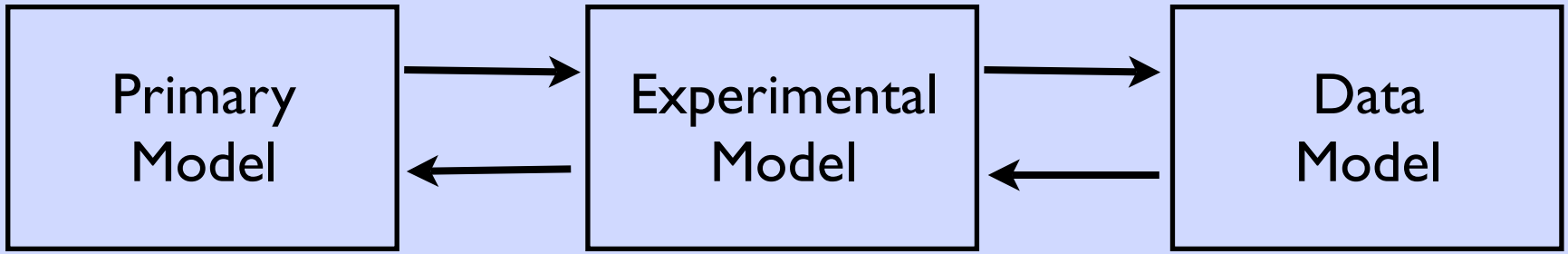
Experimental Design

Senior Research Seminar
September 20, 2007

Your thesis and your mentor's research

- Intellectual contribution
- Collaboration vs. employment
- Independence
- Professional interaction

The error-statistical scientific process



From Scheiner 2001

What is the point?

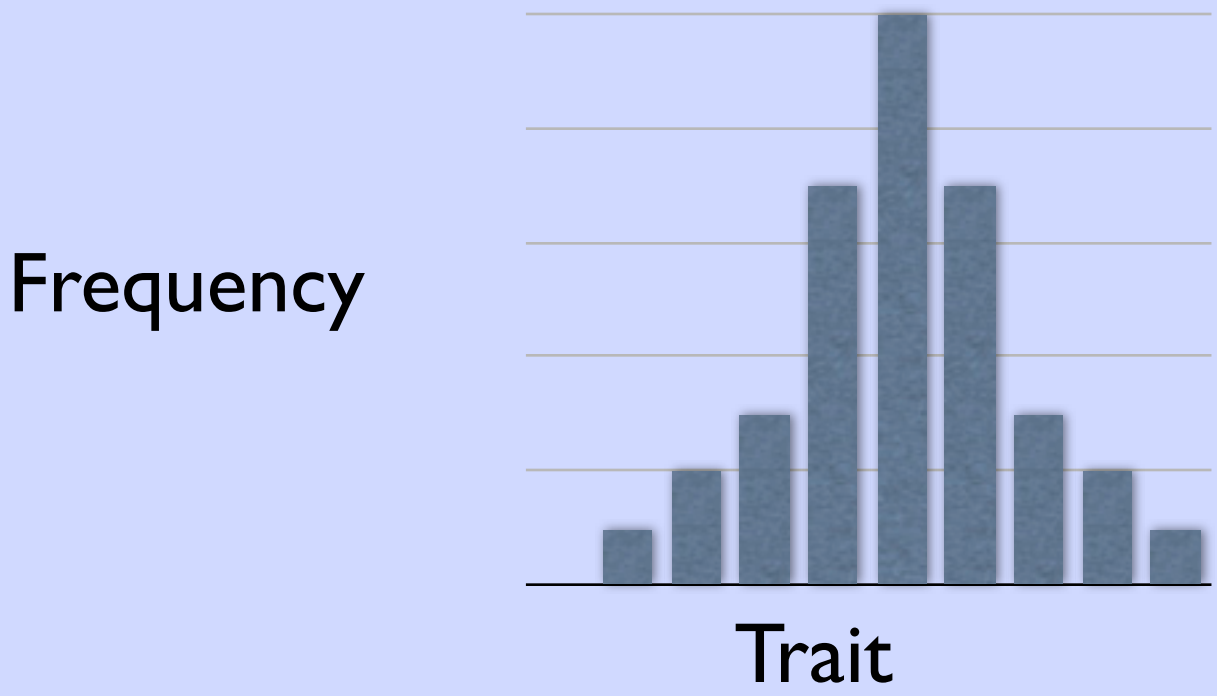
- Are there spatial or temporal differences in the variable Y?
  - Starting point for most research; sometimes the entire question for large scale or preliminary studies
- What is the effect of factor X on variable Y?
  - Typical of manipulative experiments, sometimes used in observation experiments (but the inference is weaker)
- Which mechanistic hypothesis is supported?
- What is the appropriate parameter for a particular model?

Experiments

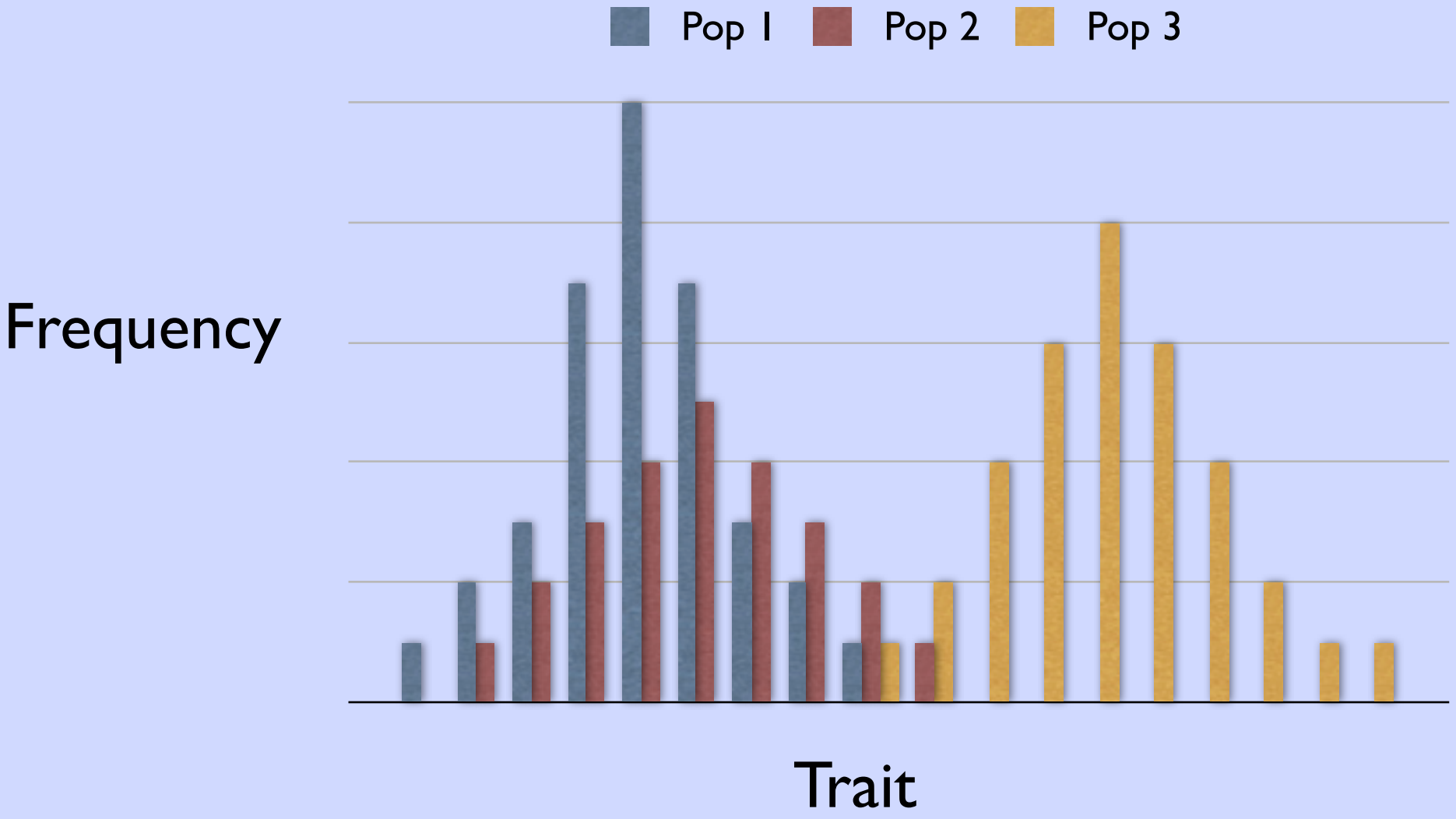
- Manipulative Experiments
  - Experimental treatment group(s) and control
  - Example: Manipulations of chemical inputs into microbiological communities
- Observational (or Natural) Experiments
  - Compare pre-existing groups which vary in the factor of interest
  - Example: Observe differences between population from different environments
- Non-Experimental Theses

Variation

Scientists replicate to distinguish effect from random variation



Distinguishing between groups



How much replication?

It depends on both variance and effect size

Unfortunately, the scientist rarely knows either of these variables before the experiment. Solutions: pilot study, previous related research

How many replicates can I afford?

- Time (include travel and prep time; lag between observations can produce error)
- Labor
- Money
- Plan for mistakes!

"Rule of Ten"

You should collect at least ten replicate observations for each category or treatment level (Gotelli and Ellison 2004)

Example: If you know you can make 50 observations during your research, you should compare a maximum of five groups.

You are almost certain to lose some data along the way!

Other Concerns

- Independence of Observations
- Confounding factors
- Randomization
- Realism (both nature and range of treatment)
- Controls
- Consistency of application
- Covariates

Where to go for help

- Your mentor and their associates (to start)
- The library
  - Statistics books
  - Methods section of related papers
- Statistical Consulting: consult@stat.columbia.edu