



# Animal Breeding & Genetics Short Course



**Summer 2017**  
**at Iowa State University**

## **INTRODUCTION TO GRAPHICAL MODELS WITH APPLICATIONS TO QUANTITATIVE GENETICS AND GENOMICS**

**June 19** (8:30 AM) – **23** (12 PM), 2017

**Instructors:** **Dr. Guilherme J. M. Rosa** University of Wisconsin-Madison  
(<http://www.ansci.wisc.edu/Facultypages/rosa.html>)  
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### **Content**

The course will provide an introduction to graphical models, including correlation networks, structural equation models, and Bayesian networks. Topics to be discussed include the concept of d-separation, causal sufficiency, and Markov blanket. The material will be illustrated with applications in quantitative genetics and genomics, including the prediction of phenotypes using earlier expressed traits, and genome-enabled prediction. Other examples of application of graphical modeling will include genome-wide association analysis (GWAS) and quantitative trait loci (QTL) mapping for multiple traits, structural equation models with latent variables, and the combination of multiple layers of omics information. Additional topics will include the concept of Mendelian randomization, direct and indirect genetic effects, and the analysis of field data in livestock production.

### **Target audience and prerequisites**

The course targets graduate students and researchers interested on the analysis of genetics and genomics data, including complex traits, molecular markers and gene expression. Some basic knowledge of quantitative and molecular genetics, linear mixed models, and elementary probability and statistics is expected. However, a brief overview of matrix algebra, probability distributions, and statistical inference will be provided at the beginning of the course. In addition, a working knowledge of R is desirable but an introduction will be offered prior to the use of specific R packages for graphical modeling.

**Registration** is at: <https://goo.gl/yAGvYQ>. Space is limited, register early (**by May 31**).

Limited shared **on-campus housing** is available (book at registration page **by May 15**).

A room block is available at the **Best Western Plus University Park Inn & Suites** (on CyRide bus route). \$109 /\$119 single/double. Please book directly with the hotel at (515) 296-2500. Be sure to mention you are with the Animal Breeding & Genetics Short Course.

For **transportation** to/from the Des Moines airport, see: <http://www.executiveexpress.biz/shuttle-service>

## **COURSE OUTLINE**

### **Correlation and Causation**

Sewall Wright and path analysis  
Observational and experimental data  
Confounding and selection bias  
Randomization

### **Basics of Matrix Algebra**

Definitions and matrix operations  
Systems of equations  
Linear regression and least squares

### **Aspects of Multivariate Distributions**

Density function or mass function  
Marginal and conditional distributions  
Expectation and variance  
Covariance and independence  
The multivariate normal distribution

### **Inference with Multivariate Models**

Likelihood principle  
Parameter estimation, Hypothesis test  
Independence tests (Discrete, Continuous, and Mixed cases)

### **Introduction to Graphical Models**

Basic concepts; network topology features  
Correlation networks  
Marginal and partial correlations  
Conditional independence and the concept of  $d$ -separation

### **Structural Equation Models in Quantitative Genetics**

Traditional multi-trait mixed effects model (MTM)  
Genetic and phenotypic correlation  
Basics of structural equation models (SEM)  
SEM with latent variables  
SEM embedded in MTM; direct and indirect genetic effects

### **Bayesian Networks**

Introduction  
Structure learning (constraint- and score-based algorithms)  
Parameter learning  
The concept of Markov blanket  
Causal inference

### **Applications in Genetics and Genomics**

Building parsimonious models  
Genome-enabled prediction  
Instrumental variable and Mendelian randomization  
Multiple-trait QTL mapping  
Combining multiple layers of omics information

**R packages:** Rgraphviz, pcalg, bnlearn, qtlnet, sem, lavaan, among others