Spring 2011 Quantitative Genetics in Plant Breeding
SCSC 643/ Gene 643

When and where:
Tue. / Thur. 9:35 am – 10:50 am
Room 224, Heep Building

Instructor:
Dr. Seth C. Murray
Agronomy Field Lab – 111
Office (979) 845-3469, Lab (979) 845-4195
sethmurray@tamu.edu

Office hours:
To be decided in class.
(Appointments are always possible)

Website:
Lectures will be available via TAMU eLearning Vista http://elearning.tamu.edu/
Static website http://maizeandgenetics.tamu.edu/SethCMurray/Teaching.html

Course description:
Graduate education in quantitative genetics is critical for success as a modern scientific plant breeder or geneticist. This course focuses on the understanding of current quantitative and population genetics for plant breeding scientists. It covers both theory and applied approaches and encourages you to reach across both commodity and discipline for interdisciplinary thinking and creative approaches. The course attempts to translate modern scientific findings and theories to application of traditional field breeding, molecular locus identification, and ultimately marker assisted breeding. A lot of material and approaches are covered briefly to reinforce different ways of viewing a few core concepts: population genetic diversity, gene effects, linkage, and epistasis always mindful of the end goal: crop improvement.

Prerequisites:
Agro 642 Plant Breeding II in addition to a genetics course and a statistics course, or permission of the instructor.

Textbooks and resource material listing:
There is no textbook required. Class notes, journal articles and presentations will be posted on eLearning before we discuss them. Other pertinent material will be handed out in class. Software required for this course includes ‘R’, Mapmaker, QTL cartographer, Structure and TASSEL, all freely available.

Recommended helpful texts that were consulted in designing this class:

Hartl, D.L, and A.G. Clark. 1997. Principles of Population Genetics. Sinauer Associates, Sunderland, MA. (Pretty clear and well written book, will cover a lot of related topics that we will not have time to.)


Lynch, M., and J. B. Walsh. 1998. Genetics and Analysis of Quantitative Traits. Sinauer Associates, Sunderland, MA. (Nice reference but terminology and writing make it very difficult to read in my opinion – if you take a summer institute in statistical genetics course it may be included freely.)

Ross, S. 2002. A First Course in Probability, sixth edition. Pearson Education, India. (There is a probability basis behind all phenomenon you will observe and all decisions you will make – this helps to understand this a little better.)


Schedule: There are 15 weeks in the semester and 12 sections below, relative emphasis of each section will be dictated by student interests.

Phenotypic Quantitative Genetics
(some understanding of molecular markers and techniques will be needed)

1: Introduction
- Syllabus overview
- Review: genetics concept, statistics concepts
- Quantitative genetics: historical overview, basic concepts
- Population genetics: historical overview, basic concepts
- Probability theory and statistics
- Introduction to R (http://www.r-project.org/)
- Introduction / review of molecular markers

2: Genetic models
- Genetic models for means
- Genetic models for variances

3: Genetic and environmental variances
- Genetic and environmental variances
- Heritability
- Yield stability
- Genetic gain from selection

4: Relationships and genetic diversity
- Covariances among relatives
- Heterosis
- Combining ability
- Inbreeding coefficients
- Genetic distance
5: Recurrent selection & linkage
- Synthetic populations
- Genetic drift
- Introgression
- Linkage and linkage disequilibrium (LD)

6: Epistasis
- Advanced epistasis
- Testers
- Hemizygosity
- Multiple trait selection

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Molecular Quantitative Genetics

7: Bi-parental QTL mapping I.
- What is a QTL, why do they matter, and how do they connect to what we have covered?
- Genetic map construction
- Single marker analysis

8: Bi-parental QTL mapping II.
- Interval mapping, composite interval mapping
- Bayesian mapping
- Reality situations (tetraploid, half sib, unknown parents, etc.)

9: Association mapping
- Linkage disequilibrium (pt. II)
- Population structure, sub-structure, kinship, genetic distance
- TASSEL

10: Selection mapping (identifying temporal selection)
- Recurrent selection revisited

11: QTL MAS & genomic Selection
- Marker assisted selection in the phenotypic quantitative genetics model
- Genomic selection (the next big thing)

12: Putting it all together
- Team research project proposal presentations

Course rationale
I assume that in your previous courses you have learned how to be a good scientific plant breeder: how to identify and use genetic diversity, how to select, how to minimize GxE, how to evaluate field data, etc. The scientific goals of this class include reinforcing these previously learned concepts, adding relevant statistical and molecular technologies, relating recent scientific discoveries to plant breeding and finally helping you synthesize new concepts. A major focus is to help you understand the complexity of what is going on in the genome and how four main concepts: population genetic diversity, gene effects, linkage, and epistasis should affect how you breed and research plants (i.e. crop improvement). Internalizing these four concepts are the learning goals of the class, not how to use specific software or perform specific calculations (but this is good too).

In this course we will first review topics with traditional (phenotypic) quantitative genetics, both the basic theory of genetic models and application for estimating the effects within these genetic models, calculating heritability, and combining ability.
We will then cover molecular quantitative genetics as it applies to scientific breeding. Although some people stress a difference between ‘field’ and ‘molecular’ breeding, these are already integrated in many breeding programs. You can think of markers as one more way we are able to partition variance. Molecular breeding is not about spending all day in a lab genotyping, it is a tool providing biologically relevant information for selection and understanding of your organism of interest. If you went to a large corporate corn or soybean program today you would see marker assisted selection for known QTL on a massive scale being done by people who are field breeders. If you went to another large company you would see complex molecular genetics models predicting which crosses will be the most successful; this has let the breeders spend more time evaluating the best plants rather than simply making crosses to determine which plants are best. In public sector breeding you will also be much more successful understanding and even applying some of these same molecular techniques. The $100 genome sequence is coming quickly. In both the public and private sector molecular breeding is becoming increasingly automated. To be most successful as a PhD breeder and/ or geneticist you must understand these tools and how to design a good experiment to take advantage of them (or at the very least understand the implications of others work). We no longer will be working with tens of markers on a few genes of interest; we will be working with thousands or millions that move towards predicting and designing the biology we want to see. Organizing, protecting, interpreting and using this data is a challenge in itself!

**Learning objectives:**

**Thinking and analysis**

1. Apply and summarize the higher Bloom’s Taxonomy thinking levels in all communication.
2. Apply computational thinking to problem solving.
3. Synthesize your discipline in a larger context and integrate concepts from other disciplines.
   (We will approach this by reading popular press articles at the beginning of class.)
4. Assess the limitations of an experiment or study, discriminate where biases might occur, and recommend how to correct these limitations.
5. Demonstrate an ability to deal with complexity. From scientific concepts, to learning new software, there are no easy answers.
6. Be able to explain and support all of your decisions

**Professionalism and leadership.** For many students it will be one of the last courses that you take before you enter your profession.

1. Demonstrate an ability to develop a professional resume / CV ; be able to explain everything about this document.
2. Demonstrate leadership and followship when working in a team with others, both in an out of class. (You will be working with these peers for potentially the rest of your life so you should get to know them now - before they are famous!)
3. Demonstrate an ability to take criticism positively and integrate others criticism to further improve your work.

**Science**

1. Describe, explain and assess scientific findings in primary source journal articles.
2. Describe, explain and assess scientific approaches presented in class.

**Data analysis, simulations, and software**

7. Apply computer simulations to research questions of interest; summarize and assess the results.
8. Distinguish the most challenging aspects of learning new computer software.
Evaluation philosophy
In this class I will present knowledge and my own interpretations. For your assignments I will not present all knowledge necessary, and in some cases present no knowledge but will expect you to conduct evaluation and synthesis of a topic. I believe that you, as PhD students should be able to find all background knowledge necessary and then use it. I expect you to be able to find information on your own and hope you will already be familiar doing so. Use Google* liberally - it is your friend and knowledge (in Bloom thinking level terms) is now easily accessible. Just because other teachers have taught you knowledge and then tested you on this, does not mean that this is a good use of your time or mine. I assume the only way to learn is by trying - find what you do not know, do the best you can, and then use criticism to improve.
* Or your favorite search engine.

Grading:
50%: Exercise Problems (5 sets) – Due one week after they are given.
10%: Reading assignments.
10%: Quizzes (2) - First 20 min. of class based on problem sets.
10%: Wiki contribution - See Wiki section of syllabus.
20%: Team research project proposals.

60% Exercise problems
Due one week after given – at the beginning of class. I expect each problem set could take more than 20 hours of your time. Genetics and statistics will be abstract unless you struggle through the problems; this course combines both. If the problem sets are taking longer than this, please see me. They are not designed to be busy work. Grades will be based on appearance, clarity, conciseness and most importantly, the amount of thought you put in. Your level of thought is graded based on Bloom’s Taxonomy thinking levels (see back of assignment #1). Late work drops grade 25% after each subsequent class. Throughout your career, if your writing is hard to follow, boring or looks messy and unattractive, people will not want to read it; therefore comments and grades are necessarily also directed at these aspects. If you do poorly you may be asked to submit a revision. If so please highlight all changes so I can find them easily.

10%: Reading assignments
Do your reading and be prepared to contribute to discussion and/ or answer questions on it. Each paper discussion will be led by one student.

10%: Quizzes
Quizzes will be unannounced and given at the beginning of class. Quiz questions will be based on assignments I have returned to you. The objective of the quizzes is to make you look over your returned work and helping you fill in your gaps in understanding.

10% Wiki contribution
Contribution to the wiki is two-fold. 1) You need to put concepts into your own words, and give your own examples – this helps reinforce what you have learned. 2) There is little available online or in print to get the “Readers Digest” version of the newest concepts, terms, systems and examples we will discuss in this class. You should describe topics however you think it will be easiest for others to learn. You can help perform Darwinian selection on scientific ideas! 3) Your examples and projects may inspire the next scientific breakthrough…but only if they are shared and published.
20% Team research proposals
You will each be a leader and a team member in groups of two to four. Your team goal is to get your research proposal funded by a fictional private science agency. You will come up with one proposal utilizing everyone’s expertise (either three independent but synergistic projects, or one project that everyone could participate in). The project must translate and build on something learned in this class and be novel (i.e. fundable). 10pg. max including budget. Brevity is desirable. Assignment benchmarks will be given to keep you on track.

Academic integrity:
Science cannot be conducted in isolation and thus I highly encourage you to collaborate with your colleagues in the class. You will likely have interactions with them or through them for the rest of your career. You will also learn more from them than you do from me. If you do not personally need help then please help others who do. This being said I will not tolerate any direct copying or lack of effort (i.e. laziness) in problem solving and neither should you.

“An Aggie does not lie, cheat or steal or tolerate those who do.”
Please see the Honor Council Rules and Procedures on the web: http://www.tamu.edu/aggiehonor

Americans with Disabilities Act (ADA) policy:
The Americans with Disabilities Act (ADA) is a federal antidiscrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities in Room B-118 in the Cain Building, or call 845-1637.

Expectations of students
- I expect you want to learn the material.
- I expect you to try hard.
- I expect you to take risks.
- I expect that you will not hesitate to ask a question or correct me if I am wrong.
- I expect that if you are having problems with the material you will contact me.
- I expect the problem sets could to take more than 20 hours of time.
- I expect you to do the assigned readings.
- I expect you to show up to class or else to notify me of your absence.
- I expect you to use higher levels of thinking and do the background research necessary to support all statements and conclusions.

Expectations of your teacher
- You should expect that I want to teach you the course material.
- You should expect that I will try my best to help you succeed.
- You should expect that I will be fair.
- You should expect me to be prepared and ready to defend anything I want you to know.
- You should expect for me to call on you when you are not paying attention.