BGEN 55 - Advanced Genetics II

Mutation-Selection Balance Simulation

Interactive Exploration Instructions

🎮 Simulation Overview

This interactive simulation allows you to explore how mutation and selection interact to maintain deleterious alleles in populations. Watch as opposing forces reach equilibrium in real-time!

⏰ Estimated Time: 20-30 minutes

1 Accessing the Simulation

Navigate to the "Mutation Simulation" section on the Week 5 webpage. The simulation will load automatically.

🖥️ **Location:** Scroll to Simulation Section

2 Understanding the Interface

The simulation has three main components:

🎛️ **Control Panel**

Adjust parameters

📊 **Visualization**

Watch allele frequencies change

📈 **Results Display**

See numerical outcomes

⚙️ Parameter Guide

Initial Frequency of A (p_0)

Purpose: Sets the starting frequency of the normal allele

Typical values: 0.5 to 1.0

Effect: Higher values take longer to reach equilibrium

Mutation Rate (μ)

Purpose: Controls how often A mutates to a

Typical values: 0.00001 to 0.001

Effect: Higher rates lead to higher equilibrium frequencies

Selection Coefficient (s)

Purpose: Measures strength of selection against aa homozygotes

Typical values: 0.1 to 1.0

Effect: Higher selection reduces equilibrium frequency

Number of Generations

Purpose: How long to run the simulation

Typical values: 100 to 10,000

Effect: More generations show approach to equilibrium

3 Running Your First Simulation

Start with these default parameters to see mutation-selection balance in action:

Default Setup:
- p_0 = 1.0 (start with only A alleles)
- μ = 0.0001 (mutation rate)
- s = 0.5 (moderate selection)
- Generations = 1000

Click "Run Simulation" and observe!

🔍 Learning Activities

Activity 1: Exploring the Balance

Goal: Verify that $\hat{q} = \sqrt{(\mu/s)}$

Steps:

1. Set μ = 0.0001, s = 0.25
2. Calculate expected $\hat{q} = \sqrt{(0.0001/0.25)} = 0.02$
3. Run simulation with p_0 = 1.0, generations = 5000
4. Compare final q with predicted $\hat{q}$

Activity 2: Strength of Selection

Goal: Understand how selection strength affects equilibrium

Steps:

1. Keep μ = 0.0001 constant
2. Run simulations with s = 0.1, 0.5, and 0.9
3. Record equilibrium frequencies

4. Note how stronger selection lowers equilibrium frequency

Activity 3: Mutation Rate Effects

Goal: Explore how mutation rate influences equilibrium

Steps:

1. Keep $s = 0.5$ constant
2. Run simulations with $\mu = 0.00001, 0.0001$, and 0.001
3. Record equilibrium frequencies
4. Note how higher mutation rates increase equilibrium frequency

4 Interpreting Results

After each simulation run, examine:

Final p
Frequency of A allele

Final q
Frequency of a allele

Δp
Total change in frequency

Theoretical p
Predicted value

Key Questions to Consider:

- Did the simulation reach equilibrium?
- How does the final q compare to $\sqrt{(\mu/s)}$?
- How quickly did the population approach equilibrium?
- What happens if you start with different initial frequencies?

🛠️ Troubleshooting Guide

Problem: Simulation runs but frequencies don't change

Solution: Check that $\mu > 0$ and ensure enough generations

Problem: Equilibrium not reached

Solution: Increase number of generations, especially for small μ

Problem: Results don't match predictions

Solution: Verify parameter values and check calculation of $\sqrt{(\mu/s)}$

Problem: Visualization not updating

Solution: Refresh the page and try again

5 Advanced Exploration

Once you're comfortable with the basics, try these challenges:

Challenge 1: Find parameter combinations where equilibrium is reached in exactly 100 generations

Challenge 2: Explore what happens when $s = 0$ (no selection) or $\mu = 0$ (no mutation)

Challenge 3: Try starting with $p_0 = 0$ (only a alleles) and see if equilibrium is different

Challenge 4: Find the combination of μ and s that gives $\hat{q} = 0.01$

📝 Learning Reflection

After completing the simulation activities, consider:

- How does the visualization help understand mutation-selection balance?
- What surprised you about the equilibrium frequencies?
- How do mutation and selection "negotiate" the final allele frequency?
- What real-world genetic conditions might follow these patterns?

Next Steps: Use these insights to better understand the mathematical derivations and real-world applications of mutation-selection balance.