### Lesson 1: Exploring Twin Studies

#### Engage
Ask students to individually answer the following question in their lab notebooks: “Can you think of any traits or diseases that have both a genetic component AND an environmental component? List as many as you can and your evidence for genetic and environmental influence.” After five minutes, discuss what students have come up with as a class and record on the board. Listen for any misconceptions.

#### Explore
1) Ask students to read “The Double Puzzle of Diabetes” (Jared Diamond, Nature, 2003, 423: 599-602) and to consider the following focus questions as they read:
   a. What evidence does the author present for a genetic component to type 2 diabetes?
   b. What evidence does the author present for an environmental component to type 2 diabetes?
   c. This article looks at diabetes from an evolutionary medicine point of view. What explanation does the author give for why the alleles that predispose people to type 2 diabetes have NOT been selected out of the human population?
2) Discuss the questions about the reading as a class.
3) Ask students to work in pairs and consider how they would design a study to determine if a trait/phenotype is solely inherited (genetic) or environmental.
   a. If students struggle to get started, ask them to define the hallmarks of genetic influence (dependent on kinship, independent of location) versus environmental influence (independent of kinship, dependent on location). How can they exploit those differences? Is there a circumstance where some people might share genes, but not the same environment? Is it possible to share an environment, but not genes?
   b. As a class, discuss the experimental designs students have created and consider the following questions:
      i. Are there any common "threads" in the proposed designs (e.g. family, adoption, twin studies)?
      ii. How many groups considered using data from twins?
      iii. What is the difference between monozygotic and dizygotic twins?
   c. If no group thought about using twins, allow the class an extra 5 minutes to create experimental designs using twin data. Discuss the new designs.

#### Explain
1) Have students read “Box I – Correlation” from the BSCS Genes, Environment, and Human Behavior module (Appendix I).
2) Discuss what a correlation means and how it applies to twin studies. Discuss how twin studies help determine the heritability of a trait/phenotype and describe the two types of twin studies com-
monly used (MZ vs DZ and MZ raised together vs MZ raised apart). What are the advantages and drawbacks of each type?

3) Ask students to read the following scenarios, and then work in pairs to interpret (in their own words) what the correlations say about the relative genetic and environmental influences for the trait in question. Discuss each scenario as a class before students analyze the next scenario.

a. You’re doing a study to find out how strongly genetic background contributes to double-jointedness. You measure the bend angle of the left elbows of pairs of monozygotic twins and pairs of dizygotic twins, all of them raised together. You find that there is a 0.8 correlation between the bend angles for monozygotic twins and a 0.4 correlation between the bend angles of dizygotic twins.

- These correlations suggest a high degree of genetic influence relative to environmental influence because there is a big difference in correlation based on genetic identity. There may be some environmental influence though, since the correlation for MZ twins is not 1.

b. You’re doing a study to find out how strongly genetic background contributes to tattoo and piercing behavior. You collect data on the number of tattoos and piercings between pairs of monozygotic twins and pairs of dizygotic twins (all of them raised together). You find that there is a 0.8 correlation between the numbers for monozygotic twins and a 0.7 correlation between the numbers for dizygotic twins.

- These correlations suggest little genetic influence on the trait because there is not a significant difference in the correlations despite the large difference in genetic identity.

c. You decide to do another study on tattoo and piercing behavior using a slightly different experimental design. This time, you collect data on the number of tattoos and piercings between monozygotic twins either raised apart OR raised together. You find that there is a 0.8 correlation for monozygotic twins raised together, but there is a 0.2 correlation for monozygotic twins raised apart.

- These correlations confirm the findings of the first study that there is a strong environmental influence on this trait since there is a large drop in correlation when genetically identical individuals no longer share the same environment. Since there is still a weak correlation among MZ raised apart, there may be a small genetic influence as well.
Correlation
Most of the methods in behavioral genetic research, such as twin studies, make inferences to genetic and environmental effects by using some measure of association between different classes of relatives. Although advanced methods use a statistic known as covariance, we will discuss a simpler measure of association called correlation. Correlation is a statistic, the value of which indicates the magnitude and direction of association between a pair of measurements (usually two types of relatives such as pairs of identical twins). The value of a correlation can range from -1 to +1. A value of +1 denotes a perfect positive relationship between two sets of measurements. This means that if you know the value of one of the observations, you can predict the value of the second observation, and they go in the same direction. For example, if a school bus happens to pass your house every day precisely when you leave for work, the correlation between the appearance of the bus and your leaving for work is 1.0. With that information, a naive observer could accurately predict that when the bus was still a block from your house you soon would get into your car to leave home. A value of -1 denotes a perfect negative relationship; in this case, you still can predict one value from the other, but they go in opposite directions. Zero denotes that the two observations are unrelated. A value in between -1 and +1 other than 0 indicates that there is a less-than-perfect relationship between the measures. Notice that correlations do not necessarily indicate causation. In our previous example, leaving for work does not cause the bus to arrive. You just happen to leave your house at the same time the bus is making its rounds to pick up students.

The scatterplots for risk scores generated in Activity 3: A Novel Trait, are graphical representations of the information summarized by correlations. If all of the points fell directly on a diagonal line that increased from left to right, this would indicate the presence of a correlation of +1. If all of the points fell upon a diagonal line that decreased from left to right, this would indicate presence of a correlation of -1. The extent to which individual points deviate from a straight line is an indication of how less-than-perfect the relationship is. In the case of zero correlation, the individual points are scattered at random and there is no “best” way to draw a line through the points.

Figure T.8 Panel a. no correlation; Panel b. low correlation of 0.2; Panel c. high correlation of 0.8.