NEW YORK UNIVERSITY
DEPARTMENT OF BIOLOGY

QUANTITATIVE METHODS IN HUMAN GENETICS
(V23.0045)

Sessions: Two 75-minute lecture classes per week
One 60-minute recitation per week

Location: Computer laboratory classroom

Required texts: *Human Molecular Genetics, 4th edition*
Tom Strachan and Andrew Read (2010, Garland Science)

Statistics: An introduction using R
Michael J. Crawley (2005, Wiley)

Supplementary texts: *Essential Genetics: A genomics perspective 5th edition*
Daniel Hartl

Introduction to Genetic Analysis, 9th Edition
Griffiths, Wessler, Lewontin and Carroll

Instructor: Professor David Gresham

Teaching Assistant: Naomi Ziv

Course Aims: To provide an integrated study of the biological basis of human heredity and statistical approaches to identifying and studying human genes. Students will learn fundamentals of statistical analysis and basic computer programming skills.

This course fulfills the "Quantitative Skills" requirement for Biology Majors

Prerequisites: Principles of Biology I
Principles of Biology II
Molecular and Cellular Biology I
Molecular and Cellular Biology II

Grading:

Weekly assignments:	50%
Quizzes:	10%
Midterm:	15%
Final Exam:	20%
Attendance/Participation:	5%

The quizzes are intended to test memorization of key facts and will be held during the first five to ten minutes of each recitation.

Assignments will typically be problem based and require the use of R. With each assignment you should submit a .R file containing the computer code used to generate your results. The code should include comments describing what each step in the code is doing.

Course Description:

Deciphering the information encoded in the human genome is one of the great challenges of the 21st century. This course will provide an introduction to the human genome and the statistical methods that are required for its study. Fundamental concepts in human genetics will be introduced including inheritance of mendelian disease, population genetics, multifactorial disease and functional genomics. Accompanying each topic will be an introduction to the statistical concepts and tools that are required to study inheritance, genes and gene function including probability, hypothesis testing, ANOVA, regression, correlation, likelihood and principal component analysis. Hands on experience will be provided through weekly exercises using the statistical programming language, R. Prior experience with statistics is beneficial, but not required.

Policy on missed tests:
Tests will be excused only for medical or family emergencies. I need to be notified by phone or email before the exam time. An **unexcused** absence from an exam will be calculated as 0% for that particular test! If you miss an exam and present a legitimate excuse, a make-up test will be made available to you. There will be only one opportunity for such an exam; it could be an essay test, and the appropriate instructors will grade it. This situation will be dealt with partly on an individual basis.

Assignments:
Must be handed in on time. Late assignments will be penalized 25% if they are handed in during the next class meeting and will not be accepted after that.

Course Syllabus

Each class will address a topic in human genetics (**Genetics**) and statistics (**Statistics**). The relevant chapters of the two text books are indicated. Additional readings will be provided in class. Please complete the readings **before** class.

Part I: Mendelian inheritance in humans

Lecture 1: ***January 25th***
Genetics: Distributions of human phenotypes
Statistics: Descriptive Statistics; *Crawley Chapter 3, 4*

Lecture 2: ***February 1st***
Genetics: Mendelian inheritance
Statistics: Introduction to Probability

Lecture 3: ***February 3rd***
Genetics: Mendelian inheritance in humans; *Strachan and Read Chap 2: 61-78*
Statistics: Application of probability to mendelian inheritance

Lecture 4: ***February 8th***

Genetics: Segregation Ratios in families, Ascertainment bias; *S&R Chap 2: 69-70*
Statistics: Binomial distribution, exact probabilities

Lecture 5: ***February 10th***
Genetics: Expected phenotypic proportions
Statistics: chi-square test, hypothesis testing

Lecture 6: ***February 15th***
Genetics: Independent assortment, introduction to linkage
Statistics: Contingency tables

Lecture 7: ***February 17th***
Genetics: Epistasis, incomplete dominance, co-dominance
Statistics: Integration of methods

Lecture 8: ***February 22nd***
Genetics: Chromosomal basis of inheritance, linkage, recombination
Statistics: Integration of methods

Lecture 9: ***February 24th***
Genetics: Three factor cross, Genetic variation in humans; *S&R Chap 13*
Statistics: Poisson distribution

Lecture 10: ***March 1st***
Guest Lecture by Professor Harry Ostrer

Lecture 11: ***March 3rd***
Genetics: Mapping functions, Linkage Analysis in human pedigrees; *S&R Ch 14*
Statistics: Mapping functions, Likelihood,

Lecture 12: ***March 8th***
Genetics: Human Linkage Analysis II, review for midterm; *S&R Ch 14*
Statistics: maximum likelihood, odds, LOD scores**;** Review

Lecture 13: ***March 10th***
Midterm exam

SPRING BREAK MARCH 14TH – MARCH 18TH

Lecture 14: ***April 21st***
Genetics: Disease Risk analysis
Statistics: Law of total probability, conditional probability; Bayes Theorem

Part II: Genes and Genomes in Populations

Lecture 15: ***March 22nd***
Genetics: Refined genetic mapping; Gene frequencies in populations
Statistics: Hardy-Weinberg equilibrium

Lecture 16: ***March 24th***
Genetics: Inbreeding coefficients, linkage disequilibrium
Statistics: recursive calculations

Lecture 17: ***March 29th***
Genetics: Genetic drift, mutation, selection
Statistics: recursive calculations

Lecture 18: ***March 31st***
Genetics: Genetic structure of human populations
Statistics: F_{ST}, variance components

Part III: Complex traits and genetic epidemiology

Lecture 19: ***April 5th***
Genetics: Distribution of quantitative traits
Statistics: The normal distribution

Lecture 20: ***April 7th***
Guest lecture by Dr John Spiro

Lecture 21: ***April 12th***
Genetics: Comparison of phenotypes between populations
Statistics: Comparing two means, t-tests

Lecture 22: ***April 14th***
Genetics: Comparison of phenotypes between populations
Statistics: ANOVA

Lecture 23: ***April 19th***
Genetics: Inheritance of multifactorial human traits, Heritability
Statistics: Covariance, Correlation; Regression;

Lecture 24: ***April 26th***
Guest lecture by Professor Matt Rockman

Lecture 25: ***April 28th***
Genetics: Association studies
Statistics: Fisher's exact test

Part IV: Studying the function of human genes

Lecture 26: ***May 3rd***
Genetics: Whole genome expression analysis;
Statistics: Multiple hypothesis testing, Principal component analysis

Lecture 27: ***May 5th***
Genetics: Cancer Genetics, Personalized medicine;

Statistics: Simulation, Permutation testing;

END OF SEMESTER