***Midterm 2***

***Part A***

1. (3 pts) What is statistical power?

The probability of detecting an effect, if one exists. More power gives more confidence to reject a false null hypothesis.

Power = 1-beta, where beta is the probability of type II error (false negative).

2. (4 pts) How do the following changes affect statistical power?

Change Effect on Power (increase/decrease/no effect)

More replicates: increases power

Decreased effect size: decreases power

Increased variance: decreases power

Alpha=0.1 instead of 0.05: increases power

3. (3 pts) In the context of ANOVA, what is a residual?

Error, or variation that is not explained by our model

4. (3 pts) What is the *F*-ratio a ratio of? Give the formula. What does it test?

F-ratio = MS1/MS2

MS: mean square = sum of squares / degrees of freedom = variance

The F-ratio gives percent variation explained by our model: explained variation / unexplained variation (residual or error). If the F-ratio >> 1, then variation explained by our model is much greater than variance explained by error.

5. (3 pts) Describe the difference among ANOVA, ANCOVA, and multiple regression in terms of the types of predictor variables in each model.

ANOVA: one or more categorical predictors

ANCOVA: one or more categorical predictors AND one or more continuous predictors (incorporates ANOVA and regression)

Multiple Regression: more than one continuous predictor variable (involves more than one linear regression for the dependent variable and comparison of partial regression coefficients)

6. (3 pts) What is the difference between a dependent and an independent variable?

A dependent variable is the response variable that is affected by the independent variables. Independent variables are predictor variables, which drive changes to the dependent variables.

7. (4pts) In multiple regression, what are partial regression coefficients? How are standardized partial regression coefficients useful to us?

Partial regression coefficients are the slopes of each predictor variable’s independent regression with the dependent variable, measuring the expected change in the dependent variable associated with a change in the predictor variable.

The standardized partial regression coefficients are useful to show the relative strength of each predictor variable. Without standardization, the partial regression coefficients may not be directly comparable due to differences in units.

8. (3 pts) How does our interpretation of biological significance differ between fixed and random factors?

Fixed factors are the specific groups we want to test for significance (test group means for p-values). They are assumed to contain all levels of interest within a population, and conclusions are restricted to the levels tested. Using fixed factors, we measure the exact effect of a treatment level, and it is assumed we would get the same results in a replicate study.

Random factors are assumed to be a random subset/sampling of groups within our study, and therefore we can extrapolate beyond our sample to all possible groups. They are included in our model to avoid pseudoreplication (no significance test, no p-value) and explain natural variation. Random factors represent a broader distribution, so we do not know the exact effect of each level, and in a repeated experiment we would expect a different set of levels and therefore a different estimate of added variance in our model.

9. (4 pts) What are two reasons why it would be advantageous to perform *a priori* (planned) comparisons instead of *post-hoc* Tukey tests?

You can test specific, logical comparisons (specific hypotheses) and gain more power in your tests, compared to a simple ANOVA. Compared to multiple comparisons, the probability of type I error is lower for planned comparisons compared to post-hoc Tukey tests.

10. (3 pts) In a two-way factorial ANOVA that includes the effects of drought stress and nutrient enrichment on plant fitness, what hypothesis does the interaction test? What does each main effect test?

In a two-way ANOVA, the interaction tests independence of stress and enrichment, where the null hypothesis is that there is no interaction between (and thus independence of) stress and enrichment. If the null is rejected, then the effect of drought stress is dependent on the level of nutrient enrichment and vice versa.

If the interaction null hypothesis is accepted (no interaction between the two factors), then the independent effects of drought stress on plant fitness and nutrient enrichment on plant fitness can be assessed independently, where the effect of drought stress is not dependent on the level of nutrient enrichment and vice versa when assessing the effect on plant fitness. For the main effects, there are two null hypotheses, which are simply that (1) there is no effect of drought on plant stress and (2) there is no effect of enrichment on plant fitness.

11. (3pts) If an interaction term in a two-way ANOVA is significant, why might we *not* trust the interpretation of the main effects?

The main effects are not independent, and the assumptions of the ANOVA would not be met when attempting to gauge the individual main effects. The effect of one group is dependent on the level of another group and vice versa, and because of this additive effect of factors, we cannot know how each main factor is independently affecting the dependent variable.

12. (3 pts) In an ANOVA with two factors, what is the difference between a crossed design and a nested design?

In a crossed design, every level of one factor is crossed with every level of the second factor, such that every combination of levels is tested across groups.

In a nested design, not all levels of one factor are present or represented in all levels of another factor. Some levels of one factor are only present in some levels of another factor.

13. (4 pts) For each of the following two-factor ANOVA designs, highlight which MS should be used as the denominator to test Factor A.

a) one factor (A) MSA MSB MSAB MSB(A) MSresidual

b) two fixed factors (A and B),crossed MSA MSB MSAB MSB(A) MSresidual

c) A fixed, B random and crossed MSA MSB MSAB MSB(A) MSresidual

d) A fixed, B nested within A MSA MSB MSAB MSB(A) MSresidual

14. (4 pts) You are interested in the effects of two different factors on growth of your study organism. You could do two separate experiments, one comparing the effects of different levels of Factor A on growth and a separate one comparing different levels of Factor B. Or you could do one factorial experiment that includes both factors A and B. What are the advantages of doing the factorial experiment over the two single-factor experiments?

You can test more hypotheses and answer more questions with a two-factor experiment than with two single-factor experiments without much more work. You can test the effects of both factors on growth and the effect of the interaction of those two factors (the effect of one factor on growth at different levels of another factor). In each single-factor experiment, you could only test the effect of each factor separately on growth, without any insight on how the interaction may affect your response variable.

15. (3 pts) In ANCOVA, what does the interaction term between a categorical variable and a continuous variable test?

The interaction term tests the homogeneity of slopes, where the null hypothesis is that there is no difference between slopes of different treatments (levels of the categorical variable). If the null is rejected, then there is a significant difference in slopes across treatments, and thus a significant interaction (effect of treatment on the continuous covariate and vice versa).