Lecture 14

Genetic Drift

(Article 14)

Please pick up 2 pennies as you come in!

Deterministic vs. Stochastic Worlds

- Deterministic processes: given initial conditions, outcome is completely determined:
- Stochastic processes: given initial conditions, outcome is a probability estimate (e.g., weather forecasting)

Stochastic Processes

- Extrinsic factors (e.g., fluctuating environment)
- Intrinsic factors, or "sampling error"
  - In population modeling, we assumed 'b' and 'd' were deterministic.
  - In the "big bang" life history (H-W), we assumed a large (actually N=∞) population of parents

Demographic stochasticity

- Imagine a simple annual plant.
- Probability of surviving to end of yr = 1 (d=0)
- b=1, but is stochastic. What does this mean?
- For example, it may mean:
  - b=0, with probability 0.25
  - b=1, with probability 0.50
  - b=2, with probability 0.25
- A population could go extinct, even though r=1! Rule of probability: If N=1, Chance of extinction = 0.25. If N=2, Chance of extinction = 0.25 x 0.25 = .0625.

Genetic Drift – Genetic Stochasticity

- Genetic Drift - allele frequency change due to small N (and resulting 'sampling error')
- How will allele frequency change?
- Model involves intensive probability theory: If you have 2N alleles combining at random, the probability that i of them will be A_1 is given by the binomial distribution;

Experimental Demonstration of Genetic Drift (Using Clickers!)

- Experiment 1: Infinite Population.
- Assume p=0.5, q=0.5
- What would p_{t+1} be after one generation of drift with N=infinity?

Expt'l Demo of Drift

- 2. N=X (Class size today). Flip your two coins; what is 'junior's genotype?

Genotype:	(A) HH	(B) HT	(C) TT	p	q
Observed					
Expected	.25	.50	.25	.5	.5

Expt'l Drift Demo

- N=class size (trial 2). Repeat!

Genotype:	(A) HH	(B) HT	(C) TT	p	q
Observed					
Expected	.25	.50	.25	.5	.5

Expt'l Demo of Drift

- N=8

Genotype:	(A) HH	(B) HT	(C) TT	p	q
Observed					
Expected	.25	.50	.25	.5	.5

Expt'l Demo of Drift

- N=8 (trial 2)

Genotype:	(A) HH	(B) HT	(C) TT	p	q
Observed					
Expected	.25	.50	.25	.5	.5

Expt'l Demo of Drift

- X populations with N=1

	# of Pop'ns		
Time	(A) HH (p=1)	(B) HT (p=.5)	(C) TT (p=0)
1			
2			
3			
4			

Genetic Drift - A Random Walk

- Genetic drift is allele frequency change without a directional driving force:

Genetic Drift - A Random Walk

- By chance, in the absence of other forces, all small populations will drift to 'fixation': p= 0 or p=1.

Genetic Drift and Small Populations

- Genetic drift results in most rapid allele frequency change in small populations
- Rare plants and animals will tend to lose genetic variability
- Is drift unimportant in large populations?
- ******Not necessarily!******

Effective Population Size

- Individuals often mate within a small neighborhood, making N *effectively small* (and therefore drift becomes a potent force)

Effective Population Size

- Even if a population is panmictic (randomly mating with no distance limitation), $N_e < N$ because not all individuals in a population are reproductive
- Skewed sex ratio may lower N_e

Population Bottlenecks

- Due to effects of stochastic factors on **population size**, the stochastic process of drift can reduce genetic variation in low N periods

Genetics of Turtles

- Demonstration of population bottleneck
- GG=Dark Green Turtles
- Gg=Dark Green Turtles
- Gg=Light Green Turtles

Summary-Genetic Drift

- Genetic drift is allele frequency change due to 'sampling error'
- Drift results in fixation of one allele or the other
- The rate of fixation is N-dependent, with fastest rates of change occurring in small populations
- A population bottleneck is a historical phenomenon that produces drift-like loss of genetic variation and differentiation