td>
</tr>
<tr>
<td>C</td>
<td>70% - 77%</td>
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<tr>
<td>D</td>
<td>60% - 70%</td>
</tr>
<tr>
<td>F</td>
<td>Below 60%</td>
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**GENERAL PENN STATE INFORMATION**

Calendars: [http://www.registrar.psu.edu/academic_calendar/calendar_index.cfm](http://www.registrar.psu.edu/academic_calendar/calendar_index.cfm)

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you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early as possible. You must follow this process for every semester that you request accommodations.

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- Counseling and Psychological Services at University Park (CAPS): http://studentaffairs.psu.edu/counseling; phone: 814-863-0395.
- Penn State Crisis Line (24 hours/7 days/week): 877-229-6400
- Crisis Text Line (24 hours/7 days/week): Text LIONS to 741741

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