

**Self-Study Problems #3: Molecular and population genetics - Answers**

1. Fill in the blanks with terms from the list below. Some terms may not be used, or may be used more than once. You may change terms from singular to plural if necessary.

Through the process of transcription, the sequence of nucleotide bases in a long segment of DNA determines the sequence of nucleotide bases in a long segment of mRNA, which in turn, through the process of translation, determines the sequence of amino acids in a protein.

amino acid, base (or nucleotide base), carbohydrate, catalyst, centromere, chromosome, division (or cell division), meiosis, mitosis, DNA, RNA, mRNA, tRNA, nucleus, protein, reduction, replication, reproduction, ribosome, transcription, translation, transmission

2. Errors occasionally occur in the processes in question 1.
- a. Are these errors likely to affect the next generation in some way?

No.

- b. Why or why not?

*The processes above affect only the proteins synthesized in one cell. They do not affect the genetic code that offspring inherit.*

3. What are the two types of cell division called?

*mitosis and meiosis*

4. What is the overall difference between the two types of cell division?

*mitosis results in two daughter cells genetically identical to the parent cell (OR both diploid) meiosis results in gametes that have only half the complement of DNA (OR they are haploid)*

5. What is the result of crossing over?

*It produces gametes that carry chromosomes that combine parts of both chromosomes of the parent. OR It reshuffles the alleles of a parent so that the offspring can get any combination of the parent's alleles. OR other ways of saying this.*

6. Why would natural selection be expected to favor organisms that were developing sexual reproduction and crossing over?

*Because both increase the variability of the offspring (OR the number of new combinations produced in the offspring, etc.). This gives selection more alternatives to weed out or favor, which would allow the population to evolve more rapidly in response to changing conditions. Organisms that evolve more rapidly are more likely to succeed and persist in changing conditions.*

7. Mendelian genetics initially seemed to apply only to dichotomous or discrete traits. How can Mendel's model explain continuously variable traits?

*Continuously variable traits are controlled by many loci, not just one. Each pair of loci follows Mendel's simple rules, but because many pairs are involved, there are many combinations that result in many different phenotypes, creating a range of outcomes, rather than distinct types. Since each genotype can actually produce a range of outcomes, depending on the environment, the different phenotypes produced by the many distinct genotypes blend together into a continuous range of variation.*

8. Explain how two parents that are 5' 8" tall could have a child who grew to 6' 2" tall, even if the environments in which they were raised, their medical care, etc. were all the same.  
Provide an explanation that routinely occurs in real life, not an extremely unlikely mutation.

*Height is a polygenic trait (OR is controlled by numerous loci OR alleles OR genes)  
Each parent has a mix of alleles (OR genes), some contributing to tallness, others to shortness, resulting in their medium height.  
By chance, the offspring could get mostly the alleles (OR genes) that contribute to tallness, resulting in greater height than either parent.*

9. What is a point mutation, and what changes can it cause?

*A point mutation is a change (OR error) in a single nucleotide base in a copy of DNA created by replication. OR an error in which a single base gets copied incorrectly during DNA replication. If the change is in a segment of "junk" DNA, it has no effect. If it is in a gene, it may still have no effect if it changes a codon to a different one for the same amino acid. If the change alters a codon to one for a different amino acid, it changes one amino acid in the primary structure of the protein produced by the gene. This may affect the protein's function to any degree from not at all to very severely. If the change creates a "start" or "stop" codon, the allele produces a truncated protein, usually affecting its function drastically. Most changes are for the worse, but in rare cases, the altered protein functions better or performs a new, useful function.*

10. Define evolution in population genetic terms.

*Evolution is a change in allele frequencies in a population from one generation to the next (OR across generations, etc. (5 pts) Same but without "in a population": 4 pts.*

11. The dominant H allele results in hitchhiker's thumb; straight thumbs are produced by the recessive s allele. Say that in the whole population, 80% of the alleles are s.
- What fraction of the alleles in the population are H? 20% (Because  $80\% + 20\% = 100\%$ )
  - Say we observe a population of 500 males and 500 females (1000 total people). They all form couples and have kids. Assuming that having hitchhiker's thumbs or straight thumbs has no effect on how well one survives, who one mates with, or how many offspring one has, what are the frequencies of each possible genotype among the offspring? Explain with a Punnett square.

*4% are HH  
32% are Hs (16% Hs + 16% sH)  
64% are ss*

	<i>Mothers' gametes: 20% H</i>	<i>Mothers' gametes: 80% s</i>
<i>Fathers' gametes: 20% H</i>	<i>Offspring: HH <math>20\% \times 20\% = 4\%</math></i>	<i>Offspring: sH <math>80\% \times 20\% = 16\%</math></i>
<i>Fathers' gametes: 80% s</i>	<i>Offspring: Hs <math>20\% \times 80\% = 16\%</math></i>	<i>Offspring: ss <math>80\% \times 80\% = 64\%</math></i>

- Say each couple has two offspring, for a total of 1000 kids. About how many of them would you expect to have straight thumbs? Explain using the equations for Hardy-Weinberg equilibrium.

*About 640 are expected to have straight thumbs. Straight thumbed people have genotype ss.  
If the frequency of the s allele =  $q = 80\% = 0.8$ ,  
then the frequency of the ss genotype should be  $q^2 = 0.8 \times 0.8 = 0.64$ .  
The total number of ss individuals in a population of 1000 should be  $1000 \times 0.64 = 640$ .*