Biology 4605/7220 Name ___________________
Exam #2 8 November 1993

1. An oncologist tests the effects of smoking on 4 rats, using an additional 4 rats as controls (non-smoking). The researcher concludes that smoking does not increase the rate of tumor production in lungs, using a criterion of $\alpha = 0.001$. Define Type II statistical error (1), then discuss the oncologist's conclusion with respect to Type II error. (2)

2. Write a complete general linear model corresponding to each of the following tests. Use Y for all response variables. Use X for all explanatory variables on a nominal scale (ie categorical varibles). Use Z for all explanatory variables on a ratio scale.

Use subscripts to distinguish and label explanatory variables as needed (e.g. X_1 X_2 etc).
Use the greek letter β (=beta) for parameters that are slopes; use the greek letter γ (=gamma) for parameters that consist of a set of means.

a. regression (one explanatory variable) (2)

____

b. two-way ANOVA, with replication in all cells. (2)

____

3. If you are interested in hypothesis testing with a statistic whose theoretical frequency distribution is unknown, how can you determine the distribution of this statistic when the null hypothesis is true ? (2)

4. Garrod (1967 *Journal of the Fisheries Research Board of Canada* 24:145) computed fishing effort (10^8 vessel ton-hours) and fishing mortality (%/yr) for fish ages 6-7 through 9-10 in the arcto-Norwegian cod fishery. Garrod's data, along with several graphs of the data, are attached on a separate sheet.

a. On the blank line below, write a general linear model to test whether fishing mortality depends upon year. (2)

Be sure to assign symbols to your variables before writing the model. (2)

____

b. Write the degrees of freedom <u>beneath</u> the appropriate terms in your model. (3)

c. List each symbol in your equation. State whether it is a variable quantity V or a parameter P. State its units. State its dimensions. (10)

Symbol	V or P ?	Units	Dimensions

5. A mycologist takes 3 replicated measurements of the standing stock of soil fungi in <u>each</u> of 3 fields at farm A, then repeats this at farms B and C.

a. Complete the following ANOVA table by filling in the blanks. (4)

Source	df	Sums of Squares
farm	_____	30.0
field	_____	2.3
replicate	_____	67.7
total	_____	

b. What proportion of the total variability (total Sums of Squares) is due to

farms _________ (1)

fields within farms _________ (1)

replication within fields ____________ (1)

c. Which factor (farm, field, or replicate) could be dropped from future studies with the least effect on sensitivity, or ability to detect change in soil fungi over time ? (1)

6. Complete the following ANOVA table, for variability in blood pH of 5 strains of mice over 6 days. (10)

Source	df	SS	MS	F
strains	4	0.3680	__________	__________
days	5	0.0505	__________	__________
interaction	20	_______	__________	__________
error	____	0.4080	__________	
Total	149	0.9305	__________	

7. You have been asked to determine whether the type of lighting affects growth of cucumbers in a greenhouse with 5 separate units, connected at a central point. An inexpensive form of xenon lighting is currently in use. Two other types of lighting, which are closer to natural lighting in their spectral characteristics but more expensive to use, are being considered. It is known that cucumbers tend to grow better on the south than on the north side of each of the 5 units.

a. Design an experiment to determine whether growth rate depends on type of lighting. (2)

b. Provide a complete definition (name, symbol, procedural statement and units) of your response variable. (4)

7. (continued)

c. Provide a complete definition (name, symbol, procedural statement) of an explanatory variable that you can manipulate. (3)

d. Provide a complete definition (name, symbol, procedural statement) of one explanatory variable that you plan to control statistically. (3)

e. Write a general linear model to analyze the results of your experiment. (2)

f. State an alternative and null hypothesis pair concerning the treatment variable. (2)

```
MTB > read 'a:garrod.dat' c1 c2 c3;
SUBC> nobs = 13.
     13 ROWS READ

MTB > print c1-c3

 ROW  effort    mort   year

   1   2.959   0.734   1950
   2   3.551   0.773   1951
   3   3.226   0.735   1952
   4   3.327   0.759   1953
   5   4.127   0.583   1954
   6   5.306   1.125   1955
   7   5.347   0.745   1956
   8   4.577   0.859   1957
   9   4.461   0.942   1958
  10   4.939   1.028   1959
  11   6.348   0.635   1960
  12   5.843   1.114   1961
  13   6.489   1.492   1962

MTB > name c1 'effort' c2 'mort' c3 'year'
MTB > plot c2 c1

    1.50+                                                      *
        -
mort    -
        -
        -
    1.20+
        -                                    *      *
        -
        -                               *
        -                        *
    0.90+
        -                         *
        -         *  *
        -   *   *                             *
        -                                                    *
    0.60+                   *
        -
          +---------+---------+---------+---------+---------+------effort
       2.80      3.50      4.20      4.90      5.60      6.30
```

```
MTB > plot c1 c3
        -                                                     *
        -                                             *
     6.0+
        -                                                 *
effort  -
        -                         *   *
        -                                         *
     4.8+
        -                                 *   *
        -
        -                     *
        -
     3.6+         *
        -                 *
        -             *
        -     *
        -
          ----+---------+---------+---------+---------+---------+--year
          1950.0    1952.5    1955.0    1957.5    1960.0    1962.5

MTB > plot c2 c3
    1.50+                                                     *
        -
mort    -
        -
        -
    1.20+
        -                         *                       *
        -
        -                                         *
        -                                     *
    0.90+
        -                                 *
        -         *       *
        -     *       *               *
        -                                             *
    0.60+                     *
        -
          ----+---------+---------+---------+---------+---------+--year
          1950.0    1952.5    1955.0    1957.5    1960.0    1962.5
```