1. An evolutionary geneticist studying leaf shape in the genus *Pelargonium* (the genus to which garden geraniums belong) performs a set of crosses between individuals of *Pelargonium triste* and grows the offspring in a common garden. She has developed an index of the degree to which leaves are dissected vs. entire. When she plots the mid-parent value of the leaf dissection index on the x-axis and the offspring value on the y-axis and fits a regression line to the points, she finds that the slope of the regression line is 0.43.

   (a) What is the heritability of the leaf dissection index in this species?
   The heritability, h^2, is the slope of the regression line. $h^2 = 0.43$**.**

   (b) What fraction of the variation in leaf dissection in this species is a result of underlying genetic differences rather than differences in the environment?
   $h^2 = \frac{V_g}{V_p}$**. In words, the heritability is the fraction of the total variance that is due to underlying genetic differences. So the fraction of variation in leaf dissection due to undrlying genetic differences is 0.43 or 43%.**

   (c) In a wild population of Pelargonium triste near De Hoop, South Africa, our evolutionary geneticist finds that the average value of the leaf dissection index among all individuals in the population is 4.58. When examines individuals that are reproductive, however, the average leaf dissection index is 6.83. Assume that the heritability of leaf dissection in this population is the same as in the experimental population she studied.

      i. What is the selection differential on leaf dissection index?

$$\begin{aligned} S &= \textbf{mean after selection} - \textbf{mean before selection} \\ &= 6.83 - 4.58 \\ &= 2.25 \end{aligned}$$

      ii. What will the response to selection be?

$$\begin{aligned} R &= h^2 S \\ &= (0.43)(2.25) \\ &= 0.9675 \end{aligned}$$

iii. What will the leaf dissection index in the next generation be?

$$4.58 + 0.9675 = 5.5475$$

2. Florida scrub jays delay reproduction to help their sibling (brothers and sisters) reproduce. The relatedness coefficient for full-siblings (brothers and sisters sharing the same father and the same mother) is 1/2. Assume that individuals delaying reproduction leave 2 fewer offspring over their lifetime than they would have if they had not delayed reproduction and that the siblings they help leave 5 more offspring than they would have otherwise.

   (a) Could this behavior be explained by Hamilton's rule?

   Hamilton's rule says that altruism can evolve through kin selection if

   $$c < rb \quad ,$$

   where c is the cost to the individual performing the altruistic act, b is the benefit to the individual receiving the altruism, and r is the coefficient of relatedness between them. In this case,

   $$\begin{aligned} c &= 2 \\ rb &= (1/2)(5) \\ &= 2.5 \quad . \end{aligned}$$

   So $c < rb$ and kin selection could explain the evolution of altruism.

   (b) Half-siblings (brothers and sisters who have only one parent in common) have a relatedness coefficient of 1/4. If the behavior involved half-siblings rather than full-siblings, could this behavior be explained by Hamilton's rule?

   $$\begin{aligned} c &= 2 \\ rb &= (1/4)(5) \\ &= 1.25 \quad . \end{aligned}$$

   So $c > rb$ and kin selection could *not* explain the evolution of altruism.