1. **[30 pts]** Welbergen (2010; Journal of Mammalogy 91:38-47) examined the relationship between body mass (grams) and forearm length (mm) for three groups of gray-headed flying foxes (*Pteropus poliocephalus*) – adult males, adult females, and juveniles (labeled as "young"). Welbergen's primary interest with these data was to see if body mass could be predicted from forearm length and whether those predictions were dependent on the group (variable called "sex") of flying fox. Welbergen's data was entered into R and analyzed with the commands shown in ***Results #1***. Use this information to answer the following questions (these do not have to be complete sentences).

   a. Construct the ultimate full model for these data, with an explicit definition of each variable. [*Variables should be entered into the model according to the order discussed in class.*]

   b. Two linear models are presented in the results – `lm1` and `lm2`. Which model do you choose to analyze and why? Be as specific as possible with evidence to support your choice.

   Check your model choice with me before continuing!!

   Use the model you identified above to answer the following questions. Note that I have put the variable names in quotes below because you may be referring to a transformed version of the variable (and you should do so in your answer).

   c. What can you say about the relationship between "body mass" and "forearm length" for these flying foxes? Be as explicit as you possibly can -- make sure to comment on any differences between groups (i.e., sexes) and specifically state what the relationship is for each group. Provide evidence for your conclusions.

   d. What can you say, if anything, about differences in "body mass" among groups (i.e., sexes) after having factored out the effect of "forearm length" on "body mass"? Again be as explicit as you possibly can. Provide evidence for your conclusions.

   e. At the end of the results for your chosen model are results from `predict()`. Interpret each of these values and comment on whether these values are statistically significantly different or not (with supporting evidence).

2. **[20 pts]** Tony Kennedy, a biologist with the Minnesota DNR, wants to predict the (1) probability that a female walleye (*Sander vitreus*) in Red Lake is mature and (2) length at which 50% of all female walleye in Red Lakes are mature. The length and maturity status (=0 is immature, =1 is mature) were recorded for a large sample of female walleye from Red Lake in 2012. The data are read and analyzed with the R code in **Results #2**. Use these results to answer the following questions.
   a. Interpret the slope and the back-transformed slope.
   b. Predict the log odds of maturity for a 406-mm (16-inch) Red Lakes female walleye.
   c. Predict the odds of maturity for a 406-mm (16-inch) Red Lakes female walleye. Specifically, interpret this result.
   d. Predict the probability of maturity for a 406-mm (16-inch) Red Lakes female walleye.
   e. Compute the length at which 50% of all female walleye in Red Lakes are mature.
   f. Compute the length at which 90% of all female walleye in Red Lakes are mature.
   g. How much do you expect the odds to change if a female walleye grows 50-mm (~2-in) larger?

3. **[20 pts]** Answer *two* of the three following questions.
   a. Suppose that you have collected a quantitative response variable. In addition you may have collected (i) a quantitative explanatory variable, (ii) a categorical explanatory variable, (iii) both a quantitative and categorical explanatory variable, or (iv) two categorical explanatory variables. Identify which statistical procedure/test you would use in each of these four situations and describe the type(s) of question(s) or hypothesis(es) that you would be able to answer with each.

   b. Kleiber's law is the observation that, for the vast majority of animals, an animal's metabolic rate scales to the ¾ power of the animal's mass. Thus, if q is the animal's metabolic rate and M is the animal's mass, then Kleiber's law states that $q = aM^{3/4}$, where a is a proportionality constant[1]. Suppose that you have metabolism and mass data for a large number and wide variety of animals. What would you do with these data to test Kleiber's Law (i.e., is the power constant in the relationship equal to ¾). Show each step of your work and be specific with your answer.

   c. Suppose that you have conducted a one-way ANOVA and received a particular result (either the groups have different means or they do not). Now suppose that you introduce a quantitative covariate to the analysis that is significantly related to the response variable and the relationship between the covariate and the response does not differ by group. The introduction of this covariate to the analysis could lead you to reverse your original conclusion – i.e., changing from concluding that the groups differed to concluding that they do not differ (or vice versa). Explain how each of these reversals could happen (you likely will want to refer to variabilities "explained" and "not explained" and may want to draw some illustrative graphics).

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[1] Thus, for example a cat that has a mass 100 times that of a mouse will have a metabolism roughly 31 times greater than that of a mouse.