Worksheet #5 - Evolutionary Mechanisms – Answer Key

1. The left hand column of the table below lists several possible characteristics of evolution due to natural selection vs. evolution resulting from genetic drift. For each characteristic, please indicate whether or not it accurately describes the two different types of evolution. (**7 marks**)

	Evolution due to natural selection	Genetic drift
Characteristic:	(Is it a characteristic of this type of evolution? Yes/No)	
1. Changes in the frequency of an allele are due to differences in the survival and/or reproductive success of individuals ***Explanation*: Remember that differences in survival and/or reproductive success between individuals are not considered to be the effects of natural selection unless they are caused by the way phenotype interacts with the environment.** **Random (i.e., unpredictable) differences in which individuals survive and which ones pass on their alleles to the next generation can result in genetic drift.**	**Yes**	**Yes**
2. The individuals that survive/reproduce are a non-representative sample of the previous generation ***Explanation*: In the case of natural selection, the individuals in the next generation are non-representative of the previous generation because they have traits (or their parents had traits) that were more successful in the current environment. If the next generation is non-representative of the previous generation for unpredictable reasons (i.e., not related to how phenotype interacts with environment), then we say that genetic drift has occurred. If we describe genetic drift as a change in allele frequencies due to sampling error, then we can describe evolution by natural selection as a change in allele frequencies due to sampling bias. If the next generation *is* representative of the previous generation in terms of its allele frequencies, then allele frequencies haven't changed (= no evolution), and neither natural selection nor genetic drift have occurred.**	**Yes**	**Yes**
3. The survival/reproduction of the allele in the population is related to the phenotype associated with that allele ***Explanation*: If there is no way we can predict fitness based on phenotype (i.e., there is no apparent pattern or causal relationship between**	**Yes**	**No**

phenotype and fitness), then natural selection is not occurring. Genetic drift is still possible, though!		
4. It appears that all alleles/individuals are equally likely to survive and reproduce (i.e., we can't predict what will happen) ***Explanation*: Same as above – if there is no way we can predict fitness based on phenotype (i.e., there is no apparent pattern or causal relationship between phenotype and fitness), then natural selection is not occurring. Genetic drift is still possible, though!**	**No**	**Yes**
5. Can occur because of a drastic reduction in population size ***Explanation*: A drastic reduction in population size could possibly be the result of a large number of deaths (or sudden widespread inability to reproduce) in the population. If there is some relationship between the alleles an individual carries and their chances of survival/reproduction, then the small number of surviving individuals might be carrying specific alleles that were selected for (i.e., natural selection has caused a change in allele frequencies). If there is no relationship between genotype and fitness, a drastic reduction in population size might still result in a change in allele frequencies, via genetic drift (i.e., even though the sample is random, it is non-representative).**	**Yes**	**Yes**
6. Can reduce the amount of genetic variation in a population ***Explanation*: If natural selection is strong (i.e., specific alleles, and only those alleles, make it into the next generation), then it's possible that only a few alleles might survive (in other words, the majority of genetic variation would disappear from the population). Similarly, if genetic drift leads to the random loss of certain alleles, this would also reduce genetic variation in the population.**	**Yes**	**Yes**
7. Is more likely to happen if the population is large (i.e., contains a large number of individuals), and stays large over multiple generations ***Explanation*: Genetic drift is more likely to occur in small populations, because random differences in survival and reproduction between individuals will have a relatively bigger impact on allele frequencies in a small population.** **Why would natural selection be more likely to result in evolution if the population is large? Because if the population is large it means that allele frequencies are less likely to be affected by genetic drift. Remember that genetic drift can cancel out the effects of evolution due to natural selection.**	**Yes**	**No**

2. Watch one (or both) of the following videos:
https://www.youtube.com/watch?v=-h8I3cqpgnA
https://www.youtube.com/watch?v=91Jw2KDEAho

a. Which of the four evolutionary mechanisms must have given rise to this trait (i.e., orchids mimicking females bees/wasps)? Explain in one sentence. (**2 marks**)

[*Note*: "Given rise to this trait" refers to the trait coming into existence (not to the trait becoming more common in a population or species).]

Mutation is the only evolutionary mechanism that can result in novel genetic variation. If we assume that this trait (i.e., orchids mimicking female bees/wasps) has at least *some* genetic basis, then whatever that genetic basis is (e.g., alleles, or a combination of alleles) must have come into being via mutation.

b. Do you think this trait (i.e., orchids mimicking females bees/wasps) could be considered an adaptation for the orchids? Justify your answer. (**2 marks**)

Hint: An adaptation can be defined as a heritable trait that is associated with higher fitness in the current environment. Does this trait fit that definition? What assumptions are you making? What information would you need to make up your mind?

An adaptation is 1) a heritable trait that 2) that is associated with higher fitness in the current environment (and therefore is currently being maintained and/or developed by evolution due to natural selection).
We don't know for sure whether or not the trait is heritable, but it plausibly could be, given this seems to be a morphological trait that all individuals in this species posses.
The trait does also seem to be something that increases the fitness of individuals that have it – by attracting male bees/wasps, the orchid both spreads its pollen and is more likely to be pollinated. Without attracting pollinators, the orchids would have zero fitness (= reproductive success)… Unless they are capable of self-pollination.

c. Do you think the male bees'/wasps' behaviour (i.e., pollinating the bee orchids) could be considered an adaptation for the male bees/wasps? Briefly explain your answer. (**2 marks**)

Probably not – although it's possible that the male bees' behaviour is heritable, it seems like it would be more likely to decrease the bees' fitness than increase it. If males are wasting their time mating with flowers, that means they have less time and energy to spend mating with real females (which would decrease the males' reproductive success).

d. Check out this web comic: https://xkcd.com/1259/. In the case of this orchid species (*Ophrys apifera*), could mimicking a female bee be considered an adaptation for the orchid? Briefly explain your answer. (**2 marks**)

An adaptation is 1) a heritable trait that 2) that is associated with higher fitness in the current environment – in this flower's current environment, no bee species exists to pollinate it. Therefore, in this case the mimicry is not an adaptation, but rather a remnant/relic of a previous adaptation.

e. Why do you think the male bees/wasps are so easily fooled by the orchid? In other words, **why haven't these insect species evolved in such a way that males can tell the difference between a real female vs. an orchid pretending to be a female?** (**3 marks**)

[*Note*: There are several possible acceptable answers to this question. The important points to address are i) why one or more of the pre-requisites for evolution due to natural selection might not been met, and/or ii) offer another plausible explanation for why the bees might not be perfectly adapted to their environment.]

Explanation 1: One or more of the pre-requisites for evolution due to natural selection have not been met

Heritable variation in traits:

- **Maybe the required heritable variation in traits does not exist in the population. Mutation has never produced a male bee that is capable of telling the difference between a real female and a fake (orchid) female. …Maybe such a trait isn't even possible for male bees because of the way their morphology and physiology are set up. Even if such a male would theoretically have higher fitness than other males, if such a heritable trait has never arisen then it can't increase in frequency in the population.**

Differential fitness associated with the trait:

- **Maybe male bees that are able to tell the difference between real females and fake (orchid) females don't actually have higher fitness than other male bees. For example, there may be a trade-off to being too picky (maybe male bees that reject fake females also accidentally reject some of the real females). Or maybe the male bees that visit the fake (orchid) females get some fitness benefit that we are unaware of…**

Explanation 2: The male bees are unable to become perfectly adapted to their environment because their environment is constantly changing

- **It's possible that the male bees *are* evolving to become better at distinguishing between real females and fake females, but at the same time the orchids are evolving to become better and better at fooling male bees. Keep in mind that the orchid is part of the male bees' environment; the presence of orchids imitating females creates an environment that should select for males that are better at distinguishing fake vs. real females. However, if that environment is constantly changing (i.e., because the orchids are evolving), then it might be impossible for males to become perfectly adapted to their environment. Male bees might be well-adapted to the environment their ancestors experienced, but their current environment isn't the same as their ancestral environment. It's like the orchids are managing to always stay one step ahead of the male bees, and the male bees are never quite able to "catch up."**

[*Note*: Explanation 1 and Explanation 2 are not mutually exclusive. It is entirely possible that a combination of factors are preventing male bees' from becoming better adapted to their environment.]