PLSC 782 "Population and Quantitative Genetics" 4 credit class

Instructor:	Ted C. Helms, Ph.D.
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Office Hours:	Monday, Tuesday, Wednesday, Thursday, Friday 9 a.m. until noon and by appointment

Class Time, Place: MTWF 2 – 2:50 p.m. Rm. _____

Prerequisites: PLSC 724 & PLSC 718.

Course Bulletin: Population and quantitative genetics theories and application to applied plant breeding.

Course Description: This course will introduce basic concepts of statistical theory and interpret these concepts to the genetics of a population. Allele and genotype frequencies, mutation, migration, selection and inbreeding will be discussed. The concepts of phenotype, genotype and relationships between relatives will be provided. The degree of dominance, the inbreeding coefficient and the coefficient of co-ancestry will be explained. Topics in quantitative genetics include heritability, genetic correlation, genotype X environment interaction, predicted gain from selection, mating designs, diallel analysis, stability analysis, generation mean analysis, selection indices and QTL analysis.

Study Materials

Texts on Reserve in the Main Library

1.) "Introduction to Quantitative Genetics" by D.S. Falconer

2.) "Quantitative Genetics in Maize Breeding" by A.R. Hallauer and J.B. Miranda, Fo.

3.) "Breeding for Quantitative Traits in Plants" by R. Bernardo.

Assessment:

Pre-test
This will be given the first class period.
Not graded, only for assessment purposes.

Post-test
This will be given in the last week or two of the class.
Not graded, only for assessment purposes.

There will be three exams, two hourly exams and the final exam. Each exam will be given in class at the regular class meeting time. Each hourly exam will be worth 25% of the final course grade. The Final Exam will be worth 35% of the course grade. You will be given at least 10 days advance notice before

each exam is given. I will announce the dates for the two hourly exams in class. The Final Exam will be given May 13 at 1 p.m. The Final Exam will be comprehensive. Exams will be mostly short answers of about one paragraph. The total value for all homework assignments will be 15% of the course grade. Exams will cover lecture material, online notes, handouts, and questions from the homework assignments.

Grade Categories	Percent of Final Class Grade	Points by Categories	Date
Exam 1	25	250	Feb. 19
Exam 2	25	250	April 14
Final Exam	35	350	May 13 1 – 3 p.m.
Homework	15	150	

Exams will be completed individually and you will not be allowed to access books, notes, electronic devices, or other sources of information unless otherwise instructed. Calculators must only be used for basic calculating. Missed exams can be made up by appointment within two weeks of the scheduled exam date.

The content of exam questions will include information from lectures and assigned reading. All problem sets may be a group effort. Some quizzes will be given. Advanced notice will be provided for the date of quizzes. Quizzes will be graded and discussed, but quiz scores will not count in the final grade. The purpose of the quizzes is to make students aware of their performance and to make the instructor aware of problems in course content.

The following point totals are a guide for letter grades.

900 - 1000	A
800 - 899	B
700 - 799	C
600 - 699	D
599 or less	F

Course Objectives:

- To comprehend and interpret the application of population genetics to plant and animal improvement.
- To summarize the theory of population genetics.
- To analyze and contrast the theory of quantitative genetics and how this applies to plant and animal breeding.
- To appreciate and evaluate past research results of quantitative genetics.
- To analyze and interpret the application of statistical tools for stability analysis and selection indices.
- To summarize and contrast the application of quantitative genetics to molecular marker assisted selection.

University holidays are below.

Class not in session	
Jan. 20	Martin Luther King Day
Feb. 17	President's Day
March 16-20	Spring break
April 10-13	Holiday

Cancellations:
Cancellation of a class meeting time automatically delays all scheduled activities, including exams, to the next scheduled meeting time.

Course Content

1. Mean and variance — Jan. 14
   a. Mean
   b. Weighted mean
   c. Deviations from mean sum to zero
   d. Population and sample variance
   e. Variance of a mean
   f. Standard deviation versus standard error
   g. Covariance — Jan. 15
   h. Correlation
   i. Regression
   j. Expectation
2. Genotypic values and phenotypic values — Jan. 17
   a. Concepts of conceptual population of environments and genotypes
   b. Concepts of phenotype and genotype
   c. Multiple environments
   d. Genotypic value is the phenotypic value when averaged across all environments
3. Genotype X environment interaction — Jan. 21
   a. Definition
   b. Change in rank
   c. Change in magnitude
   d. Fixed versus random environment — Jan. 22
4. Probability — Jan. 24
   a. Relative frequency and probability
   b. Mutually exclusive events
   c. Union of two events
   d. Independent events
   e. Probability that both events occur
   f. Conditional probability — Jan. 27
5. Genotype and allele frequencies — Jan. 28
   a. F2 population
   b. General case
   c. Biological processes that change gene frequency — Jan. 29
6. Continuous self-fertilization — Jan. 31
   a. Decrease in heterozygotes
   b. Increase in homozygotes
   c. Mean of fully inbred population with no epistasis — Feb. 3

7. Dominance gene action — Feb. 4
    a. Mid-parent
    b. Falconer's coded values
    c. Additive and dominance values
    d. No dominance, partial dominance, complete dominance, over-dominance gene action (see also pseudo-overdominance pg. 122 Hallauler)
    e. High-parent and mid-heterosis (pg. 351 Hallauer)
8. Hardy-Weinberg equilibrium – one locus — Feb. 5
9. Changes in gene frequency — Feb. 7
    a. Migration
    b. Mutation
    c. Selection
    d. Identity by descent and alike in state — Feb. 10
    e. Genetic drift
10. Idealized population — Feb. 11
    a. Genetic drift due to sampling
    b. Inbreeding (pg. 307 Hallauer) — Feb. 12
11. Effective population size — Feb. 14
    a. Equal numbers of males and females (pg. 308 Hallauer)
    b. Different numbers of males and females (pg. 308 Hallauer)
    c. Recombining inbred progenies (pg. 308 Hallauer)
    d. Minimizing inbreeding — Feb. 18

Exam 1 — **Feb. 19**

12. Pedigree populations — Feb. 21
    a. Base population
    b. Definition of inbreeding coefficient and coefficient of coancestry — Feb. 24
    c. Inbreeding coefficient
    d. Coefficient of kinship
    e. Close inbreeding — Feb. 25
    f. Inbreeding due to continuous self-fertilization — Feb. 26
    g. Backcrossing
13. Inbreeding in random mated populations — Feb. 28
    a. Effective population size (pg. 308 Hallauer)
    b. Exclusion of self-fertilization
14. Continuous variation — March 2
    a. Quantitative traits
    b. Qualitative traits
15. Values and means — March 3
    a. Population mean for one locus model
    b. Average effect of a gene — March 4
    c. Breeding value
    d. Dominance deviation
16. Genetic variance — March 6
    a. Components of variance
    b. Additive genetic variance is the variance due to regression
    c. Dominance genetic variance is due to the variance of deviations from regression

d. Genetic components of variance with continuous self-fertilization March 9
e. Genetic variance varies among populations of same species for the same trait (Hallauer, pg 121)

17. Resemblance between relatives March 10
    a. Offspring and one parent
    b. Offspring and mid-parent
    c. Half-sibs March 11
    d. Full-sibs
    e. S1 lines
18. Experimental design March 13
    a. Definition of fixed versus random effects
    b. Inference of fixed and random effects
    c. Nested versus crossed classification
    d. Deriving expected mean squares March 23
19. Heritability March 24
    a. Definition from Falconer
    b. Assumptions and use
    c. Single plant versus family basis
    d. Single-plot basis
    e. Entry-mean basis
    f. Offspring-parent regression March 25
    g. Offspring mid-parent regression
    h. Smith-Kinman adjustment to heritability (Hallauer, pg. 51)
    i. Heritability is not a constant and varies among populations and environments for the same trait
20. Genetic gain March 27
    a. Derivation of formula (see pg. 165 Hallauer)
    b. Predicted mass selection (pg. 168 & 169 & 187 Hallauer)
    c. Family selection (pg. 170 & 188 Hallauer) March 30
    d. Assumptions
    e. Interpretation and use March 31
    f. Selection differential (pg. 166 Hallauer)
    g. Choice of family structure (pg. 190 Hallauer)
    h. Allocation of resources (pg. 193-195 Hallauer)
    i. Pollen control (pg. 168 Hallauer)
    j. Selection and genetic drift (pg. 185 Hallauer) April 1
    k. Manuscripts
    l. Genotype X environment correlations and genetic gain formula April 3
    m. G X L, G X Y, and GYL interactions
    n. Realized gain (pg. 208, 217, 225, 227Hallauer) April 6
21. Choice of parents for breeding April 7
    a. Breeding objectives
    b. At least one parent must have the desired trait
    c. Hybrids that result from crossing two inbreds
    d. Choice of population (Hallauer pg. 375)
    e. Mean of recombinant inbred lines (RILs)
    f. F2 versus backcross for self-pollinated species April 8
    g. Utility function
    h. Predicting the genetic variance

Exam 2 **April 14**

22. Correlations — April 15
    a. Genetic
    b. Correlated response (see pg. 153 & 195 & 198 Hallauer)
    c. Manuscript by Atlin and Frey — April 17
23. Matrix algebra — April 20
    a. Basic operations
    b. Normal equations in matrix form — April 21
    c. Solution vector
24. Mating designs — April 22
    a. Design I
    b. Design II — April 24
    c. Inbred progeny
25. Hierarchical design — April 27
    a. Derivation
    b. Manuscript by Elias et al.
26. Diallel analysis — April 28
    a. Interpretation of fixed and random models
    b. Manuscript by Spraque, G.F. and L.A. Tatum
    c. Manuscript by Sughroue, J.R. and A.R. Hallauer
27. Modern maize breeding — April 29
    a. Replacing one parent of an elite hybrid
    b. Segregating populations developed within the same heterotic group
    c. Choice of tester for experimental hybrids
28. Mather-Jinks generation mean analysis — May 1
    a. Generation means
    b. Assumptions and use
    c. Manuscript by Miller, J.F. and J.J. Hammond
29. Gardner-Eberhart generation mean analysis — May 4
    a. Purpose (see pg. 159 Hallauer)
    b. Derivation
    c. Inter-varietal heterosis (pg. 366 Hallauer)
    d. Manuscript by Sfakianakis et al. (pg. 346 Hallauer) — May 5
    e. Manuscript by Fuller et al.
30. Selection indicies — May 6
    a. Independent culling (pg. 199 Hallauer)
    b. Smith-Hazel (pg. 200 Hallauer)
    c. Base index
31. Stability analysis — May 8
    a. Eberhart-Russell regression
    b. AMMI model
    c. Manuscripts

CAFSNR Syllabus Attachment – Spring 2018

Academic Honesty: All students taking any course in the College of Agriculture, Food Systems, and Natural Resources are under the Honor System (http://www.ag.ndsu.edu/academics/honor-system-1). The Honor System is a system that is governed by the students and operates on the premise that most students are honest and work best when their honesty, and the honesty of others, is not in question. It functions to prevent cheating as well as penalize those who are dishonest. It is the responsibility of the students to report any violations of the honor pledge to the instructor, honor commission or the Dean of the College of Agriculture, Food Systems, and Natural Resources.

The academic community is operated on the basis of honesty, integrity, and fair play. NDSU Policy 335: Code of Academic Responsibility and Conduct applies to cases in which cheating, plagiarism, or other academic misconduct have occurred in an instructional context. Students found guilty of academic misconduct are subject to penalties, up to and possibly including suspension and/or expulsion. Student academic misconduct records are maintained by the Office of Registration and Records. Informational resources about academic honesty for students and instructional staff members can be found at www.ndsu.edu/academichonesty.

Students with special requirements: Any students with disabilities or other special needs, who need special accommodations in this course are invited to share these concerns or requests with the instructor as soon as possible. The instructor may ask for verification and that, plus other assistance, can be requested from Disability Services in NDSU Library Suite 17 (231-8463). http://www.ndsu.edu/disabilityservices/.

Veterans and military personnel: Veterans or military personnel with special circumstances or who are activated are encouraged to notify the instructor as early as possible.

Important Dates

January 15	Martin Luther King Jr. Holiday (no class, offices closed)
January 18	Last day to add classes via Campus Connection
January 18	Last day for no-record drop of classes @ 100% refund
January 18	Last day to withdraw to 0 credits @ 100% refund
January 23	Financial Aid applied to Student Accounts
January 29	Last day to submit request to audit, pass/fail
February 2	Undergraduate Spring graduation application due
February 16	Graduate Student Spring Intent to Graduate forms due
February 19	Presidents' Day Holiday (no classes, offices closed)
March 2	Grades of Incomplete convert to F
March 12-16	Spring Break (no classes)

March 22	Last day to withdraw to 0 credits
March 26	Summer/Fall registration begins
March 30	Holiday (no classes, offices closed)
April 2	Holiday (no classes)
April 6	Last day to drop classes with record (W)
April 6	Last day to withdraw to 0 credits
April 17	Spring commencement participation deadline
April 30-May 4	Dead Week
May 7-11	Final Examinations
May 12	Commencement
May 15	Spring grade access begins online