[[Lab 08]]**Instructor’s Manual**

Lab 8 Modern Human Variation

**Answers to Lab 8 Concept Review Questions**

1. **B. Central Africa** is home to people with the darkest skin colors (not eastern Asia, Northern Europe, or eastern North America).

2. **False**; adaptations are *not* reversible and temporary, while acclimatizations are *not* permanent. The opposite is true: Adaptations are permanent, and acclimatizations are temporary.

3. **Hypoxia is the condition whereby the body is not getting the necessary amount of oxygen.**

4. Hypoxia is common at high altitudes because **oxygen concentrations are lower in the air**.

5. **C. Larger body size** is advantageous in a cold climate (not smaller body size, equiaxed form, or elongated form).

6. **D. Central Eurasia** is the region in which the B blood antigen allele is most frequent (not South America, Australia, or southern Africa).

7. **Lactose is a sugar found in milk. Lactase is a protein that allows for the digestion of lactose.**

8. **False**; lactose tolerance is *not* common among adult humans worldwide. As with most mammals, humans are usually lactose intolerant as adults.

9. **Areas of Africa and Asia** are where we find populations with high frequencies of the sickle-cell trait (see FIGURE 8.10).

10. **Areas of Africa and Asia** are where we find populations with high exposure to malaria (see FIGURE 8.10).

**Answers to Lab 8 Exercises**

Exercise 1: Skin Color Activity 1 (5 minutes)

While exploring a remote area of the world, you have just come across a previously unknown population of people with very light skin color.

1. Where in the world were you most likely exploring?

**Somewhere away from the equator**

2. Why would light skin color be advantageous for this population?

**Light skin color allows for maximal absorbance of limited sun exposure for vitamin D synthesis. Also, these people don’t need dark skin color for protection from UV radiation because their sun exposure is limited.**

3. How might the skin color of this population negatively impact their health if they moved elsewhere?

**They could suffer negative effects of UV radiation, including sunburn, cell death, increased likelihood of cancer, and the various consequences of folate depletion.**

Exercise 2: Skin Color Activity 2 (10 minutes)

Recent research has identified a gene (*SLC45A2*) that codes for a protein that impacts melanin production in humans and other animals. There is a mutation in this gene called L374F with two allele variations. The L374 allele correlates with darker pigmentation, and the 374F allele correlates with lighter pigmentation. Researchers collected DNA samples from people in 14 European, Asian, and African populations and identified the frequency of the 374F allele in these groups. Review the data in the chart and answer the questions that follow.

1. In what populations do we see the highest frequencies of the F374 allele?

**German (0.965), French (0.893), Italian (0.851), Turkish (0.615)**

2. In what populations do we see the lowest frequencies of the F374 allele?

**African (0.000), Indonesian (0.005), Japanese (0.000), Han (0.000, 0.005, 0.028), Bengladeshi (0.059)**

3. The map shows the locations of the populations studied superimposed on FIGURE 8.1 (showing regional skin color variation). Are these results what you would expect based on the skin color information in the map? Why or why not?

**For the most part, yes. The European and Turkish populations have lighter skin color and higher frequencies of the F374 allele. Similarly, the African, South Asian, and Southeast Asian populations have darker skin color and lower frequencies of the F374 allele. In contrast, the East Asian populations have light skin color but low frequencies of the F374 allele—this seems inconsistent. See next question for more.**

4. Why might some light-skinned populations, such as the Japanese, be missing the F374 allele? (*Hint*: Consider the various forces of evolution that may be at play.)

**Numerous factors could be considered. First, pigmentation is a complex polygenic trait—more than one gene is responsible, so there is more to skin color than simply the F374 allele. It may be that light skin color is determined by other mutations in these populations. At the same time, it suggests some population isolation. The F374 allele is found most frequently in Europe and in lesser degrees moving eastward across Asia. It is likely that South and Central Asians engaged in more interbreeding (gene flow) with Europeans than did East Asians. This would result in the presence of the F374 allele in South and Central Asia but not in East Asia.**

Exercise 3: Altitude (10 minutes)

You and your fellow classmates have decided to take a vacation to the Andes Mountains in South America. You plan to spend 2 weeks hiking, camping, and exploring the area.

1. While you are there, you can expect to undergo some acclimatization to this higher altitude environment. Describe *one* of these possible acclimatizations.

**Increase in respiration, lung capacity, and red blood cell production**

2. Why would your body undergo such a change? What benefit or benefits does this acclimatization afford while you are vacationing in higher altitudes?

**These acclimatizations allow for greater intake of air and oxygen and/or better transport of oxygen through the body.**

3. Several weeks after you have returned home from your vacation, can you expect to still have this acclimatization?

**No, acclimatizations will be lost because they are temporary.**

4. Also, while you are in the Andes, you notice that local people seem to be better adapted to the altitude conditions than you are. Describe *one* of the possible adaptations that the indigenous people may have.

**Increased oxygen intake; higher proportion of red blood cells**

5. If someone with this adaptation were to come visit you in a lower altitude, would they lose their adaptation?

**No, these adaptations are permanent.**

Exercise 4: Climate (10 minutes)

Scenario A: Examine the material provided by your instructor (or the image in the lab Appendix).

1. Is this person adapted for a cold climate or a hot climate? **Hot climate**

2. Describe *one* trait that helped you make this determination.

**Thin body type (high surface area to volume); elongated body shape**

3. Is this trait related to Bergmann’s or Allen’s rule?

**Bergmann’s rule (thin body type); Allen’s rule (elongation)**

Scenario B: Examine the material provided by your instructor (or the image in the lab Appendix).

1. Is this person adapted for a cold climate or a hot climate? **Cold climate**

2. Describe *one* trait that helped you make this determination.

**Thicker body type (low surface area to volume); equiaxed body shape**

3. Is this trait related to Bergmann’s or Allen’s rule?

**Bergmann’s rule (thicker body type); Allen’s rule (equiaxed form)**

Exercise 5: ABO Blood Group (10 minutes)

Review FIGURES 8.5, 8.6, and 8.7. Use this information, as well as your understanding of the forces of evolution, to help you answer the following questions.

1. Many populations throughout central Eurasia share high frequencies of the B allele. What does this pattern suggest about the evolutionary history of these populations? Describe the evolutionary force that likely caused this trait distribution.

**The pattern suggests these populations have been interbreeding for many generations. This gene flow has given them relatively similar frequencies of the B allele across large geographic distances.**

2. The O allele is unusually frequent in the Americas. What does this pattern suggest about the evolutionary history of these populations? Describe the evolutionary force that likely caused this trait distribution.

**The pattern suggests these populations are descended from a founding population from Asia. The founding population had an unusually high frequency of the O allele, which skewed descendent populations in this direction.**

Exercise 6: Lactose Tolerance (10 minutes)

1. Describe a population where you would expect to find a low frequency of adult lactose tolerance.

**Answers will vary, but the population should not have a history of raising dairy animals for their milk products. This makes almost any population, aside from a few exceptions in Europe and Africa, acceptable.**

2. Why is adult lactose tolerance infrequent in that population?

**Lactose tolerance is infrequent because it is the norm for all mammals and because there has not been selection to preserve lactose tolerance into adulthood.**

3. Describe a population where you would expect to find a high frequency of adult lactose tolerance.

**Answers will vary, but the population should have a history of raising dairy animals for their milk products. There is a longer history of this in parts of Europe and Africa than elsewhere. So populations are likely to be from these areas.**

4. Why is adult lactose tolerance frequent here?

**Natural selection has favored maintenance of lactose tolerance into adulthood here to take advantage of available food sources.**

*Note: Students might suggest that America is a place to find high lactose tolerance, but it is important to distinguish between European Americans (high lactose tolerance) and non-European Americans (low lactose tolerance).*

Exercise 7: The Sickle-Cell Trait Activity 1 (5 minutes)

You are conducting a survey about human variation at the bus station. While conducting your survey, you meet a very large student tour group. The tour group has a high number of people who are carriers of the sickle-cell trait.

1. Based on this information, what can you suggest about the group’s geographic or cultural background (such as their economic practices, location in the world, and history)?

**They are from a population where the sickle-cell trait is maintained as a protection from malaria. They are probably from a tropical area with higher mosquito populations and greater incidence of malaria. They may have a history of practicing slash-and-burn agriculture, which would exacerbate the mosquito and malaria problems.**

Exercise 8: The Sickle-Cell Trait Activity 2 (10 minutes)

Glucose-6-phosphate dehydrogenase deficiency (G6PD deficiency) is an inherited disorder where either the body has less of the G6PD enzyme than normal or the available G6PD is not functioning correctly. This deficiency impacts red blood cell function and may result in anemia (the destruction of red blood cells) when people with the condition have infections, are taking certain medications, or eat certain foods. People with G6PD may have some protection from malaria because their abnormal red blood cells interfere with the reproduction of the malaria parasite in their bodies.

1. Compare the distribution of G6PD deficiency estimated by the World Health Organization (WHO) to the distribution of the sickle-cell trait and malaria (FIGURE 8.10). What do you notice is similar? What is different?

**Similarities: G6PD deficiency and sickle-cell trait are high in Africa, particularly Central Africa. Both traits overlap with areas where malaria is present in Central Africa.**

**Differences: G6PD deficiency is more prevalent across the board (with some populations having frequencies up to 26%) compared to sickle-cell trait (where almost all populations have frequencies less than 14%). G6PD deficiency is also more prevalent in Mediterranean areas (Northern Africa, Western Asia, and Southern Europe) than is sickle-cell.**

2. Why might these similarities and differences exist? Be sure to consider the evolutionary context (including the natural environment, cultural practices, and interbreeding).

**Sickle-cell and G6PD deficiency may both afford some protection from malaria, so they are more common in areas with malaria (or in populations who trace ancestry to areas with malaria, such as African-Americans). As with the sickle-cell trait, high frequencies of G6PD deficiency correlate with tropical environments that have higher mosquito populations and greater incidence of malaria. Cultural practices, such as slash-and-burn agriculture, may contribute to the mosquito and malaria prevalence in these locations. The presence of G6PD outside areas of high malaria frequency reflects population movements and/or interbreeding (as in the case of African-Americans).**

Exercise 9: Variation in the *ADH1B* Gene (10 minutes)

The *ADH1B* gene is one of the genes that codes for alcohol dehydrogenase (ADH)—an enzyme that helps in the digestion of alcohol. A variant of this gene called the *ADH1B\*47His* allele helps metabolize alcohol faster than other versions of the trait, thus reducing the amount of alcoholthat saturates the bloodstream. It also causes a negative side effect, where a person’s face flushes red when he or she consumes alcohol. This allele is rarely found in African or European populations, but it is very frequent in East Asian populations, where it is often found in more than 50% of the population and may even be found in almost 100% of people in certain populations. These East Asian populations also have a long history of growing rice and making fermented rice beverages over the past 9,000 years. The map shows the frequency of the *ADH1B\*47His* allele in East Asia. Sites where evidence of rice cultivation has been found are superimposed on the map.

1. Based on what you know about the evolutionary forces behind human variations, how would you explain the distribution of the *ADH1B\*47His* allele? **W**hy do you think this allele is common in East Asian populations? Do you see a relationship between rice cultivation and allele frequency? *Hint*: Consider the benefits and drawbacks of consuming alcoholic beverages and how this might factor into the evolution of the *ADH1B\*47His* allele.

**It has been suggested that the *ADH1B\*47His* allele is an adaptation for digesting alcohol. It allows the alcohol to be metabolized quickly, thereby limiting drunkenness. This may have been selectively favored in populations with a very long history of fermentation and alcohol production and consumption, such as the rice farmers of East Asia. The trait would allow people to partake in the benefits of rice wine (for example, using it as a painkiller) without experiencing many of the negative side-effects of drinking alcoholic beverages. In contrast, the allele is not frequent in other populations who lack this long history of fermentation and therefore lack the selective pressure for the trait.**

**Answers to Lab 8 Critical Thinking Questions**

1. If races are universal and based on underlying biological differences, then racial classifications should be the same across cultures. The biology is the same, therefore the races should be the same. In reality, racial classifications vary from one culture to another. People are viewing and interpreting physical variations differently. This supports the idea that races are more cultural than biological.

2. The peopling of the Americas is a classic example of a founder effect situation. The Americas were settled recently (within the last 15,000 years or so) by subsets of populations from eastern and northern Asia. These Asian populations had lighter skin color because they lived further from the equator. As people spread into the equatorial areas of the Americas, they brought this lighter skin color with them. This has not yet been selected out and replaced by darker skin colors, probably because this all occurred very recently.

3. Answers regarding traits that show clinal variation will vary, but almost any polygenic trait would work, such as hair color, eye color, and stature.

4. Answers regarding high-altitude adaptations will vary, depending on the students’ research, but they are likely to mention such characteristics as the Tibetan circulatory system, which allows for greater blood flow and oxygen movement (although this does seem to vary somewhat within the population, depending on demographics such as sex). Answers to the question of where else such adaptations may be expected may also vary, but students are likely to include populations in places such as the Rocky Mountains. It is important for students to recognize that *indigenous* populations may have traits that facilitate oxygen intake and distribution through the body. For example, recent European settlers to the Rockies are not likely to have the same specialized traits seen in the Tibetans. Also, as discussed with the Tibetan and Andean populations, the specific traits seen may vary depending on the founding population and the length of settlement in the region.

5. *Lepus americanus* is adapted for a cold climate, and *Lepus californicus* is adapted for a hot climate. *L. americanus* has a short, stocky build (with a large body size relative to surface area *and* relatively equiaxed form with shorter limbs and ears). *L. californicus* has a long, lean build (with a smaller body size relative to surface area *and* elongated limbs and ears). Yes, humans living in similar environments have similar body proportions, as seen in Exercise 4.

*Note*: Students might comment on the coloring of the hares, *L. americanus* being white and *L. californicus* being brown, to blend into their environment. Thinking along these lines may cause students to make comparisons to human skin color variation. It is important to distinguish between animal fur coloring, which is often related to camouflage, and human skin color, which is related to melanin providing more of a protective layer to the skin.

6. Lactose tolerance: Humans began concentrating on the dairy products produced by their herds, not just the animals’ meat or labor potential. This is a shift in cultural practices. This shift, however, creates an environmental context where adult lactose tolerance is selectively favored. Humans created the circumstances that natural selection then acted within.

Sickle-cell trait: Some of the African populations with high frequencies of the sickle-cell trait have a history of slash-and-burn agriculture. Humans began clearing large tracts of land for crop cultivation. This is a shift in cultural practices. The shift then created an environmental context where mosquitoes (and malaria) thrived even more than before. This worsens an existing situation and causes the sickle-cell trait to be even more selectively favored as protection from malaria. Again, humans impacted the circumstances within which natural selection acted.

The future: Answers will vary, but students are likely to discuss issues of technology, pollution, global warming, etc. For example, a student might argue that we are constructing an environment with unnatural levels of air pollution. Over time, trait variants that allow for better breathing in poor air conditions might be selectively favored. This could be similar to the altitude adaptations discussed in the lab.

7. Answers will vary greatly, but students should recognize that lighter skin color indicates nonequatorial areas, darker skin color indicates equatorial areas, lactose tolerance indicates European areas, lactose intolerance indicates non-European areas, short and stocky bodies indicate cold climates, and long and lean body types indicate warm climates. The students should use the geographic overlap of all three traits to narrow down to a more particular region. For example, a student with dark skin color, lactose intolerance, and a long, lean body may trace ancestry to sub-Saharan Africa. In some cases, students may find that they have adaptations that seem contradictory, such as dark skin color but a short and stocky body. In these cases, students should account for this by describing other forces at play, such as gene flow mixing traits from different populations or founder effect causing some traits to be distributed unusually (such as lighter skin color in equatorial South America compared to equatorial Africa).

8. *NOTE: If your students have computer and Internet access in the classroom, this would be a great activity to complete and discuss in class (allow between 20 and 40 minutes, depending on whether students will be estimating their height and weight or measuring it in the classroom). Be sure to check that the WHO URL is up-to-date and active before assigning this question to students (*[*http://apps.who.int/bmi/index.jsp?introPage=intro.html*](http://apps.who.int/bmi/index.jsp?introPage=intro.html)*).*

Answers will vary to the first part where students calculate their BMI using the equation,

[Weight in pounds / (height in inches × height in inches) ] × 703 = BMI

but the average person in the United States is in the overweight category (BMI ≥ 25). The average total daily calorie intake for a person in the United States is 3,766. Worldwide trends in calorie intake show that some regions (North America, Western Europe, Australia/New Zealand, China, parts of South America, etc.) are consuming a lot of calories, while other regions (Eastern Europe, much of Africa and Asia, and parts of South America) are living on far fewer calories, sometimes even less than the recommended 2,000 calories a day. Worldwide trends in the percentage of overweight adults (BMI ≥ 25) in the population show that many of the areas with high calorie intake are also areas with high BMI. These trends reflect differences in regional food abundance and scarcity, and related differences in health. Implications of this include regionally specific health concerns, such as obesity-related illness in wealthy counties and undernourishment in poorer countries.