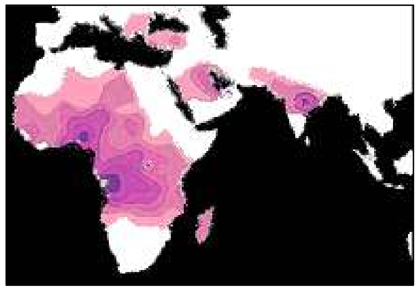
Introduction to Natural Science 2007 **Name (Print):**________________________________

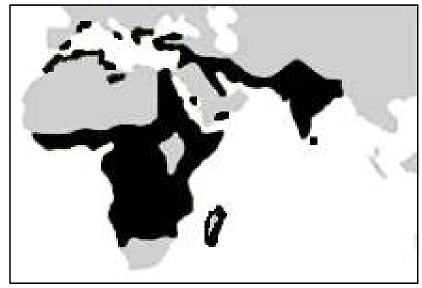
Biology Exam II

1. Sickle-cell anemia is a genetic disease caused by a mutation in the β-globin gene**.** Individuals who are homozygous recessive for this mutation have red blood cells that readily collapse when deoxygenated; these individuals generally die from the genetic defect. Those who are heterozygous for this condition have an intermediate phenotype and can live with the defect. Interestingly, the malaria parasite cannot survive within these individuals or those with severe sickle-cell anemia.

A. Compare the two images on the right and describe what evolutionary force is at work and why. Use specific vocabulary in your description.



Sickle Cell Distribution (shades of grays)



Malaria Distribution (in black)

The images on the right show that Malaria distribution correlates with populations that have the sickle cell allele. Normally the sickle cell allele would be purified from a population because those individuals possessing the sickle cell allele would be less fit. However, when malaria is present in a population that has the sickle cell allele, those individuals who are heterozygous for the mutated allele are selected for because they are more fit – they are resistant to malaria. So, natural selection is the evolutionary force and heterozygote advantage is the outcome.

B. If 9% of an African population is born with this severe form of sickle-cell anemia, what percentage of the population will be resistant to malaria but not suffer from sickle-cell anemia? Show your work.

$0.9 = q^2$; take the square root for $q = 0.3$; solve for p using $p = 1-q$ or $p = 0.7$

Those resistant to malaria but do not suffer from sickle-cell anemia are the heterozygotes, so solve for 2pq! $2pq = (0.3)(0.7) + (0.3)(0.7) = 0.42$ or 42%

2. Four-o'-clocks produce flowers that are white (recessive), purple (dominant) or an intermediate color, lavender. In a large population that undergoes random mating, what allele frequencies will generate twice as many white flowers compared to lavender flowers? Show your work.

There are many ways to solve this problem; I have given you two below. One thing to note is that the population is not necessarily in Hardy Weinburg equilibrium, but you could set it to HW equilibrium to solve it.

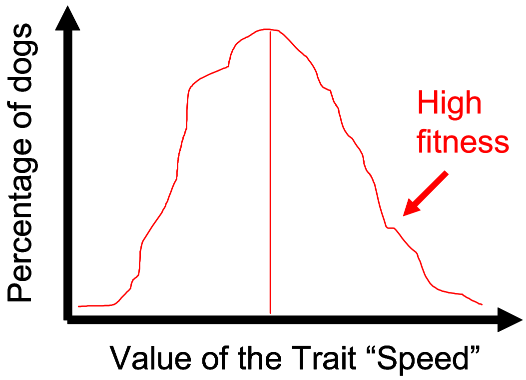
Method 1: For the equation $p^2 + 2pq + q^2 = 1$, set q^2 to 0.5 and 2pq to 0.25 (thus p^2 is also 0.25 for it to add up to one) and solve for p using $p = 0.25 + ½(0.25) = 0.375$ and then for q using $q = 1-p$. This works out to be 0.625 and the alleles are not in HW equilibrium.

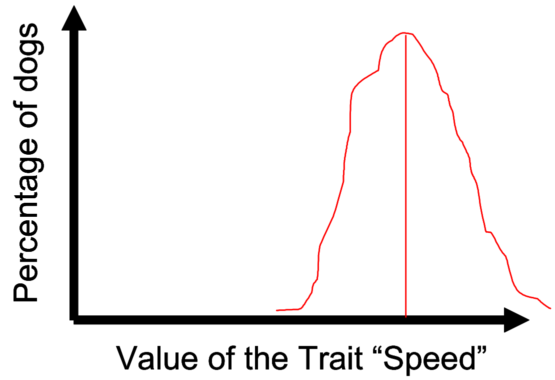
Method 2: There are twice as many recessive (q^2) flowers as lavender (2pq) flowers so the equation is as follows: $x + x + 2x = 1.0$; solving for x gives you: $4x = 1.0$, $x = 0.25$; then plug the number back into the equation to solve for each allele.

3. Early dog breeders were interested in creating a greyhound dog with the greatest speed. They carefully selected from a group of hounds those who ran the fastest. From their offspring, the greyhound breeders again selected those dogs that ran the fastest. By continuing this selection for dogs who ran faster than most of the hound dog population, they gradually produced a dog who could run up to 64km/h (40mph).

A. On the left, draw a graph corresponding to the time <u>during</u> selection and <u>clearly indicate</u> where there is high fitness.

B. On the right, draw a graph corresponding to the time <u>after</u> selection.

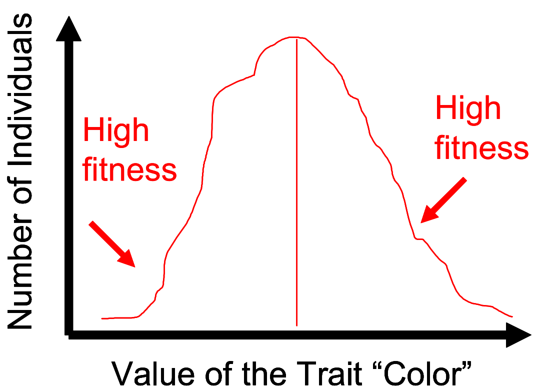


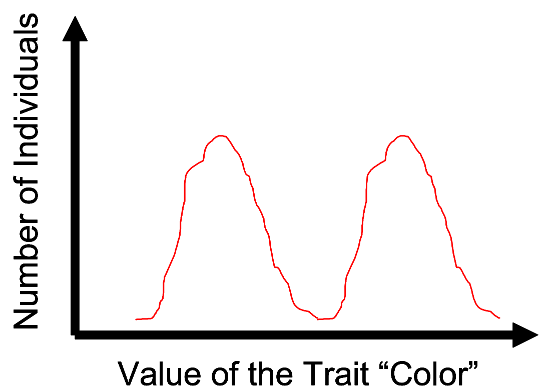


4. In a species of African butterfly, *Pseudacraea eurytus*, wing colorations range from a reddish yellow to blue. In both cases, these extremes of color from different ends of the spectrum look like (mimic) other species of butterflies that are not normally the prey of other the local predator group of birds and insects. Those butterflies that are moderate in coloration are eaten in far greater numbers that those at the extremes of the color spectrum.

A. On the left, draw a graph corresponding to the time <u>during</u> selection and <u>clearly indicate</u> where there is high fitness.

B. On the right, draw a graph corresponding to the time <u>after</u> selection.



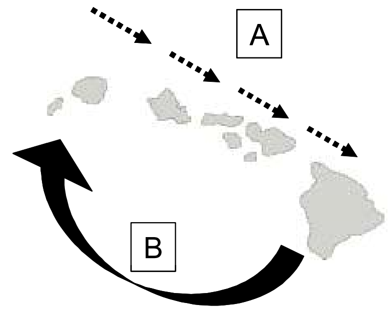


5. <u>Describe</u> in your own words why sexual dimorphism exists. <u>Provide</u> an example.

Sexual dimorphism exists due to sexual selection. One sex needs to attract mates or fight for mates. As a result the traits that allow them to attract more mates or fight better for mates are selected for in a population. Extreme traits between males and females are the result. There are many examples of this. Elephant seal males are much larger than the females because they must fight other males for territories. Male birds have more colors and are much brighter colored than females because females select males based on the intensities of their coloring. They do this because it is associated with a fitter male.

6. Hawaiian Drosophila show remarkable patterns of speciation. There are hundreds of species of Drosophilids on the Hawaiian islands and most are endemic (found only in one location/island). Some traits include: large body sizes, dramatic "picture wings", and "hammer-head" shaped heads. Phylogenetic studies show that flies on each sequential islands are related to species on nearby islands (i.e., flies on Hawaii are derived from ancestors on Maui and so on - indicated by the dashed arrows).

A. The events described above are indicated by the process "A" in the drawing on the right. Please <u>describe</u> the specific type of speciation event that has occurred **and** <u>discuss</u> the possible evolutionary forces involved.



Allopatric speciation has occurred due to founder effect via dispersal. Once a group of the Drosophilids moved to the next island, natural selection or genetic drift played a role in speciation.

B. If you took a relatively large group of flies from the big island and dispersed them onto the island indicated by the arrow "B", there could be two outcomes: 1) the flies from the big island mate with the flies on the small island and produce offspring, or 2) the flies from the big island and the small island do not produce offspring.
If outcome 1 is occurs, then what evolutionary force is playing a role in changing allele frequencies on both islands?

Gene flow would be playing a role. Individuals emigrating from the large island would bring new alleles into the population in which they are immigrating.

If outcome 2 occurs, then please <u>describe</u> at least 2 possible mechanisms for the reproductive isolation.

Pre- and post-zygotic mechanisms could explain the reproductive isolation. For example, their mating behaviors or chromosomal numbers may be different. Thus, they would not be able to either mate or produce viable offspring.

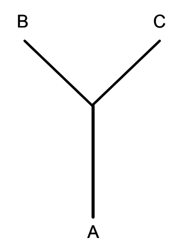
7. A misconception about evolution is that organisms have gotten better, more advanced, or more complex. Discuss why this is a misconception, using at least one example in your rebuttal.

Natural selection acts on individuals and evolution occurs in a population given a particular environment. There is nothing in this model that makes an organism or population better or more advanced, but rather they are only adapted to the environment. Thus, in a particular environment, certain traits may be selected. However, in another environment the same trait is not associated with fitness. For example, individuals who have a mutation in the CCR5 receptor were more fit during outbreaks of the small pox virus which uses this receptor for cell entry. However, when West Nile virus began to spread it was realized that these individuals are more susceptible to West Nile virus because the protein plays an important role in the immune system.

8. *Rhagoletis pomonella* is a fly that is native to North America. Its normal host is the hawthorn tree, but sometime during the nineteenth century it began to infest apple trees. There appear to be differences in host preferences among populations. Offspring of females collected from one of these two hosts are more likely to select that host location for having offspring. Laboratory studies have shown an asynchrony in emergence time of adults between these two host races. Flies from apple trees take about 40 days to mature, whereas flies from hawthorn trees take 54-60 days to mature. This makes sense when we consider that hawthorn fruit tends to mature later in the season than apple trees. Hybridization studies show that host preferences are inherited, but give no evidence of barriers to mating.
A. Based on this scenario, make a prediction about the outcome of these organisms.

The flies using different food sources will become separate species because their matings are becoming more and more dependent on their food source.

B. If the tree to the right represents the fate of this population A, what event occurred? Be very specific in your answer for full credit.



Sympatric speciation has occurred. The population A speciated into B and C even though the flies are in the same relative locations.

9. Red-Green color blindness is an X-linked trait. A woman who is a carrier and a man who does not have color blindness have three children: one child is a carrier, one child has color blindness, and the other is a normal female. Draw a pedigree of this family, indicating females (circles), males (squares), carriers and those with colorblindness. Include their genotypes in the pedigree.

You needed to a) have the proper genotypes and b) the correct pedigree showing relationships. The genotypes are:
XX^c x XY children were XX^c, XX, X^cY