DAT 494 (#31031): Forensic DNA Analysis
Course Syllabus - Spring 2025

Instructor: Jay Taylor; office: LSC L2-26; email: jetaylo6@asu.edu
Time: Monday and Wednesday 3:00 - 4:15 pm
Location: TBA

Prerequisites: One semester of calculus (MAT 270 or similar). No prior knowledge of genetics is required.

Text: *Statistical DNA Forensics: Theory, Methods and Computation* (2008) by Wing Kam Fung and Yue-Qing Hu. Additional material will be taken from the book *Weight-of-Evidence for Forensic DNA Profiles* (2015) by David Balding and Christopher Steele, which is available online through the ASU Library.

Description:

Catalogue Description: Applications of probability theory and statistics to forensic DNA analysis, with an emphasis on human STR markers. Identification of individuals from DNA samples, parentage and kinship testing, and interpretation of DNA mixtures. Phylogenetic inference with applications to forensic epidemiology and bioterrorism.

Extended Description: The use of DNA evidence in the courtroom is now common knowledge thanks to several high-profile criminal cases and popular television dramas such as *CSI: Crime Scene Investigation*. However, the important role played by statistics in this endeavor is largely unknown to the general public. This course will provide an introduction to the mathematical and statistical foundations of forensic DNA analysis. After covering background material on probability theory, hypothesis testing, and molecular and population genetics, we will examine four forensic problems that involve genetic data: (1) identification of individuals from DNA samples; (2) maternity and paternity testing; (3) kinship determination; and (4) interpretation of DNA mixtures. In each case, we will see how probabilistic models of genetic processes can be used to assess the evidentiary value of DNA data for a collection of competing hypotheses. Some common fallacies in the presentation of DNA evidence in the courtroom will also be highlighted. In the final part of the course, we will examine some of the ways in which DNA evidence from non-human species has been used to investigate crimes involving domestic animals, wildlife, and infectious disease. Bayesian and likelihood-based approaches to phylogenetic inference will be introduced and we will see how gene genealogies can be used to identify possible sources of microbial pathogens responsible for accidental and deliberate disease outbreaks.

Objectives: At the end of this course, students will be able to:

1. Explain the principle molecular and population genetical processes that impact on forensic DNA analyses;
2. Calculate likelihood ratios and perform weight-of-evidence computations for identity and kinship determination problems using multilocus genetic data;
3. Interpret DNA mixtures involving up to three profiles;
4. Understand how DNA substitution models can be used to infer gene genealogies using DNA sequence data;
5. Use BEAST to perform Bayesian phylogenetic analyses of genetic sequence data and interpret the results in the context of infectious disease transmission.

Assessment: Grades will be based on two exams (50%) and several problem sets (50%).

Tentative Syllabus:

- Lecture 1. Forensic DNA Analysis: History and Simple Examples
- Lecture 2. Probability I: Definitions and Axioms
- Lecture 3. Probability II: A Bestiary of Important Distributions
- Lecture 4. Probability III: Conditional Probabilities; Bayes' Formula
- Lecture 5. Mendelian Genetics: DNA, Chromosomes, Heredity
- Lecture 6. Genetic Markers: STR's and SNP's
- Lecture 7. Hypothesis Testing I: Frequentist approaches; Likelihood Ratios
- Lecture 8. Hypothesis Testing II: Bayesian approaches; Weight-of-Evidence
- Lecture 9. Population Genetics I: Drift, Mutation, Migration and Selection
- Lecture 10. Population Genetics II: Hardy-Weinberg Equilibrium
- Lecture 11. Population Genetics III: Quantifying Inbreeding; Linkage Disequilibrium
- Lecture 12. Identification from DNA Profiles I: Likelihood Calculations
- Lecture 13. Identification from DNA Profiles II: Applications to STR and Haploid Profiles
- Lecture 14. The Prosecutor's and Defendant's Fallacies
- Lecture 15. Parentage Testing I: Trios
- Lecture 16. Parentage Testing II: Incorporating Data from Other Relatives
- Lecture 17. Kinship Testing I: Two Persons
- Lecture 18. Kinship Testing II: Three Persons
- Lecture 19. DNA Mixtures I: Examples
- Lecture 20. DNA Mixtures II: Subdivided Populations
- Lecture 21. DNA Mixtures III: One Pair of Relatives
- Lecture 22. DNA Mixtures IV: Several Pairs of Relatives
- Lecture 23. DNA Mixtures V: Relatives from Subdivided Populations
- Lecture 24. Forensic Analysis of non-human DNA: Examples
- Lecture 25. Phylogenetic Analysis I: DNA Substitution Models
- Lecture 26. Phylogenetic Analysis II: Maximum Likelihood and Bayesian Inference
- Lecture 27. Phylogenetic Analysis III: Introduction to BEAST2
- Lecture 28. Phylogenetic Analysis IV: Interpreting BEAST2 Analyses
- Lecture 29. Forensic Epidemiology I: Intentional Transmission of HIV-1
- Lecture 30. Forensic Epidemiology II: Bioterrorism and the 2001 Anthrax Attacks