Name ______________________ Course/Section ______________________

Date ______________________ Professor/TA ______________________

Activity 23.1 A Quick Review of Hardy-Weinberg Population Genetics

Part A. Review Chapter 23 of *Biology,* 7th edition. Then complete the discussion by filling in the missing information.

If evolution can be defined as a change in gene (or more appropriately, allele) frequencies, is it conversely true that a population not undergoing evolution should maintain a stable gene frequency from generation to generation? This was the question that Hardy and Weinberg answered independently.

1. **Definitions.** Complete these definitions or ideas that are central to understanding the Hardy-Weinberg theorem.

a. Population: An interbreeding group of individuals of the same ___________.
b. Gene pool: All the alleles contained in the gametes of all the individuals in the ___________.
c. Genetic drift: Evolution (defined as a change in allele frequencies) that occurs in ______________ populations as a result of chance events.

2. **The Hardy-Weinberg theorem.** The Hardy-Weinberg theorem states that in a population that _____________ **(is/is not)** evolving, the allele frequencies and genotype frequencies remain constant from one generation to another.

3. **Assumptions.** The assumptions required for the theorem to be true are listed on page 449 of *Biology,* 6th edition, and are presented here in shortened form.

a. The population is very ______________.
b. There is no net _______________ of individuals into or out of the population.
c. There is no net _______________; that is, the forward and backward mutation rates for alleles are the same. For example, A goes to a as often as a goes to A
d. Mating is at _____________ for the trait/gene(s) in question.
e. There is no ______________. Offspring from all possible matings for the trait/gene are equally likely to survive.

4. **The Hardy-Weinberg proof.** Consider a gene that has only two alleles, *R* (dominant) and *r* (recessive). The sum total of all *R* plus all *r* alleles equals all the alleles at this gene locus or 100% of all the alleles for that gene.

Let p = the percentage or probability of all the *R* alleles in the population
Let q = the percentage or probability of all the *r* alleles in the population

If all *R* + all *r* alleles = 100% of all the alleles, then

$$p + q = 1 \text{ (or } p = 1 - q \text{ or } q = 1 - p)$$

[*Note:* Frequencies are stated as percentages (for example, 50%) and their associated probabilities are stated as decimal fractions (for example, 0.5).]

Assume that 50% of the alleles for fur color in a population of mice are *B* (black) and 50% are *b* (brown). The fur color gene is autosomal.

a. What percentage of the gametes in the females (alone) carry the *B* allele? ____
b. What percentage of the gametes in the females (alone) carry the *b* allele? _____
c. What percentage of the gametes in the males carry the *B* allele? ______
d. What percentage of the gametes in the males carry the *b* allele? ______
e. Given the preceding case and all the Hardy-Weinberg assumptions, calculate the probabilities of the three possible genotypes (*RR*, *Rr*, and *rr*) occurring in all possible combinations of eggs and sperm for the population.

		Female gametes and probabilities	
		(*R*)(p)	(*r*)(q)
Male gametes and probabilities	(*R*)(p)	RR (p^2)	____ ( )
	(*r*)(q)	____ ( )	____ ( )

Because the offspring types represent all possible genotypes for this gene, it follows that

$$p^2 + 2pq + q^2 = 1 \text{ or } 100\% \text{ of all genotypes for this gene}$$

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Part B. Use your understanding of the Hardy-Weinberg proof and theorem to answer the questions.

1. According to the Hardy-Weinberg theorem, $p + q = 1$ and $p^2 + 2pq + q^2 = 1$. What does each of these formulas mean, and how are the formulas derived?

2. Assume a population is in Hardy-Weinberg equilibrium for a given genetic autosomal trait. What proportion of individuals in the population are heterozygous for the gene if the frequency of the recessive allele is 1%?

3. About one child in 2,500 is born with phenylketonuria (an inability to metabolize the amino acid phenylalanine). This is known to be a recessive autosomal trait.

a. If the population is in Hardy-Weinberg equilibrium for this trait, what is the frequency of the phenylketonuria allele?

b. What proportion of the population are carriers of the phenylketonuria allele (that is. what proportion are heterozygous)?

4. In purebred Holstein cattle, about one calf in 100 is spotted red rather than black. The trait is autosomal and red is a recessive to black.

a. What is the frequency of the red alleles in the population?

b. What is the frequency of black homozygous cattle in the population?

c. What is the frequency of black heterozygous cattle in the population?

5. Assume that the probability of a sex-linked gene for color blindness is $0.09 = q$ and the probability of the normal allele is $0.91 = p$. This means that the probability of X chromosomes carrying the color blindness allele is 0.09 and the probability of X chromosomes carrying the normal allele is 0.91.

a. What is the probability of having a color-blind male in the population?

b. What is the probability of a color-blind female?

6. The ear tuft allele in chickens is autosomal and produces feathered skin projections near the ear on each side of the head. This gene is dominant and is lethal in the homozygous state. In other words, homozygous dominant embryos do not hatch from the egg. Assume that in a population of 6,000 chickens, 2,000 have no tufts and 4,000 have ear tufts. What are the frequencies of the normal versus ear tuft alleles in this population?

7. How can one determine whether or not a population is in Hardy-Weinberg equilibrium? What factors need to be considered?

8. Is it possible for a population's genotype frequencies to change from one generation to the next but for its gene (allele) frequencies to remain constant? Explain by providing an example.