Name:

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Student number:

MID-TERM BIOL 300: October 2017

For all statistical tests, make sure that you clearly state your hypotheses. Unless otherwise stated, assume α = 0.05. Show your work. Be as precise as possible about P-values.

By taking this test and putting your name above, you are declaring that your answers on this test are all your own work.

Make sure that your copy of the test includes 7 pages, including this one.

	Points
Q1	4
Q2	4
Q3	8
Q4	8
Q5	16
Q6	12
Q7	6
Q8	9
Q9	18
Q10	15
	100

1. (*4 points*). Assume a null hypothesis is true and the significance level has been set to 0.01. What is the probability of rejecting this null hypothesis?

0.01

2. (*4 points*) In a particular study, the Type II error rate is 20%. What is the power of that study?

80%. Power is 1 minus the Type II error rate.

3. (*2 points each*) Match the following R commands to their intended use:

__E__	na.rm = TRUE	A. Load a package
__B__	read.csv()	B. Load a data set from a file into a data frame
__A__	library()	C. The column named y in data frame x
		D. The column named x in data frame y
__C__	x$y	E. Ignore missing data

4. (*8 points*) Give a numerical value that you should expect if you asked R to calculate the following command:

```
> dpois(x = 2, lambda = 3)
```

This is the probability with a Poisson distribution with mean 3 of getting a value of x = 2:

$$\Pr[x = 2] = \frac{\mu^x \, e^{-\mu}}{x!} = \frac{3^2 e^{-3}}{x!} = 0.224$$

5. (*16 points*) In class we turned up several red cards in a row (from a trick deck which turned out to have been all red cards). If the deck instead had been a regular, well-shuffled deck, what is the chance that the first 5 cards turned over would all be red? (Remember that a regular deck has 52 cards, half of which are red and half of which are black.)

The probability that the first card is red is ½. After removing that first red card from the deck, there are 25 red cards out of the 5 remaining, so the probability that the second card is also red is 25/51. Continuing like this, the probability that the first 5 cards are red is

$$\left(\frac{1}{2}\right)\left(\frac{25}{51}\right)\left(\frac{24}{50}\right)\left(\frac{23}{49}\right)\left(\frac{22}{48}\right) = 0.0253$$

6. (*12 points*) The weights of 25 song sparrows were measured with a scale that was later determined to give a value for each measurement that was 3 g too high. The mean of these measured weights was 28.4g. The standard error of this estimate of the mean was 0.8 g.

a. What is the bias in this estimate?

The bias is 3g.

b. If the weights of 240 song sparrows were measured on this scale, would the bias be greater, smaller or about the same, compared to the values given above?

The bias would be the same with a larger sample size.

c. If the weights of 240 song sparrows were measured on this scale, would the sampling error be expected to be greater, smaller or about the same, compared to the values given above?

With a larger sample size, the sampling error would be smaller.

7. (*6 points*) For the following data, estimate the standard error of the mean:

12, 20, 10, 5, 32

The sample standard deviation, *s*, is 10.545.

The sample size, *n*, is 5.

The standard error of the mean is $\frac{s}{\sqrt{n}} = \frac{10.545}{\sqrt{5}} = 4.72$

8. (*9 points*) The following table show the number of infants who had malocclusion (misalignment) of their teeth, as a function of whether they were breast-fed or bottle-fed.

	Normal teeth	**Malocclusion**
Breast fed	**4**	**16**
Bottle-fed	**1**	**21**

a. What kind of table is this?

A contingency table.

b. What are the expected values for a test of independence between feeding method and malocclusion?

	Normal teeth	**Malocclusion**
Breast fed	**2.38**	**17.62**
Bottle-fed	**2.62**	**19.38**

c. Give the name of the most appropriate hypothesis test for this data?

Fisher's exact test. (The expected values are too small for a χ^2 contingency analysis.)

9. (*18 points*) In the original Star Trek series from the 1960's, the characters wore different color shirts to distinguish their rank and job. Those wearing red shirts, called "Redshirts" in Star Trek lore, are the lowest ranking crewpersons. These Redshirts are widely believed to be more likely to die than the gold-shirted command personnel.

However, is this true? According to the Star Trek technical manual (apparently there is such a thing), there are 239 Redshirts onboard the ship and 55 Goldshirts. During all the episodes put together, there were 25 Redshirts who died, compared to 10 Goldshirts.

a. Test the hypothesis that Redshirt and Goldshirt individuals were equally likely to die, compared to their proportions on the ship.

H_0: Redshirts and gold shirts had equal chances of dying on the original Star Trek. (Shirt color and survivorship are independent.)

Observed:

	Red-shirt	**Gold-shirt**
Die	**25**	**10**
Survive	**214**	**45**

Expected:

	Red-shirt	**Gold-shirt**
Die	**28.45**	**6.55**
Survive	**210.55**	**48.45**

$$\chi^2 = \frac{(25-28.45)^2}{28.45} + \frac{(10-6.55)^2}{6.55} + \frac{(214-210.55)^2}{210.55} + \frac{(45-48.45)^2}{48.45} = 2.54$$

df = (number of rows -1)(number of columns – 1) = (2-1)(2-1) = 1

$$\chi^2_{(0.05),1} = 3.84$$

2.54 <3.84, therefore $P > 0.05$. We do not reject the null hypothesis. There is no evidence that shirt color and survivorship are related.

b. Do the data support that Redshirts had a higher probability of death, based on these data?

No (in fact the probability of death for gold shirts (10/45 = 0.222) is estimated to be higher that the probability for redshirts (25/239 = 0.104).

(ref: https://boingboing.net/2017/04/20/turns-out-star-trek-redshirts.html)

10. (*15 points*) A sample of people who were all admitted to emergency rooms with broken hands had 12 people who had punched walls with their bare hands. Of these 12 people, 9 were male and 3 female. Do an appropriate test to ask whether males and females are equally likely to be admitted to hospital for breaking their hands punching walls. The calculations for the appropriate null hypothesis are partially completed in the following table. Finish the table and complete the hypothesis test.

Number of males	Probability
0	0.00024
1	0.00293
2	0.01611
3	0.05371
4	0.12085
5	0.19336
6	0.22559
7	0.19336
8	0.12085
9	0.05371
10	0.01611
11	0.00293
12	0.00024

$$\Pr[1] = \binom{12}{1}(0.5)^1(1-0.5)^{12-1} = 0.00293$$

$$\Pr[10] = \binom{12}{10}(0.5)^{10}(1-0.5)^{12-10} = 0.01611$$

$$\Pr[11] = \binom{12}{11}(0.5)^{11}(1-0.5)^{12-11} = 0.00293$$

H_0: Out of all people admitted to ER rooms for broken hands from punching walls, half are men.

Binomial test

$P = 2(0.05371 + 0.01611 + 0.00293 + 0.00024) = 0.146$.

P is greater than 0.05, therefore we do not reject this null hypothesis. There is no evidence from these data that men are more likely to punch walls and break their hands compared to women.