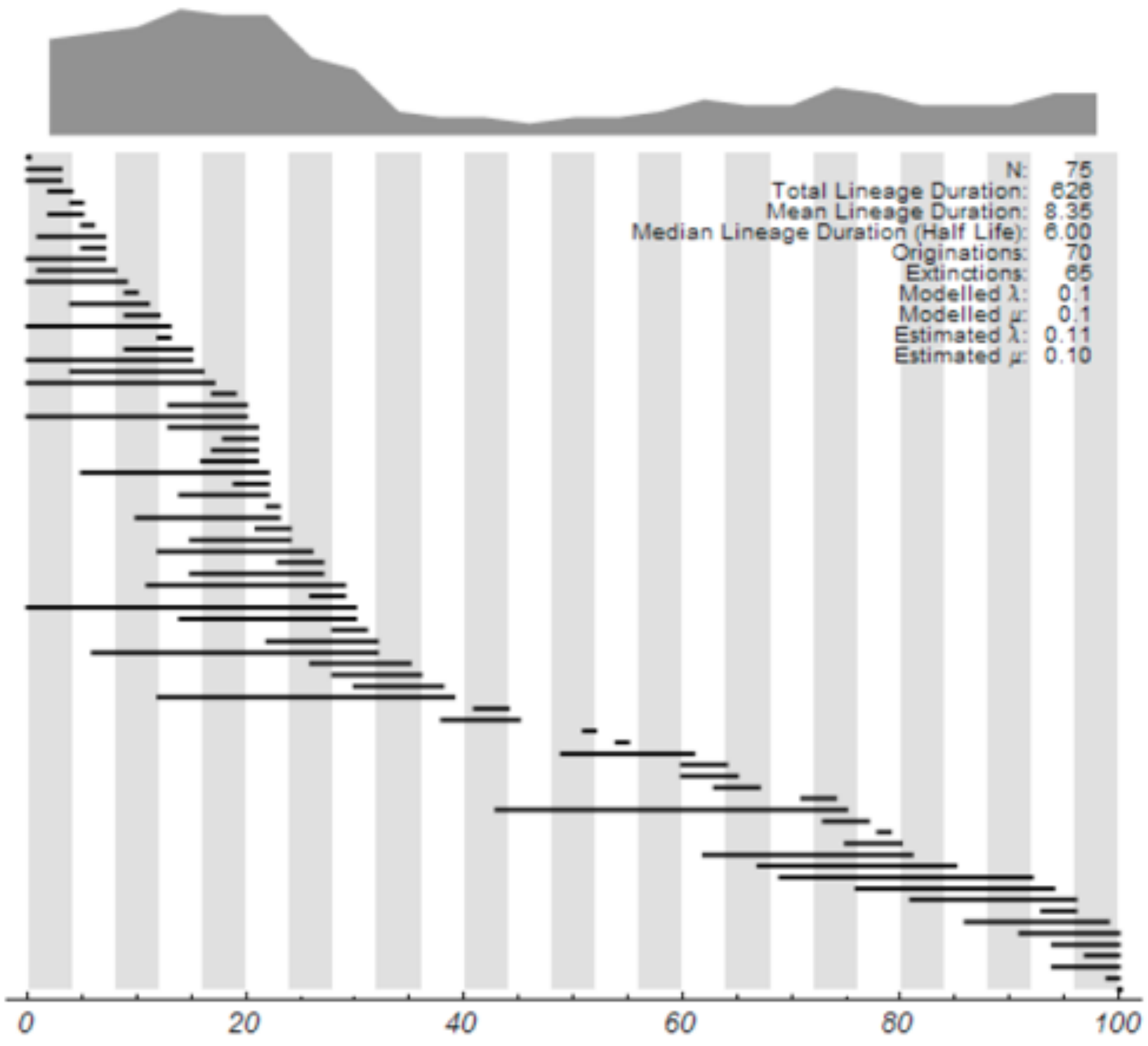
Quantitative Analysis

The Science and the Art



The Science of Quantitative Analysis

Empirical Description vs. Quantitative Modeling

Empirical Description

Presenting real data as graphic or numerical summaries

This kind of descriptive quantitative work involves no assumptions,
but the interpretations that are drawn from the summaries do require assumptions, many of which are not obvious.

Some scientist view empirical description as the only "safe" kind of quantitative analysis, but it is actually the most risky in terms of being deceived by assumptions and unknown parameters.

Quantitative Modeling

Generating artificial data based on parameters and rules that are programmed into the analysis

This kind of quantitative work puts the assumptions up front and allows one to test them by comparing the artificial data to real data.

Modeling is the most powerful kind of quantitative analysis and, indeed, is fundamental component of hypothesis testing in all sciences where the processes are fuzzy, poorly understood, poorly predictable, or historical.

But models must be grounded in empirical data at both ends: data should be involved in developing parameters and other data involved in testing the output.

Aims of the Course

This class introduces practical applications of quantitative analysis as they relate to paleontology.

Morphological evolution in evolving lineages
Morphological evolution on phylogenies
Reconstruction of phylogenies
Estimating rates and modes of evolution
Morphological diversity and disparity
Morphological functional properties
Taxonomic diversity

Scripting (programming) in Mathematica
Relational databases in MySQL
Monte Carlo methods for simulating and analyzing trait data
Finite element analysis for studying biomechanical properties of structures

In short, we will learn about major kinds of quantitative analysis by reading scientific papers (often the original descriptions of the techniques), and then learn to apply them ourselves to our own data.

Major Topics

Trait Evolution - Evolution of morphological traits in a fossil lineages: theory, simulations, rates of evolution, modes of evolution. Modeling trait evolution.

Phylogeny - Reconstructing phylogeny with parsimony analysis, maximum-likelihood and Bayesian analysis, and paleontological phylogenetic methods. Evolution of traits on a phylogeny, rates of evolution, modes of evolution, ancestor reconstruction. Modeling traits on phylogenetic tree.

Trait Diversity - Analysis of trait disparity within clades, bootstrapping and randomization tests.

Taxonomic Diversity - Patterns of taxonomic diversity through time, rates of origination and extinction, techniques for measuring diversity and correcting for biases in the fossil record. Modeling patterns of taxonomic diversity.

Three-dimensional analysis of morphology - Working with 3D morphology. Finite element analysis of the strength of morphological structures. Functional analysis and evolution.

Format and Grading

The class meets Thursday, 1:25 – 3:45. A typical session will include debriefing recent assignments, interactive lecture about the week's readings, and conducting analyses related to the current week's reading. Please bring a laptop computer to each session.

Participation (30%), presentation (20%), weekly work and final project (50%).

Projects consist of synthesizing the analyses that we cover each week based on a taxonomic group of your choice. The group you choose should have a good modern and fossil record (or should consist of two analogous groups, one with a fossil record and the other with a modern record) and should be reasonably diverse in terms of numbers of species, geographic locations, and morphological diversity. As part of weekly assignments, you'll collect data for your group of organisms (sometimes from online databases, sometimes from published literature, sometimes from your own observations or measurements) and you will perform original analyses on those data. For the final project, you will write up all the analyses as a synthetic "report" on the evolution of your group. Presuming you keep up week-by-week, at the end of the semester all you'll have to do is the synthesis.

Expectations

No background in paleontology is required,
but interest in learning about paleontology is.

No background in quantitative analysis is required,
but willingness to work at learning and understanding quantitative analysis is.

No programming or database experience is required,
but willingness to put time into learning to program and use a database is.

Course Website

http://www.indiana.edu/~g563/

Slides, handouts, assignments, links will be posted there. Readings will be posted to OnCourse.

For next week

1. Install Apache (webserver), mySQL (database), and PHP (scripting language)

   Windows: WAMP server (http://www.wampserver.com/)
   Mac: MAMP server (http://www.mamp.info/)
   Linux: LAMP server (installation varies with LINUX variety)

2. Install *Mathematica* Student Version from the Research Analytics office

   Contact: Kevin Wilhite, smsale@indiana.edu
   Location: 200 Woodburne Hall
   Cost: $30
   Recommended time: tomorrow morning (29 August)
   hhttp://rt.uits.iu.edu/visualization/analytics/math/mathematica.php

3. Install PAST, Mesquite, PHYLIP, MeshLab