Philosophy 3334: Philosophy of Biology
Fall 2023 - Homework 5 - practice

1) Let's assume a farmer has two genetic varieties (G_1 and G_2) of the same type of pumpkin. They plant them in four different fields (E_1 – E_4) where each field has one of two different types of soil (S_1 or S_2). Then one field of each type of soil is fertilized and the other is not. One hundred of each type of pumpkin are planted in each field. The average mass in kilograms of each type of plant in each field is given in the chart below:

	G_1	G_2	average
E_1 (S1 + F)	10	6	8
E_2 (S1 without F)	8	4	6
E_3 (S2 + F)	2	4	3
E_4 (S2 without F)	4	2	3
average	6	4	5

Overall mean = 5

From this information, calculate each of the following quantities (and show your work):

For these problems we will need averages (means). The overall mean is M = 40/8=5. M(g1) = 6, M(g2) = 4, M(e1) = 8, M(e2) = 6, M(e3) = 3, M(e4) = 3. I have added those numbers in the chart above.

Vp – overall phenotypic variance
This is the overall 'spread' of the data. What is the average (squared) distance from the overall mean. Formally, $Vp=1/n \, \Sigma \, (x-m)^2$. In this case that is:

$$Vp = 1/8 \; [(10-5)^2 + (8-5)^2 + (2-5)^2 + (4-5)^2 + (6-5)^2 + (4-5)^2 + (4-5)^2 + (2-5)^2] = 7.$$

Vg – overall genotypic variance
Vg = treats each of the genotypes as a single thing with its mean for its phenotype. Then it looks at the spread around the overall mean. So for example, if the genotypes are the same *on average* then Vg overall is 0. In this case,

$$Vg = ½ \, [(M(g1) – M)^2 + (M(g2)-M)^2] = 1$$

Ve – overall environmental variance
$$Ve = 1/4 \, [(M(e1) – M)^2 + (M(e2)-M)^2 + (M(e3) -M)^2 + (M(e4)-M)^2] =$$
$$= 1/4 \, [(8-5)^2 + (6-5)^2 + (3-5)^2 + (3-5)^2] = 18/4 = 4.5$$

Vgxe – overall variance due to the interaction of genetic and environmental factors (called I in Sober). NOTE: In this case, because there are the same number of each type of plant in each type of environment the covariance between genotype and environment Cov(g,e) = 0 so you do not need to worry about this term.

In full generality, Vp = Vg + Ve + Vgxe + 2Cov(g,e). Covariance of g and e refers to how much more likely some genes are to be found in some environments rather than others.

In this case, there are 100 plants in each type of environment so the covariance is 0. In these kinds of cases, Vp = Vg + Ve + Vgxe. Therefore in this case, Vgxe = Vp-Vg-Ve = 1.5

H^2 - broad score heritability (h^2 in Sober)

H^2 = Vg/Vp. This is the 'percent of the variation explained by genetic variation'. In this case, H^2 = 1/7.

2) Now let's use the data from problem 1 to ask about causation. Calculate the following:

2a) The average mass of a pumpkin in fertilized soil.
This is the average of pumpkins in E1 and E3 = 5.5
2b) The average mass of a pumpkin in non-fertilized soil.
This is the average of pumpkins in E2 and E4 = 4.5
2c) The average mass of a pumpkin in soil type 1.
This is the average of pumpkins in E1 and E2 = 7
2d) The average mass of a pumpkin in soil type 2.
This is the average of pumpkins in E3 and E4 = 3

2e) Harden doesn't actually give a definition of causation in her book, but she does say on page 108, "All" that is required to assert that you have identified a cause is to demonstrate evidence that the average outcome for a group of people *would have been different* if they had experienced **X** instead of **Not-X**. – According to this, do you think Harden would say that the fertilizer causes the pumpkins to be larger? What about being in soil type 1? Carefully explain your answers. Do you think this is correctly capturing causation here? What would happen if almost all of the pumpkins of this type in the wild were G_1 and G_2 was a rare mutant type? Would this change the answer at all? Should it?

I would like you to answer this one yourself on the homework.