SI Biology - Full Discipline Demo

Population Genetics: Natural Selection and Hardy-Weinberg Equilibrium - Digital

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Biology - Full Discipline Demo
Course	SI Biology - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each term with the best description.

Terms	Description	Answer
Mutation	Alleles beneficial to survival and reproduction are passed to the next generation at higher frequencies than other alleles	1
Evolution	Change in gene frequencies of a population over time	2
Genetic drift	Change in allele frequencies resulting from chance	3
Population genetics	The study of heritable variation within groups of organisms	4
Natural selection	Change to gene sequences that creates new alleles within a population	5

Correct answers:

1 Natural selection 2 Evolution 3 Genetic drift

4 Population genetics 5 Mutation

Identify each statement as true or false.

The sum of genetic frequencies for dominant and recessive alleles in a population must equal 1 for populations at Hardy-Weinberg equilibrium.

The Hardy-Weinberg equation is used to predict gene frequencies in rapidly evolving populations.

The Hardy-Weinberg equilibrium principle assumes that selection does not occur.

The Hardy-Weinberg equation states the frequency of the dominant allele as q^2.

True	False
1	2

Correct answers:

1

The Hardy-Weinberg equilibrium principle assumes that selection does not occur.

The sum of genetic frequencies for dominant and recessive alleles in a population must equal 1 for populations at Hardy-Weinberg equilibrium.

2

The Hardy-Weinberg equation states the frequency of the dominant allele as q^2.

The Hardy-Weinberg equation is used to predict gene frequencies in rapidly evolving populations.

Exploration

_____ alleles are expressed in both homozygous and heterozygous individuals.

- Dominant ✔
- Recessive
- Redundant
- Population

_____ is a process that results in better adapted populations to their environment that produce more offspring.

- Genetic drift
- Mutation
- Natural selection ✔
- Equilibrium

The Hardy-Weinberg equation is a mathematical formula that predicts the distribution of alleles and genotypes in a population at equilibrium.

- True ✔
- False

Exercise 1

What is genetic drift? How did the model population size relate to this process?

Genetic drift is a change in allele frequencies in a population over time resulting from chance. Small populations are more prone to genetic drift than larger populations. The model population consisted of only 50 individuals. Genetic drift changes allele frequencies purely by chance, as some individuals produce more descendants than other individuals due to luck rather than being better adapted to their environment.

How do the predicted allelic frequencies recorded in Data Table 3 compare to the frequencies after 10 generations of sampling recorded in Data Table 4? Does the comparison indicate the model population was at equilibrium?

The model population was not at equilibrium because the predicted 0.25:0.5:0.25 genotypic ratios are significantly different than those recorded in the final row of Data Table 4 for generation which were 10: 0:0.12:0.88.

List the five assumptions of the Hardy-Weinberg Equilibrium Principle. Describe why the principle was or was not supported by the model population.

1 - The population is very large.
2 - Mating is random.
3 - No genes transfer in to or out of the population (no migration of individuals into or out of
the population occurs).
4 - There are no changes in the gene pool due to mutation.
5 - Natural selection does not take place: all genotypes are equal in reproductive success.
The principle was not supported by the model population because of the small population size of only 50 individuals.

What is evolution? Was evolution observed in your model population? Reference Graph 1 in your explanation.

Evolution is the change in gene frequencies over time in a population. Graph 1 illustrates that evolution occurred by the elimination of the homozygous dominant genotype and the proliferation of the homozygous recessive genotype over 10 generations.

Data Table 1: Preliminary Analysis of the Population
(SAMPLE ANSWER BELOW)

Diploid allele number	2
Diploid individuals in population	50

Allelic frequency of p in the gene pool	0.5
Allelic frequency of q in the gene pool	0.5

Data Table 2: Descriptions of Genotype and Phenotype of Individuals
(SAMPLE ANSWER BELOW)

Description	Genotype	Phenotype
Homozygous dominant	BB	Brown fur
Heterozygous	Bb	Brown fur
Homozygous recessive	bb	White fur

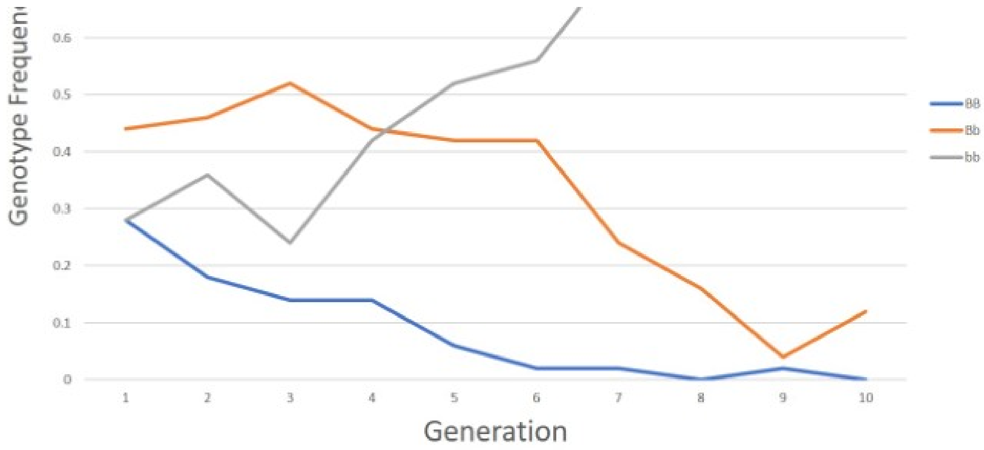
Data Table 3: Expected Genotypic Frequency and Number
(SAMPLE ANSWER BELOW)

Expected Data	Genotype		
	BB (p^2)	Bb (2pq)	bb (q^2)
Expected Frequency	0.25	0.50	0.25
Expected Number	12.5	25	12.5

Data Table 4: Modeling Genetic Drift
(SAMPLE ANSWER BELOW)

Generation	Starting Allelic Number		Genotypic Number			Allelic Number		Genotypic Frequency			Allelic Frequency	
	B	b	BB	Bb	bb	B	b	p^2	2pq	q^2	p	q
1	50	50	14	22	14	50	50	0.28	0.44	0.28	0.5	0.5
2	50	50	9	23	18	41	59	0.18	0.46	0.36	0.41	0.59
3	41	59	7	26	17	40	60	0.14	0.52	0.34	0.4	0.6
4	40	60	7	22	21	36	64	0.14	0.44	0.42	0.36	0.64
5	36	64	3	21	26	27	73	0.06	0.42	0.52	0.27	0.73
6	27	73	1	21	28	23	77	0.02	0.42	0.56	0.23	0.77
7	23	77	1	12	37	14	86	0.02	0.24	0.74	0.14	0.86
8	14	86	0	8	42	8	92	0	0.16	0.84	0.08	0.92
9	8	92	1	2	47	4	96	0.02	0.04	0.94	0.04	0.96
10	4	96	0	6	44	6	94	0	0.12	0.88	0.06	0.94

Graph 1: Genotypic Frequencies by Generation
(SAMPLE ANSWER BELOW)



Exercise 2

What is natural selection? How did the simulation population model this process?

Natural selection is the process where alleles beneficial to survival of individuals in a particular environment are passed to the next generation at a higher frequency than other alleles, resulting in populations that are better adapted to the environment over time. Natural selection was modeled in the simulation by the depredation of all homozygous recessive individuals (bb) from each generation so that only individuals expressing the dominant allele contributed to the gene pool of future generations.

How did the allelic frequencies change over the 10 generations modeled in response to natural selection? Do you think the white allele could be eliminated from the population if the model had continued for 10 more generations? Reference Graph 2 in your explanation.

The frequency of the B allele increased from 0.5 in Generation 1 to 0.9 in Generation 10, whereas the frequency of the b allele decreased from .05 to 0.1. It is unlikely the b allele would be eliminated by Generation 20 as the frequencies of both alleles stabilized after Generation 7 as shown in Graph 2.

A mutation occurs in a population of rabbits affecting ear length. After multiple generations, 30% of the population exhibit the new recessive phenotype for short ears. Use the Hardy-Weinberg equation to determine the genotypic frequencies of the rabbit population. Show all work in your answer.

1. List the possible genotypes for each of the phenotypes.

   LL – Long ear rabbit

   Ll – Long ear rabbit

   ll – Short ear rabbit

2. Determine the phenotypic frequencies in the population.

   The long ear phenotype occurs in 70% of the population for a frequency of 0.7. The short ear phenotype occurs in 30% for a frequency of 0.3.

3. Determine the allelic frequencies of the long allele (L) and the short allele (l) in the population.

   Short ear rabbits have a phenotypic frequency of 0.3. All white cats have the genotype ll. Thus, short ear rabbits must also have the genotypic frequency of 0.3.

   Genotypic frequency of ll = q^2 = 0.3

   If q^2 = 0.3, then q = 0.55. Since p + q = 1, solve for p: p = 0.45. Therefore, frequency of the l allele in the population is q = 0.55 and the frequency of the L allele in the population is p = 0.45.

4. Determine the genotypic frequencies of LL, Ll, and ll in the population.

Genotypic frequency can be determined from the Hardy-Weinberg Equation: $p^2 + 2pq + q^2 = 1$, where p^2 = frequency of LL, pq = frequency Ll, and q^2 = frequency of ll. The values of p and q have already been determined (p = 0.45 and q = 0.55): $0.45^2 + 2(0.45)(0.55) + 0.55^2 = 0.2 + 0.5 + 0.3 = 1$

Frequency of LL = p^2 = 0.2

Frequency of Ll = 2pq = 0.5

Frequency of ll = q^2 = 0.3

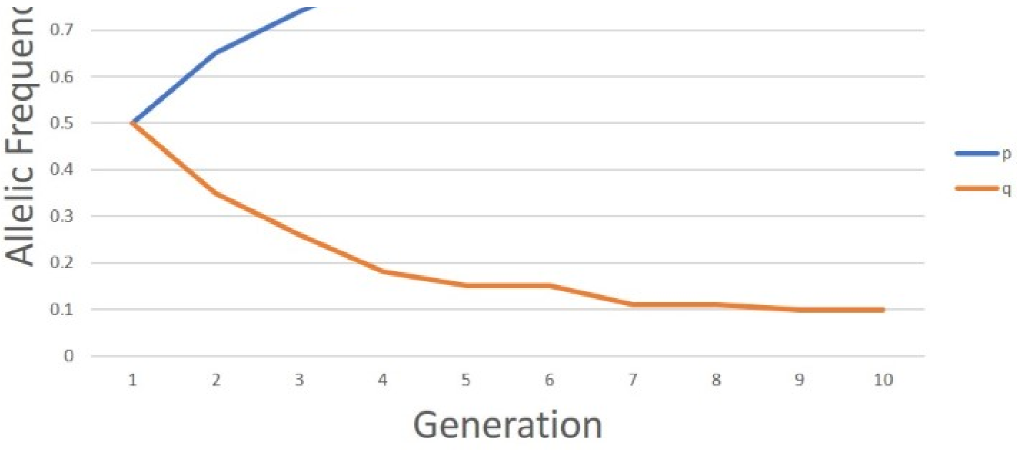
How would the allelic frequencies and resulting graph differ from the results in Data Table 5 and Graph 2 for a population at Hardy-Weinberg equilibrium for 10 generations?

0 / 10000 Word Limit

Data Table 5: Modeling Natural Selection
(SAMPLE ANSWER BELOW)

Generation	Starting Allelic Frequency		Starting Allelic Number		Genotypic Number			Final Genotypic Frequency			Final Allelic Number	
	p	q	B	b	BB	Bb	Deaths (bb)	p^2	2pq	q^2	B	b
1	0.50	0.50	50	50	12	26	12	0.32	0.68	0	50	26
2	0.65	0.35	65	35	21	22	7	0.49	0.51	0	66	22
3	0.74	0.26	74	26	29	16	5	0.64	0.36	0	74	16
4	0.82	0.18	82	18	34	14	2	0.71	0.29	0	82	14
5	0.85	0.15	85	15	35	15	0	0.70	0.30	0	85	15
6	0.85	0.15	85	15	37	11	2	0.77	0.23	0	85	11
7	0.89	0.11	89	11	39	11	0	0.78	0.22	0	89	11
8	0.89	0.11	89	11	39	10	1	0.80	0.20	0	88	10
9	0.90	0.10	90	10	40	10	0	0.80	0.20	0	90	10
10	0.90	0.10	90	10	41	8	1	0.84	0.16	0	90	8

Graph 1: Allelic Frequencies
(SAMPLE ANSWER BELOW)



Competency Review

A(n) _____ is a group of individuals of the same species living and interbreeding within a given area.

- allele
- gene pool
- population ✔
- gene frequency

A(n) _____ is the total of all alleles within a population.

- mutation
- evolution
- Hardy-Weinberg equilibrium
- gene pool ✔

Genetic drift is a change in allele frequencies in a population over time resulting from _____.

- chance ✔
- mutations
- natural selection
- evolution

The Hardy-Weinberg equilibrium principle states that the frequencies of alleles and genotypes in a population will remain constant over time when evolution is not occurring.

- True ✔
- False

The Hardy-Weinberg equation states the sum of the frequencies for each allele must always equal _____.

- 0
- 1 ✔
- 2
- 4

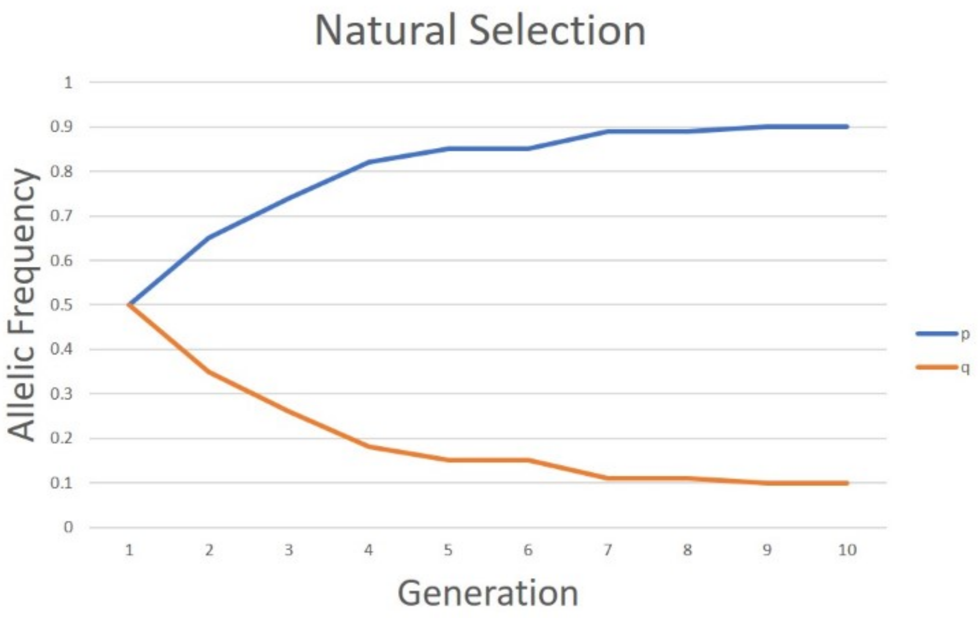
When sampling individuals from a simulation model, the genotype of each individual should be recorded.

- True ✔
- False

The frequency of the dominant allele (B) in a population at equilibrium is 0.5. The frequency of the homozygous dominant genotype (BB) is _____.

- 0.75
- 0.5
- 0.25 ✔
- 1

The graph below represents natural selection for the recessive allele.



- True
- False ✔

Extension Questions

A plant breeder has observed a dominant allele mutation occurring in 50% of a population of commercially important orchids. This mutation diminishes the value of the plant and the breeder wishes to remove the trait from the population. Apply your knowledge of population genetics to advise the plant breeder for how many generations it will take to remove the mutated allele from the population. Include the concepts of gene frequencies and selection in your answer.

(SAMPLE ANSWER BELOW)

The mutated dominant allele will only require one generation to be removed from the gene pool of the population. 50% of the population contain the allele which is expressed in both homozygous and heterozygous individuals. By removing all individuals displaying the mutated trait and not allowing them to reproduce, the breeder will be left with only homozygous recessive individuals in the population. These members will only produce offspring that are also homozygous and therefore the mutated dominant allele will have been eliminated from the population.