BGEN 55 - Advanced Genetics II

Scenario-Based Quiz

Mutation-Selection Balance Applications

📝 Quiz Instructions

This quiz presents real-world scenarios to test your understanding of mutation-selection balance. For each scenario:

- Read the scenario carefully
- Consider which concepts apply
- Choose the best answer
- Check the explanation to learn from each question
- Take your time - these are application questions, not memorization

⏰ Estimated Time: 25-35 minutes

📐 Formula Reference

`Recessive: q^= √(μ/s)  |  Dominant: q^= μ/s  |  Additive: q^= μ/(hs)`

Scenario 1: The Mystery of Cystic Fibrosis

You're a genetic counselor studying cystic fibrosis (CF), a recessive lethal disorder. The CF allele frequency in European populations is about 0.02, much higher than predicted by mutation-selection balance alone. Historical records suggest CF carriers might have had resistance to cholera outbreaks.

Question: Why is the observed CF frequency higher than the mutation-selection balance prediction?

A) The mutation rate for CF is much higher than estimated

B) Heterozygote advantage in the past increased the frequency

C) Modern medical care reduces selection against CF

D) All of the above could contribute

Scenario 2: Conservation Genetics Dilemma

You're working with an endangered species of big cats with a population of only 200 individuals. Genetic testing reveals a high frequency of a recessive deleterious allele that causes skeletal deformities in homozygotes. The mutation rate is normal, but the allele frequency is much higher than expected.

Question: What evolutionary force most likely explains the high frequency of this deleterious allele?

A) Increased mutation rate due to environmental factors

B) Genetic drift in the small population

C) Heterozygote advantage for this allele

D) Recent positive selection for the allele

Scenario 3: Pharmaceutical Development

A pharmaceutical company is developing a gene therapy for a rare dominant disorder. The disorder has complete penetrance and reduces fitness by 30% ($s = 0.3$). The mutation rate is 2×10^{-6}. The therapy would effectively make $s = 0$.

Question: If the therapy is widely successful, what will happen to the disorder frequency over many generations?

A) It will immediately drop to zero

B) It will increase due to mutation pressure

C) It will stay at the current equilibrium frequency

D) It will slowly decrease due to other evolutionary forces

Scenario 4: Agricultural Genetics

You're breeding corn plants and notice a recessive allele that reduces yield by 20% in homozygotes. The mutation rate is 5×10^{-6}. You're trying to decide whether to implement an expensive screening program to eliminate this allele.

Question: What is the expected equilibrium frequency of this allele if you don't intervene?

A) 0.005

B) 0.0005

C) 0.05

D) 0.00005

Scenario 5: Evolutionary Medicine

Researchers are studying a late-onset dominant disorder that appears after age 50. The mutation rate is 8×10^{-7}, and the disorder completely prevents reproduction (s = 1). However, the observed frequency is higher than predicted.

Question: What factor most likely explains the higher-than-expected frequency?

A) The mutation rate is underestimated

B) Some affected individuals reproduce before symptoms appear

C) There's heterozygote advantage for this allele

D) Genetic drift maintains the higher frequency

Scenario 6: Public Health Planning

A public health agency is planning for a recessive genetic disorder in a population of 10 million. The mutation rate is 1×10^{-6} and the disorder is lethal (s = 1). They want to estimate how many affected births to expect per year.

Question: Approximately how many affected births would you predict per year? (Assume 25 years/generation)

A) 1

B) 10

C) 40

D) 400

📊 Self-Assessment

How did you do? Consider:

- Which scenarios were most challenging?
- Did you apply the formulas correctly?
- How well did you consider multiple evolutionary forces?
- What real-world applications surprised you?

Learning Tip: The key to applying mutation-selection balance is understanding when it applies and when other forces might be more important.
