Life history theory is the branch of evolutionary biology that attempts to understand patterns of investment in growth, reproduction, and survival across the life cycle. It is the theory that explains all the major transitions that mark individual organisms’ life cycles from conception to death. The diversity of life reflects a tremendous diversity in life histories. Some organisms live very short lives and reproduce in large numbers. Others spread a modest amount of reproduction out over a long lifespan. Still others live an extraordinarily long time and still manage to reproduce in massive numbers. Why do organisms differ so much in traits such as age at maturity, age-specific fertility, life expectancy, or clutch size? How do humans fit into this diversity?

Life history theory lies at the very heart of evolutionary explanation because it deals with the mechanics of natural selection. If you want to argue that a trait – any trait – evolved via natural selection, you need to have at least a rudimentary understanding of life history theory.

In this class, we will focus on the central themes of life history theory and how they relate to specific problems of the human life cycle. Our class reading will focus on classic works that should be in the bibliography of any evolutionary anthropologist or biologist. The approaches that we discuss will not be exhaustive, but instead will focus on the more explicitly demographic models of life history evolution. In addition, we will read some recent anthropological applications of specific approaches to the theory or applications of specific models. In addition to the classic questions of life history theory (e.g., evolution of reproductive effort, size vs. quality, etc.), we will discuss some peculiar issues that relate specifically to humans. These include: (1) the evolution of childhood, (2) the evolution of post-reproductive lifespan, (3) the evolution of late age at maturity and low fertility, (4) the evolution of biparental care – and alloparental care more generally.
2 Expectations

This course uses mathematics to describe processes relevant to the study of human biology and social behavior. It is not, however, a course in mathematics. You will not be expected to do mathematical proofs or derive complex formulae. You will be expected to understand the demographic, social, and biological theory contained in the mathematics as described in class lectures and in the readings.

The reading load for this class is comparatively light. I therefore expect that you will do the readings. Problem sets and exams will draw questions from weekly readings.

Students will propose and execute an original analysis on a topic in demography and life history theory. The written form of the project should be on the order of 10-15 pages and composed in the form of a scientific research paper, complete with full citations. The paper should be organized into the following sections: Introduction, Methods, Results, Discussion.

3 Grading

The breakdown of grading for this class will be as follows:

50% Weekly problem sets designed to reinforce lectures and readings and build confidence in your analytic skills. Problem sets will be due on Tuesday at the beginning of class each week. Late work will lose a third of a grade per day past due.

15% Take-Home Midterm Exam. This cumulative exam must reflect your own work.

25% Final Project.

10% Class Participation. This is a small class. If you have questions, ask them in class. Show me that you are actually working to understand the material.

4 Prerequisites

I expect that you have a basic understanding of ecology and evolution and, specifically, natural selection. We will employ mathematical tools in developing the theory discussed in this class. Mathematical preparation at the level of calculus is necessary to understand the material presented. While we will use some techniques from linear algebra, students should be able to acquire an instrumental understanding sufficient for this class without having any specific background.

5 Readings

There are no required texts for this class. All readings will be taken from the primary scientific literature. Many of these readings are “classics” – frequently cited and rarely read. I will supplement these readings with fairly extensive course notes.

All readings are available in electronic format, and can be accessed at the secure readings section of the class website.
6 Course Outline (Subject to Change)

Week 1 Reproductive Effort
   1. Cole’s Paradox
   2. Gadgil & Bossert’s Framework

   Readings: Cole (1954), Gadgil and Bossert (1970), Charnov and Schaffer (1973)

Week 2 Reproductive Effort 2
   1. Cole’s Paradox Resolved
   2. Variable Environments and Unstructured Models
   3. Arithmetic Means, Geometric Means, and Bet-Hedging

   Assignment: Problem Set 1

Week 3 Risk
   1. Risk and Risk Aversion
   2. Expected Utility/Expected Loss
   3. Arrow-Pratt

   Assignment: Problem Set 2

Week 4 Matrix Models for Structured Populations
   1. Motivation and model formulation
   2. Relationship to other models
   3. Eigenvalues, eigenvectors, etc.
   4. Sensitivities and elasticities

   Assignment: Problem Set 3

Week 5 More Matrix Models 2:
   1. Uses of sensitivities
   2. Second derivatives
   3. Sensitivities and trade-offs

   Assignment: Problem Set 4
Week 6  Matrix Models 4: Variable Environments

1. Types of variable environments

**Readings:** Hirshfield and Tinkle (1975), Orzack and Tuljapurkar (1989)

**Assignment:** Problem Set 5

Week 7  Matrix Models 3: Non-Linear Models

1. The invasion exponent $\vartheta$
2. Density-dependence
3. Parental investment

**Readings:** Benton and Grant (1996), Grant (1997)

**Assignment:** Take-Home Midterm

Week 8  Clutch Size, and State-Dependent Life Histories

1. Quality-quantity trade-off
2. Lack Clutch

**Readings:** Smith and Fretwell (1974), Kaplan and Robson (2002)

**Assignment:** Problem Set 6

Week 9  Senescence

1. Gompertz and related curves
2. Mutation accumulation
3. Antagonistic pleiotropy
4. Disposable soma

**Readings:** Williams (1957), Baudisch (2005), Hawkes et al. (1998)

**Assignment:** Problem Set 7

Week 10  Virulence

1. Pathogen fitness: $R_0$
2. Optimal virulence in clonal pathogens
3. Interactions with host life history

**Readings:** van Baalen and Sabelis (1995), Lipsitch et al. (1996), Frank (1996)

**Assignment:** Final Project Due on Thursday, 11 December
References


