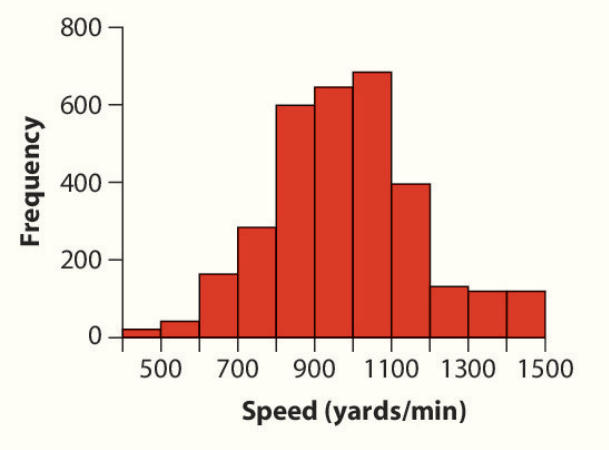
Assignment 2

1. Francis Galton (1894) presented the following data on the flight speeds of 3207 "old" homing pigeons traveling at least 90 miles.



a. What type of graph is this?
b. Examine the graph and visually determine the approximate value of the mean (to the nearest 100 yards per minute). Explain how you obtained your estimate.
c. Examine the graph and visually determine the approximate value of the median (to the nearest 100 yards per minute). Explain how you obtained your estimate.
d. Examine the graph and visually determine the approximate value of the mode (to the nearest 100 yards per minute). Explain how you obtained your estimate.
e. Examine the graph and visually determine the approximate value of the standard deviation (to the nearest 50 yards per minute). Explain how you obtained your estimate.

ANSWER:
1. **(a)** This is a histogram.
(b) Mean: approximately 1000 yards/minute. The frequency distribution is fairly symmetric, so the mean should lie near the middle.
(c) Median: approximately 900 yards/minute. The frequency distribution is fairly symmetric, so the median should lie near the middle, close to the mean.
(d) Mode: 1000–1100 yards/minute (the most frequently occurring interval in a frequency distribution)
(e) Standard deviation (s): approximately 200 yards/minute. Based on the fact that if the distribution is roughly bell-shaped (normal distribution) then about 95% of the observations will lie between the mean minus $2s$ and the mean plus $2s$. From the histogram we observe that 600 to 1400 yards/min should include about 95% of the frequency distribution, so $(1400 - 600)/4 = 200$ yards/min. This is a very rough calculation!

2. Measurements of lifetime reproductive success (LRS) of individual wild animals reveal the disparate contributions they make to the next generation. Jensen et al. (2004) estimated LRS of male and female house sparrows in an island population in Norway. They measured LRS of an individual as the total number of "recruits" produced in its lifetime, where a recruit is an offspring that survives to breed one year after birth. Parentage of recruits was determined from blood samples using DNA techniques. Their results are tabulated as follows:

	Frequency	
Lifetime reproductive success	**Females**	**Males**
0	30	38
1	25	17
2	3	7
3	6	6
4	8	4
5	4	10
6	0	2
7	4	0
8	1	0
> 8	0	0
Total	81	84

a. Which sex has the higher mean lifetime reproductive success?
b. Every recruit must have both a father and a mother, so it is not easy to see why male and female LRS should differ. Can you think of a biological explanation?
c. Which sex has the higher variance in reproductive success?

R exercise
d. read the data file on sparrow reproductive success and calculate the mean reproductive success for each sex.
e. Calculate the variance for each sex.
Do the same but for males and females with lifetime reproductive success >= 4 and > 4.

ANSWER
2. **(a)** Females had slightly higher mean LRS (1.7 recruits) than males (1.5 recruits).
(b) One possibility is that females live longer than males. Another possibility is that some females in the study mated with other males that were not part of the sample.
(c) Females had slightly higher variance in LRS (4.3 recruits^2) than males (3.5 recruits^2).

3. A massive survey of sexual attitudes and behavior in Britain between 1999 and 2001 contacted 16,998 households and interviewed 11,161 respondents aged 16–44 years (one per responding household). The frequency distributions of ages of men and women respondents were the same. The following results were reported on the number of heterosexual partners individuals had had over the previous five-year period (Johnson et al. 2001).

	Sample size, *n*	**Mean**	**Standard deviation**
Men	4620	3.8	6.7
Women	6228	2.4	4.6

a. What is the standard error of the mean in men? What is it in women? Assume that the sampling was random.
b. Which is a better descriptor of the variation among men in the number of sexual partners, the standard deviation or the standard error? Why?
c. Which is a better descriptor of uncertainty in the estimated mean number of partners in women, the standard deviation or the standard error? Why?
d. A mysterious result of the study is the discrepancy between the mean number of partners of heterosexual men and women. If each sex obtains its partners from the other sex, then the true mean number of heterosexual partners should be identical. Considering aspects of the study design, suggest an explanation for the discrepancy.

ANSWER

3. **(a)** SE = 6.7 / $\sqrt{4620}$ = 0.10. In women, 4.6 / $\sqrt{6228}$ = 0.06.
(b) Standard deviation, because it describes the spread of the distribution of the variable itself. In contrast, the standard error describes the spread of the sampling distribution of the sample mean.
(c) The standard error, because it describes the spread of the distribution of sample means. If the standard error is small, then the sample mean is likely close to the population mean (low uncertainty).
(d) The study did not actually measure number of sexual partners, but merely reported the number that respondents claimed. Perhaps men exaggerate their numbers or women underestimate theirs. Another possibility is that men obtain partners also from women not included in the survey (e.g., prostitutes or women living outside Britain).

4. *Amorphophallus johnsonii* is a plant growing in West Africa, and it is better known as a "corpseflower." Its common name comes from the fact that when it flowers, it gives off a "powerful aroma of rotting fish and faeces" (Baeth 1996). The flowers smell this way because their principle pollinators are carrion beetles, who are attracted to such a smell.
Baeth (1996) observed the number of carrion beetles (*Phaeochrous amplus*) who arrive per night to flowers of this species. The data are given below:

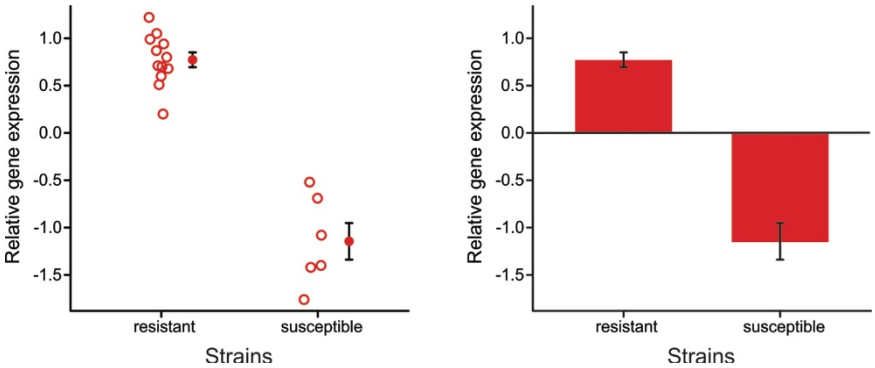
51 45 61 76 11 117 7 132 52 149

a. What is the mean and standard deviation of beetles per flower?
b. What is the standard error of this estimate of the mean?
c. Give an approximate 95% confidence interval of the mean. Provide lower and upper limits.
d. If you had been given 25 data points instead of 10, would you expect the mean to be greater, less than, or about the same as the mean of this sample?
e. If you had been given 25 data points instead of 10, would you have expected the standard deviation to be greater, less than, or about the same as this sample?
f. If you had been given 25 data points instead of 10, would you have expected the standard error of the mean to be greater, less than, or about the same as this sample?

R exercise
g. Load the data into R, visualize the data and check your answer of a-c using R.
h. Assume for now that the data are normally distributed (we will take about this later this week) and use the mean and standard deviation you calculated above to simulate a new data set of n = 25. Check your answers for e and f. Use the function *rnorm*(), take the mean and round to whole numbers using *round*().
i. Redo h for n = 50 and n = 100 as well to check.

ANSWER
4. **(a)** Mean: 70.1; Standard deviation: 48.5. **(b)** 15.3. **(c)** $39.4 \leq \mu \leq 100.8$. **(d)** About the same. **(e)** About the same. **(f)** Less than this sample.

5. The accompanying figure shows two alternative ways of presenting means with standard error bars in a graph. The data are from Dabord et al. (2002), who showed that elevated expression of the gene *Cyp6g1* in *Drosophila* causes resistance to DDT. Expression levels of the gene (relative to a standard) were measured in 12 resistant strains of *Drosophila* and 6 susceptible strains. Which graphical method is superior? Explain.



ANSWER
5. The strip chart on the left is superior because it fulfills the first principle of effective graphs: show the data. The bar graph on the right shows only the means and standard errors, which hides the data.

6. How long do you hug somebody? Nagy (2011) measured the duration of spontaneous embraces at the 2008 Summer Olympic Games in Beijing, China. The data are the durations of hugs, in seconds, of athletes immediately after competing in the finals of an event. Hugs were either with their coach, a supporter (e.g., a team member), or a competitor. Descriptive statistics calculated from the data are in the accompanying table. *n* refers to the sample size.

Relationship	Mean	Standard deviation	*n*
Coach	3.77	3.96	77
Supporter	3.16	2.76	75
Competitor	1.81	1.13	33

a. According to the values in the table, which relationship group gets the longest hugs, on average, and which the briefest hugs? Do the values shown represent parameters or sample estimates? Explain.
b. Using the numbers in the table, calculate the standard error of the mean hug duration for each relationship group. What do these values measure?
c. What assumption(s) about the samples are you making in (b)?
d. Using the numbers in the table, calculate an approximate 95% confidence interval for the mean hug duration when athletes embrace competitors. Provide the lower and upper limits of the confidence interval.
e. In light of your results in (d), consider the most-plausible values for the mean duration of hugs-with-competitors in the population of athletes. Is 2 seconds among the most plausible values for the population mean hug duration?
f. For which of the relationship groups is the possibility of a 3-second mean hug duration in the population plausible?

ANSWER
6. **(a)** Coaches get the longest hugs, competitors the briefest hugs. The values are sample estimates because they are based on measurements of a sample of hugs of athletes. Parameters refer to the true mean hug duration in the population of athletes, and are unknown.
(b) coaches: 0.45, supporters: 0.32, competitors: 0.20 (rounded). These values estimate the standard deviation of the sampling distributions of sample means.
(c) That they are random samples.
(d) Use the 2SE rule of thumb: $1.42 \leq \mu \leq 2.20$.
(e) Yes, because 2 seconds lies within the confidence interval.

(f) A mean hug duration of 3 seconds is plausible for coaches (approximate 95% CI is $2.87 \leq \mu \leq 4.67$) and for supporters ($2.52 \leq \mu \leq 3.80$), but not for competitors ($1.42 \leq \mu \leq 2.20$).