Little Tubes Data With SAS

```
bash-3.00$ ls

bash-3.00$ curl
http://www.utstat.toronto.edu/~brunner/appliedf11/data/littletubes.data >
littletubes.data
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100  1400  100  1400    0     0   116k      0 --:--:-- --:--:-- --:--:--  341k

bash-3.00$ ls
littletubes.data

bash-3.00$ cat littletubes.data
                            mcg    length10    weight
                         1    198      27.80     0.5996
                         2    198      28.20     0.6040
                         3    198      27.60     0.6172
                         4    198      27.50     0.6053
                         5    205      24.95     0.6769
                         6    205      25.70     0.7057
                         7    205      25.40     0.7271
                         8    205      25.30     0.6029
                         9    213      26.85     0.6023
                        10    213      24.35     0.6976
                        11    213      24.70     0.7154
                        12    213      24.35     0.6575
                        13    221      23.35     0.5958
                        14    221      23.00     0.6789
                        15    221      22.30     0.6965
                        16    221      23.15     0.6433
                        17    223      24.10     0.5479
                        18    223      24.55     0.5604
                        19    223      24.35     0.5446
                        20    223      24.40     0.5398
                        21    225      23.55     0.5615
                        22    225      24.55     0.6363
                        23    225      24.70     0.5753
                        24    225      23.85     0.6627

bash-3.00$ emacs 2101f11tubes1.sas

/********************* 2101f11tubes1.sas ***********************/
options linesize=79 noovp formdlim='_';
title 'Little Fungus Tube data: Basics';

data mould;
     infile 'littletubes.data' firstobs=2; /* Skip the header */
     input tube mcg length10 weight;
     if tube eq 9 then mcg = .;

proc freq;
     tables mcg;

proc means;
     title2 'Means etc. for all cases';
     var length10 weight;

proc means n mean std;
     title2 'Mean, N, SD of length10 broken down by Fungus Type';
     class mcg;
     var length10 weight;
```

```
bash-3.00$ ls
2101f11tubes1.sas  littletubes.data

bash-3.00$ sas 2101f11tubes1
bash-3.00$ ls
2101f11tubes1.log  2101f11tubes1.lst  2101f11tubes1.sas  littletubes.data


bash-3.00$ less 2101f11tubes1.log
1                                                       The SAS System
21:01 Thursday, November 3, 2011

NOTE: Copyright (c) 2002-2008 by SAS Institute Inc., Cary, NC, USA.
NOTE: SAS (r) Proprietary Software 9.2 (TS1M0)
      Licensed to UNIVERSITY OF TORONTO/COMPUTING & COMMUNICATIONS, Site
0070072784.
NOTE: This session is executing on the SunOS 5.10 platform.



You are running SAS 9. Some SAS 8 files will be automatically converted
by the V9 engine; others are incompatible.  Please see
http://support.sas.com/rnd/migration/planning/platform/64bit.html

PROC MIGRATE will preserve current SAS file attributes and is
recommended for converting all your SAS libraries from any
SAS 8 release to SAS 9.  For details and examples, please see
http://support.sas.com/rnd/migration/index.html


This message is contained in the SAS news file, and is presented upon
initialization.  Edit the file "news" in the "misc/base" directory to
display site-specific news and information in the program log.
The command line option "-nonews" will prevent this display.



NOTE: SAS initialization used:
      real time           0.13 seconds
      cpu time            0.13 seconds

1          /********************* 2101f11tubes1.sas ***********************/
2          options linesize=79 noovp formdlim='_' ;
3          title 'Little Fungus Tube data: Basics';
4
5          data mould;
6               infile 'littletubes.data' firstobs=2; /* Skip the header */
7               input tube mcg length10 weight;
8               if tube eq 9 then mcg = .;            /* Discard contaminated
8        ! case */
9

NOTE: The infile 'littletubes.data' is:
      Filename=/u/brunner/2101f11/lecture/tubes/littletubes.data,
      Owner Name=brunner,Group Name=dos,
      Access Permission=rw-r--r--,
      Last Modified=Mon Oct 31 14:30:39 2011,
      File Size (bytes)=1400

NOTE: 24 records were read from the infile 'littletubes.data'.
      The minimum record length was 55.
      The maximum record length was 55.
```

```
NOTE: The data set WORK.MOULD has 24 observations and 4 variables.
NOTE: DATA statement used (Total process time):
      real time           0.04 seconds
      cpu time            0.04 seconds


10         proc freq;
11              tables mcg;

2                                The SAS System

12

NOTE: There were 24 observations read from the data set WORK.MOULD.
NOTE: The PROCEDURE FREQ printed page 1.
NOTE: PROCEDURE FREQ used (Total process time):
      real time           0.14 seconds
      cpu time            0.12 seconds


13         proc means;
14              title2 'Means etc. for all cases';
15              var length10 weight;
16

NOTE: There were 24 observations read from the data set WORK.MOULD.
NOTE: The PROCEDURE MEANS printed page 2.
NOTE: PROCEDURE MEANS used (Total process time):
      real time           0.10 seconds
      cpu time            0.05 seconds


17         proc means n mean std;
18              title2 'Mean, N, SD of length10 broken down by Fungus Type';
19              class mcg;
20              var length10 weight;
21
22
23
24
25
26         /* Must sort cases for "by" to work.
27         proc sort;
28              by mcg;
29
30         proc means n mean std;
31              title2 'Mean, N, SD of length10 broken down by Fungus Type';
32              var length10;
33              by mcg;
NOTE: There were 24 observations read from the data set WORK.MOULD.
NOTE: The PROCEDURE MEANS printed page 3.
NOTE: PROCEDURE MEANS used (Total process time):
      real time           0.47 seconds
      cpu time            0.08 seconds


NOTE: SAS Institute Inc., SAS Campus Drive, Cary, NC USA 27513-2414
NOTE: The SAS System used:
      real time           0.92 seconds
      cpu time            0.42 seconds

bash-3.00$ less 2101f11tubes1.lst
```

Little Fungus Tube data: Basics 1

The FREQ Procedure

mcg	Frequency	Percent	Cumulative Frequency	Cumulative Percent
198	4	17.39	4	17.39
205	4	17.39	8	34.78
213	3	13.04	11	47.83
221	4	17.39	15	65.22
223	4	17.39	19	82.61
225	4	17.39	23	100.00

Frequency Missing = 1

Little Fungus Tube data: Basics 2
Means etc. for all cases

The MEANS Procedure

Variable	N	Mean	Std Dev	Minimum	Maximum
length10	24	24.9395833	1.6023067	22.3000000	28.2000000
weight	24	0.6272708	0.0581010	0.5398000	0.7271000

Little Fungus Tube data: Basics 3
Mean, N, SD of length10 broken down by Fungus Type

The MEANS Procedure

mcg	N Obs	Variable	N	Mean	Std Dev
198	4	length10	4	27.7750000	0.3095696
		weight	4	0.6065250	0.0075230
205	4	length10	4	25.3375000	0.3092329
		weight	4	0.6781500	0.0542194
213	3	length10	3	24.4666667	0.2020726
		weight	3	0.6901667	0.0296571
221	4	length10	4	22.9500000	0.4564355
		weight	4	0.6536250	0.0444501
223	4	length10	4	24.3500000	0.1870829
		weight	4	0.5481750	0.0088024
225	4	length10	4	24.1625000	0.5513242
		weight	4	0.6089500	0.0483767

```
bash-3.00$ cp 2101f11tubes1.sas 2101f11tubes2.sas

bash-3.00$ emacs 2101f11tubes2.sas
```

```
/******************** 2101f11tubes2.sas ***********************/
options linesize=79 noovp formdlim='_';
title 'One-factor analysis of Little Fungus Tube data';

data mould;
     infile 'littletubes.data' firstobs=2; /* Skip the header */
     input tube mcg length10 weight;
     label mcg      = 'Fungus Type'
           length10 = 'Mean Length on Day 10'
           weight   = 'Sclerotial Weight';
     if tube eq 9 then mcg = .;
     /* Make my own dummy variables for use with proc reg*/
     if mcg = . then mcg198 = .;
        else if mcg = 198 then mcg198=1;
        else mcg198=0;
     if mcg = . then mcg205 = .;
        else if mcg = 205 then mcg205=1;
        else mcg205=0;
     if mcg = . then mcg213 = .;
        else if mcg = 213 then mcg213=1;
        else mcg213=0;
     if mcg = . then mcg221 = .;
        else if mcg = 221 then mcg221=1;
        else mcg221=0;
     if mcg = . then mcg223 = .;
        else if mcg = 223 then mcg223=1;
        else mcg223=0;
     if mcg = . then mcg225 = .;
        else if mcg = 225 then mcg225=1;
        else mcg225=0;

proc freq;
     title2 'Check MCG dummy variables';
     tables mcg*(mcg198--mcg225) / norow nocol nopercent missing;

proc glm;
     title2 'One-Factor ANOVA: Just the defaults';
     class mcg;
     model length10 = mcg;

proc glm;
     title2 'With contrasts and multiple comparisons';
     class mcg;
     model length10 = mcg / clparm; /* clparm will give CI for contrasts
                                       down in the estimate statement. */
     means mcg;
     /* Multiple Comparisons */
     means mcg / Tukey Bon Scheffe; /* Simultaneous Confidence Intervals */
     /* Tables of adjusted p-values -- more convenient */
     lsmeans mcg / pdiff adjust=bon;
     lsmeans mcg / pdiff adjust=tukey;
     lsmeans mcg / pdiff adjust=scheffe;

     /* Test custom contrasts, or "planned comparisons" */
     /* For convenience, MCGs are:  198 205 213 221 223 225  */
     contrast '198vs205'       mcg   1   -1     0   0   0   0;
     contrast "223vs225"       mcg   0    0     0   0   1  -1;
     contrast '223n225vsRest'  mcg  -1   -1    -1  -1   2   2;
     /* Test equality of mcgs excluding 198: a COLLECTION of contrasts */
     contrast 'AllBut198'      mcg   0   1  -1   0   0   0,
                               mcg   0   0   1  -1   0   0,
                               mcg   0   0   0   1  -1   0,
                               mcg   0   0   0   0   1  -1;
```

```
     /* Replicate overall F test just to check. */
     contrast 'OverallF=76.70' mcg   1  -1   0   0   0   0,
                               mcg   0   1  -1   0   0   0,
                               mcg   0   0   1  -1   0   0,
                               mcg   0   0   0   1  -1   0,
                               mcg   0   0   0   0   1  -1;
     /* Estimate will print the value of a sample contrast and do a t-test
        of H0: Contrast = 0 (F = t-squared) */
     estimate '223n225vsRest'  mcg -.25 -.25 -.25 -.25 .5 .5;
     estimate 'AnotherWay'     mcg  -3   -3    -3  -3   6  6 / divisor=12;

/* Get Scheffe critical value from proc iml */
proc iml;
     title2 'Scheffe critical value for all possible contrasts';
     numdf = 5;   /* Numerator degrees of freedom for initial test */
     dendf = 17;  /* Denominator degrees of freedom for initial test */
     alpha = 0.05;
     critval = finv(1-alpha,numdf,dendf);
     scrit = critval * numdf;

     print "Initial test has"  numdf " and " dendf "degrees of freedom."
           "-----------------------------------------------------------"
           "Using significance level alpha = " alpha
           "-----------------------------------------------"
           "Critical value for the initial test is " critval
           "-----------------------------------------------"
           "Critical value for Scheffe tests is " scrit
           "-----------------------------------------------";

/******************* Regression with cell means coding **************/

proc reg;
     title2 'With Intercept: MCG198 is reference';
     model length10 = mcg205 mcg213 mcg221 mcg223 mcg225;
     /* Reproduce test of 198 vs 205 and overall test. */
     MCG198vs205: test mcg205=0;
     Overall: test mcg205=mcg213=mcg221=mcg223=mcg225 = 0;
     Overall2: test mcg205=0, mcg213=0, mcg221=0,
                              mcg223=0, mcg225=0;
proc reg;
     title2 'No Intercept: Use Test statement for contrasts';
     model length10 = mcg198 mcg205 mcg213 mcg221 mcg223 mcg225 / noint;
     /* SSTO is now sum of Y^2, and R^2 is weird. */
     Overall3: test mcg198=mcg205=mcg213=mcg221=mcg223=mcg225;
     AllBut198: test mcg205=mcg213=mcg221=mcg223=mcg225;
     Ave223n225vsRest: test mcg198+mcg205+mcg213+mcg221 = 2*mcg223 + 2*mcg225;

/******************* Multivariate Tests *****************/

proc glm;
     title2 'Multivariate on length10 and weight with proc glm';
     class mcg;
     model length10 weight = mcg;
     /* Test equality of mcgs excluding 198: a COLLECTION of contrasts */
     contrast 'AllBut198'      mcg   0   1  -1   0   0   0,
                               mcg   0   0   1  -1   0   0,
                               mcg   0   0   0   1  -1   0,
                               mcg   0   0   0   0   1  -1;
     manova h = _all_;

proc reg;
     title2 'Multivariate on length10 and weight with proc reg';
     model length10 weight = mcg198 mcg205 mcg213 mcg221 mcg223 mcg225 / noint;
     AllBut198: mtest mcg205=mcg213, mcg213=mcg221,
                      mcg221=mcg223, mcg223=mcg225;
```

```
     if mcg = . then mcg198 = .;
        else if mcg = 198 then mcg198=1;
        else mcg198=0;
```

2101f11tubes2.lst

Check MCG dummy variables

The FREQ Procedure

Table of mcg by mcg198

mcg(Fungus Type)	mcg198			
Frequency	.	0	1	Total
.	1	0	0	1
198	0	0	4	4
205	0	4	0	4
213	0	3	0	3
221	0	4	0	4
223	0	4	0	4
225	0	4	0	4
Total	1	19	4	24

Table of mcg by mcg205

mcg(Fungus Type)	mcg205			
Frequency	.	0	1	Total
.	1	0	0	1
198	0	4	0	4
205	0	0	4	4
213	0	3	0	3
221	0	4	0	4
223	0	4	0	4
225	0	4	0	4
Total	1	19	4	24

Check MCG dummy variables

The FREQ Procedure

Table of mcg by mcg213

mcg(Fungus Type)	mcg213			
Frequency	.	0	1	Total
.	1	0	0	1
198	0	4	0	4
205	0	4	0	4
213	0	0	3	3
221	0	4	0	4
223	0	4	0	4
225	0	4	0	4
Total	1	20	3	24

Table of mcg by mcg221

mcg(Fungus Type)	mcg221			
Frequency	.	0	1	Total
.	1	0	0	1
198	0	4	0	4
205	0	4	0	4
213	0	3	0	3
221	0	0	4	4
223	0	4	0	4
225	0	4	0	4
Total	1	19	4	24

The FREQ Procedure

Table of mcg by mcg223

mcg(Fungus Type) mcg223

Frequency	.	0	1	Total
.	1	0	0	1
198	0	4	0	4
205	0	4	0	4
213	0	3	0	3
221	0	4	0	4
223	0	0	4	4
225	0	4	0	4
Total	1	19	4	24

Table of mcg by mcg225

mcg(Fungus Type) mcg225

Frequency	.	0	1	Total
.	1	0	0	1
198	0	4	0	4
205	0	4	0	4
213	0	3	0	3
221	0	4	0	4
223	0	4	0	4
225	0	0	4	4
Total	1	19	4	24

```
proc glm;
     title2 'One-Factor ANOVA: Just the defaults';
     class mcg;
     model length10 = mcg;
```

One-factor analysis of Little Fungus Tube data 4
One-Factor ANOVA: Just the defaults

The GLM Procedure

Class Level Information

Class	Levels	Values
mcg	6	198 205 213 221 223 225

Number of Observations Read 24
Number of Observations Used 23

One-factor analysis of Little Fungus Tube data 5
One-Factor ANOVA: Just the defaults

The GLM Procedure

Dependent Variable: length10 Mean Length on Day 10

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	52.94360507	10.58872101	78.34	<.0001
Error	17	2.29791667	0.13517157		
Corrected Total	22	55.24152174			

R-Square	Coeff Var	Root MSE	length10 Mean
0.958402	1.479116	0.367657	24.85652

Source	DF	Type I SS	Mean Square	F Value	Pr > F
mcg	5	52.94360507	10.58872101	78.34	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
mcg	5	52.94360507	10.58872101	78.34	<.0001

```
proc glm;
     title2 'With contrasts and multiple comparisons';
     class mcg;
     model length10 = mcg / clparm; /* clparm will give CI for contrasts
                                       down in the estimate statement. */
     means mcg;
     /* Multiple Comparisons */
     means mcg / Tukey Bon Scheffe; /* Simultaneous Confidence Intervals */
     /* Tables of adjusted p-values -- more convenient */
     lsmeans mcg / pdiff adjust=bon;
     lsmeans mcg / pdiff adjust=tukey;
     lsmeans mcg / pdiff adjust=scheffe;
```

One-factor analysis of Little Fungus Tube data 6
With contrasts and multiple comparisons

The GLM Procedure

Class Level Information

Class	Levels	Values
mcg	6	198 205 213 221 223 225

Number of Observations Read 24
Number of Observations Used 23

One-factor analysis of Little Fungus Tube data 7
With contrasts and multiple comparisons

The GLM Procedure

Dependent Variable: length10 Mean Length on Day 10

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	52.94360507	10.58872101	78.34	<.0001
Error	17	2.29791667	0.13517157		
Corrected Total	22	55.24152174			

R-Square	Coeff Var	Root MSE	length10 Mean
0.958402	1.479116	0.367657	24.85652

Source	DF	Type I SS	Mean Square	F Value	Pr > F
mcg	5	52.94360507	10.58872101	78.34	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
mcg	5	52.94360507	10.58872101	78.34	<.0001

The GLM Procedure

Level of mcg	N	length10 Mean	length10 Std Dev
198	4	27.7750000	0.30956959
205	4	25.3375000	0.30923292
213	3	24.4666667	0.20207259
221	4	22.9500000	0.45643546
223	4	24.3500000	0.18708287
225	4	24.1625000	0.55132416

The GLM Procedure

Tukey's Studentized Range (HSD) Test for length10

NOTE: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	17
Error Mean Square	0.135172
Critical Value of Studentized Range	4.52365

Comparisons significant at the 0.05 level are indicated by ***.

mcg Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
198 - 205	2.4375	1.6059	3.2691	***
198 - 213	3.3083	2.4101	4.2065	***
198 - 223	3.4250	2.5934	4.2566	***
198 - 225	3.6125	2.7809	4.4441	***
198 - 221	4.8250	3.9934	5.6566	***
205 - 198	-2.4375	-3.2691	-1.6059	***
205 - 213	0.8708	-0.0274	1.7690	
205 - 223	0.9875	0.1559	1.8191	***
205 - 225	1.1750	0.3434	2.0066	***
205 - 221	2.3875	1.5559	3.2191	***
213 - 198	-3.3083	-4.2065	-2.4101	***
213 - 205	-0.8708	-1.7690	0.0274	
213 - 223	0.1167	-0.7815	1.0149	
213 - 225	0.3042	-0.5940	1.2024	
213 - 221	1.5167	0.6185	2.4149	***
223 - 198	-3.4250	-4.2566	-2.5934	***
223 - 205	-0.9875	-1.8191	-0.1559	***
223 - 213	-0.1167	-1.0149	0.7815	
223 - 225	0.1875	-0.6441	1.0191	
223 - 221	1.4000	0.5684	2.2316	***
225 - 198	-3.6125	-4.4441	-2.7809	***
225 - 205	-1.1750	-2.0066	-0.3434	***
225 - 213	-0.3042	-1.2024	0.5940	

225 - 223	-0.1875	-1.0191	0.6441	
225 - 221	1.2125	0.3809	2.0441	***
221 - 198	-4.8250	-5.6566	-3.9934	***
221 - 205	-2.3875	-3.2191	-1.5559	***
221 - 213	-1.5167	-2.4149	-0.6185	***
221 - 223	-1.4000	-2.2316	-0.5684	***
221 - 225	-1.2125	-2.0441	-0.3809	***

The GLM Procedure

Bonferroni (Dunn) t Tests for length10

NOTE: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than Tukey's for all pairwise comparisons.

Alpha	0.05
Error Degrees of Freedom	17
Error Mean Square	0.135172
Critical Value of t	3.41020

Comparisons significant at the 0.05 level are indicated by ***.

mcg Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
198 - 205	2.4375	1.5509	3.3241	***
198 - 213	3.3083	2.3507	4.2659	***
198 - 223	3.4250	2.5384	4.3116	***
198 - 225	3.6125	2.7259	4.4991	***
198 - 221	4.8250	3.9384	5.7116	***
205 - 198	-2.4375	-3.3241	-1.5509	***
205 - 213	0.8708	-0.0868	1.8284	
205 - 223	0.9875	0.1009	1.8741	***
205 - 225	1.1750	0.2884	2.0616	***
205 - 221	2.3875	1.5009	3.2741	***
213 - 198	-3.3083	-4.2659	-2.3507	***
213 - 205	-0.8708	-1.8284	0.0868	
213 - 223	0.1167	-0.8409	1.0743	
213 - 225	0.3042	-0.6534	1.2618	
213 - 221	1.5167	0.5591	2.4743	***
223 - 198	-3.4250	-4.3116	-2.5384	***
223 - 205	-0.9875	-1.8741	-0.1009	***
223 - 213	-0.1167	-1.0743	0.8409	
223 - 225	0.1875	-0.6991	1.0741	
223 - 221	1.4000	0.5134	2.2866	***
225 - 198	-3.6125	-4.4991	-2.7259	***
225 - 205	-1.1750	-2.0616	-0.2884	***
225 - 213	-0.3042	-1.2618	0.6534	
225 - 223	-0.1875	-1.0741	0.6991	
225 - 221	1.2125	0.3259	2.0991	***
221 - 198	-4.8250	-5.7116	-3.9384	***
221 - 205	-2.3875	-3.2741	-1.5009	***
221 - 213	-1.5167	-2.4743	-0.5591	***
221 - 223	-1.4000	-2.2866	-0.5134	***
221 - 225	-1.2125	-2.0991	-0.3259	***

The GLM Procedure

Scheffe's Test for length10

NOTE: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than Tukey's for all pairwise comparisons.

Alpha	0.05
Error Degrees of Freedom	17
Error Mean Square	0.135172
Critical Value of F	2.81000

Comparisons significant at the 0.05 level are indicated by ***.

mcg Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
198 - 205	2.4375	1.4630	3.4120	***
198 - 213	3.3083	2.2558	4.3609	***
198 - 223	3.4250	2.4505	4.3995	***
198 - 225	3.6125	2.6380	4.5870	***
198 - 221	4.8250	3.8505	5.7995	***
205 - 198	-2.4375	-3.4120	-1.4630	***
205 - 213	0.8708	-0.1817	1.9234	
205 - 223	0.9875	0.0130	1.9620	***
205 - 225	1.1750	0.2005	2.1495	***
205 - 221	2.3875	1.4130	3.3620	***
213 - 198	-3.3083	-4.3609	-2.2558	***
213 - 205	-0.8708	-1.9234	0.1817	
213 - 223	0.1167	-0.9359	1.1692	
213 - 225	0.3042	-0.7484	1.3567	
213 - 221	1.5167	0.4641	2.5692	***
223 - 198	-3.4250	-4.3995	-2.4505	***
223 - 205	-0.9875	-1.9620	-0.0130	***
223 - 213	-0.1167	-1.1692	0.9359	
223 - 225	0.1875	-0.7870	1.1620	
223 - 221	1.4000	0.4255	2.3745	***
225 - 198	-3.6125	-4.5870	-2.6380	***
225 - 205	-1.1750	-2.1495	-0.2005	***
225 - 213	-0.3042	-1.3567	0.7484	
225 - 223	-0.1875	-1.1620	0.7870	
225 - 221	1.2125	0.2380	2.1870	***
221 - 198	-4.8250	-5.7995	-3.8505	***
221 - 205	-2.3875	-3.3620	-1.4130	***
221 - 213	-1.5167	-2.5692	-0.4641	***
221 - 223	-1.4000	-2.3745	-0.4255	***
221 - 225	-1.2125	-2.1870	-0.2380	***

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Bonferroni

mcg	length10 LSMEAN	LSMEAN Number
198	27.7750000	1
205	25.3375000	2
213	24.4666667	3
221	22.9500000	4
223	24.3500000	5
225	24.1625000	6

Least Squares Means for effect mcg
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: length10

i/j	1	2	3	4	5	6
1		<.0001	<.0001	<.0001	<.0001	<.0001
2	<.0001		0.0973	<.0001	0.0215	0.0045
3	<.0001	0.0973		0.0007	1.0000	1.0000
4	<.0001	<.0001	0.0007		0.0007	0.0033
5	<.0001	0.0215	1.0000	0.0007		1.0000
6	<.0001	0.0045	1.0000	0.0033	1.0000	

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

mcg	length10 LSMEAN	LSMEAN Number
198	27.7750000	1
205	25.3375000	2
213	24.4666667	3
221	22.9500000	4
223	24.3500000	5
225	24.1625000	6

Least Squares Means for effect mcg
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: length10

i/j	1	2	3	4	5	6
1		<.0001	<.0001	<.0001	<.0001	<.0001
2	<.0001		0.0603	<.0001	0.0151	0.0034
3	<.0001	0.0603		0.0006	0.9981	0.8814
4	<.0001	<.0001	0.0006		0.0006	0.0026
5	<.0001	0.0151	0.9981	0.0006		0.9766
6	<.0001	0.0034	0.8814	0.0026	0.9766	

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Scheffe

mcg	length10 LSMEAN	LSMEAN Number
198	27.7750000	1
205	25.3375000	2
213	24.4666667	3
221	22.9500000	4
223	24.3500000	5
225	24.1625000	6

Least Squares Means for effect mcg
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: length10

i/j	1	2	3	4	5	6
1		<.0001	<.0001	<.0001	<.0001	<.0001
2	<.0001		0.1431	<.0001	0.0459	0.0128
3	<.0001	0.1431		0.0026	0.9993	0.9419
4	<.0001	<.0001	0.0026		0.0027	0.0099
5	<.0001	0.0459	0.9993	0.0027		0.9899
6	<.0001	0.0128	0.9419	0.0099	0.9899	

```
    /* Test custom contrasts, or "planned comparisons" */
    /* For convenience, MCGs are:  198 205 213 221 223 225  */

    contrast '198vs205'       mcg   1   -1     0   0   0   0;
    contrast "223vs225"       mcg   0    0     0   0   1  -1;
    contrast '223n225vsRest'  mcg  -1   -1    -1  -1   2   2;
    /* Test equality of mcgs excluding 198: a COLLECTION of contrasts */
    contrast 'AllBut198'      mcg   0   1  -1   0   0   0,
                              mcg   0   0   1  -1   0   0,
                              mcg   0   0   0   1  -1   0,
                              mcg   0   0   0   0   1  -1;
    /* Replicate overall F test just to check. */
    contrast 'OverallF=76.70' mcg   1  -1   0   0   0   0,
                              mcg   0   1  -1   0   0   0,
                              mcg   0   0   1  -1   0   0,
                              mcg   0   0   0   1  -1   0,
                              mcg   0   0   0   0   1  -1;
    /* Estimate will print the value of a sample contrast and do a t-test
       of H0: Contrast = 0 (F = t-squared) */
    estimate '223n225vsRest'  mcg -.25 -.25 -.25 -.25 .5 .5;
    estimate 'AnotherWay'     mcg  -3   -3    -3  -3   6  6 / divisor=12;
```

The GLM Procedure

Dependent Variable: length10 Mean Length on Day 10

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
198vs205	1	11.88281250	11.88281250	87.91	<.0001
223vs225	1	0.07031250	0.07031250	0.52	0.4806
223n225vsRest	1	3.98243806	3.98243806	29.46	<.0001
AllBut198	4	11.70089912	2.92522478	21.64	<.0001
OverallF=76.70	5	52.94360507	10.58872101	78.34	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
223n225vsRest	-0.87604167	0.16139606	-5.43	<.0001
AnotherWay	-0.87604167	0.16139606	-5.43	<.0001

Parameter	95% Confidence Limits	
223n225vsRest	-1.21655759	-0.53552575
AnotherWay	-1.21655759	-0.53552575

```
/* Get Scheffe critical value from proc iml */

proc iml;
     title2 'Scheffe critical value for all possible contrasts';
     numdf = 5;   /* Numerator degrees of freedom for initial test */
     dendf = 17;  /* Denominator degrees of freedom for initial test */
     alpha = 0.05;
     critval = finv(1-alpha,numdf,dendf);
     scrit = critval * numdf;

     print "Initial test has"  numdf " and " dendf "degrees of freedom."
           "--------------------------------------------------------"
           "Using significance level alpha = " alpha
           "-----------------------------------------------"
           "Critical value for the initial test is " critval
           "-----------------------------------------------"
           "Critical value for Scheffe tests is " scrit
           "-----------------------------------------------";
```

```
                One-factor analysis of Little Fungus Tube data              16
               Scheffe critical value for all possible contrasts

                              numdf           dendf

          Initial test has         5  and         17 degrees of freedom.
            ------------------------------------------------------------
                                                    alpha

                  Using significance level alpha =       0.05
               ------------------------------------------------
                                                     critval

               Critical value for the initial test is  2.8099962
               ------------------------------------------------
                                                     scrit

                Critical value for Scheffe tests is  14.049981
               ------------------------------------------------
```

```
/****************** Regression with cell means coding **************/

proc reg;
     title2 'With Intercept: MCG198 is reference';
     model length10 = mcg205 mcg213 mcg221 mcg223 mcg225;
     /* Reproduce test of 198 vs 205 and overall test. */
     MCG198vs205: test mcg205=0;
     Overall: test mcg205=mcg213=mcg221=mcg223=mcg225 = 0;
     Overall2: test mcg205=0, mcg213=0, mcg221=0,
                              mcg223=0, mcg225=0;
```

The REG Procedure
Model: MODEL1
Dependent Variable: length10 Mean Length on Day 10

Number of Observations Read	24
Number of Observations Used	23
Number of Observations with Missing Values	1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	52.94361	10.58872	78.34	<.0001
Error	17	2.29792	0.13517		
Corrected Total	22	55.24152			

Root MSE	0.36766	R-Square	0.9584
Dependent Mean	24.85652	Adj R-Sq	0.9462
Coeff Var	1.47912		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value
Intercept	Intercept	1	27.77500	0.18383	151.09
mcg205		1	-2.43750	0.25997	-9.38
mcg213		1	-3.30833	0.28080	-11.78
mcg221		1	-4.82500	0.25997	-18.56
mcg223		1	-3.42500	0.25997	-13.17
mcg225		1	-3.61250	0.25997	-13.90

Parameter Estimates

Variable	Label	DF	Pr > |t|
Intercept	Intercept	1	<.0001
mcg205		1	<.0001
mcg213		1	<.0001
mcg221		1	<.0001
mcg223		1	<.0001
mcg225		1	<.0001

One-factor analysis of Little Fungus Tube data 18
With Intercept: MCG198 is reference

The REG Procedure
Model: MODEL1

Test MCG198vs205 Results for Dependent Variable length10

Source	DF	Mean Square	F Value	Pr > F
Numerator	1	11.88281	87.91	<.0001
Denominator	17	0.13517		

Compare earlier

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
198vs205	1	11.88281250	11.88281250	87.91	<.0001

One-factor analysis of Little Fungus Tube data 19
With Intercept: MCG198 is reference

The REG Procedure
Model: MODEL1

Test Overall Results for Dependent Variable length10

Source	DF	Mean Square	F Value	Pr > F
Numerator	5	10.58872	78.34	<.0001
Denominator	17	0.13517		

Compare earlier

Source	DF	Type III SS	Mean Square	F Value	Pr > F
mcg	5	52.94360507	10.58872101	78.34	<.0001

One-factor analysis of Little Fungus Tube data 20
With Intercept: MCG198 is reference

The REG Procedure
Model: MODEL1

Test Overall2 Results for Dependent Variable length10

Source	DF	Mean Square	F Value	Pr > F
Numerator	5	10.58872	78.34	<.0001
Denominator	17	0.13517		

```
proc reg;
     title2 'No Intercept: Use Test statement for contrasts';
     model length10 = mcg198 mcg205 mcg213 mcg221 mcg223 mcg225 / noint;
     /* SSTO is now sum of Y^2, and R^2 is weird. */
     Overall3: test mcg198=mcg205=mcg213=mcg221=mcg223=mcg225;
     AllBut198: test mcg205=mcg213=mcg221=mcg223=mcg225;
     Ave223n225vsRest: test mcg198+mcg205+mcg213+mcg221 = 2*mcg223 + 2*mcg225;
```

The REG Procedure
Model: MODEL1
Dependent Variable: length10 Mean Length on Day 10

Number of Observations Read	24
Number of Observations Used	23
Number of Observations with Missing Values	1

NOTE: No intercept in model. R-Square is redefined.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	14263	2377.23618	17586.8	<.0001
Error	17	2.29792	0.13517		
Uncorrected Total	23	14266			

Root MSE	0.36766	R-Square	0.9998
Dependent Mean	24.85652	Adj R-Sq	0.9998
Coeff Var	1.47912		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value
mcg198		1	27.77500	0.18383	151.09
mcg205		1	25.33750	0.18383	137.83
mcg213		1	24.46667	0.21227	115.26
mcg221		1	22.95000	0.18383	124.84
mcg223		1	24.35000	0.18383	132.46
mcg225		1	24.16250	0.18383	131.44

Parameter Estimates

Variable	Label	DF	Pr > |t|
mcg198		1	<.0001
mcg205		1	<.0001
mcg213		1	<.0001
mcg221		1	<.0001
mcg223		1	<.0001
mcg225		1	<.0001

One-factor analysis of Little Fungus Tube data 22
No Intercept: Use Test statement for contrasts

The REG Procedure
Model: MODEL1

Test Overall3 Results for Dependent Variable length10

Source	DF	Mean Square	F Value	Pr > F
Numerator	5	10.58872	78.34	<.0001
Denominator	17	0.13517		

Compare earlier

Source	DF	Type III SS	Mean Square	F Value	Pr > F
mcg	5	52.94360507	10.58872101	78.34	<.0001

One-factor analysis of Little Fungus Tube data 23
No Intercept: Use Test statement for contrasts

The REG Procedure
Model: MODEL1

Test AllBut198 Results for Dependent Variable length10

Source	DF	Mean Square	F Value	Pr > F
Numerator	4	2.92522	21.64	<.0001
Denominator	17	0.13517		

Compare earlier

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
AllBut198	4	11.70089912	2.92522478	21.64	<.0001

One-factor analysis of Little Fungus Tube data 24
No Intercept: Use Test statement for contrasts

The REG Procedure
Model: MODEL1

Test Ave223n225vsRest Results for
Dependent Variable length10

Source	DF	Mean Square	F Value	Pr > F
Numerator	1	3.98244	29.46	<.0001
Denominator	17	0.13517		

Compare earlier

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
223n225vsRest	1	3.98243806	3.98243806	29.46	<.0001

```
/******************* Multivariate Tests *****************/

proc glm;
     title2 'Multivariate on length10 and weight with proc glm';
     class mcg;
     model length10 weight = mcg;
     /* Test equality of mcgs excluding 198: a COLLECTION of contrasts */
     contrast 'AllBut198'      mcg   0   1  -1   0   0   0,
                               mcg   0   0   1  -1   0   0,
                               mcg   0   0   0   1  -1   0,
                               mcg   0   0   0   0   1  -1;
     manova h = _all_;
```

The GLM Procedure

Class Level Information

Class	Levels	Values
mcg	6	198 205 213 221 223 225

Number of Observations Read	24
Number of Observations Used	23

The GLM Procedure

Dependent Variable: length10 Mean Length on Day 10

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	52.94360507	10.58872101	78.34	<.0001
Error	17	2.29791667	0.13517157		
Corrected Total	22	55.24152174			

R-Square	Coeff Var	Root MSE	length10 Mean
0.958402	1.479116	0.367657	24.85652

Source	DF	Type I SS	Mean Square	F Value	Pr > F
mcg	5	52.94360507	10.58872101	78.34	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
mcg	5	52.94360507	10.58872101	78.34	<.0001

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
AllBut198	4	11.70089912	2.92522478	21.64	<.0001

The GLM Procedure

Dependent Variable: weight Sclerotial Weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.05306225	0.01061245	7.54	0.0007
Error	17	0.02392889	0.00140758		
Corrected Total	22	0.07699114			

R-Square	Coeff Var	Root MSE	weight Mean
0.689199	5.970775	0.037518	0.628357

Source	DF	Type I SS	Mean Square	F Value	Pr > F
mcg	5	0.05306225	0.01061245	7.54	0.0007

Source	DF	Type III SS	Mean Square	F Value	Pr > F
mcg	5	0.05306225	0.01061245	7.54	0.0007

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
AllBut198	4	0.05075443	0.01268861	9.01	0.0004

The GLM Procedure
Multivariate Analysis of Variance

Characteristic Roots and Vectors of: E Inverse * H, where
H = Type III SSCP Matrix for mcg
E = Error SSCP Matrix

Characteristic Root	Percent	Characteristic Vector V'EV=1 length10	weight
23.1250855	91.33	0.66239677	0.41451296
2.1956407	8.67	0.02141695	6.48133679

MANOVA Test Criteria and F Approximations for
the Hypothesis of No Overall mcg Effect
H = Type III SSCP Matrix for mcg
E = Error SSCP Matrix

S=2 M=1 N=7

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.01297099	24.90	10	32	<.0001
Pillai's Trace	1.64562308	15.79	10	34	<.0001
Hotelling-Lawley Trace	25.32072622	39.10	10	21.419	<.0001
Roy's Greatest Root	23.12508552	78.63	5	17	<.0001

NOTE: F Statistic for Roy's Greatest Root is an upper bound.
NOTE: F Statistic for Wilks' Lambda is exact.

Characteristic Roots and Vectors of: E Inverse * H, where
H = Contrast SSCP Matrix for AllBut198
E = Error SSCP Matrix

Characteristic Root	Percent	Characteristic Vector length10	V'EV=1 weight
5.36723533	72.89	0.65035983	1.85591011
1.99625848	27.11	-0.12751573	6.22375652

Multivariate on length10 and weight with proc glm

The GLM Procedure
Multivariate Analysis of Variance

MANOVA Test Criteria and F Approximations for
the Hypothesis of No Overall AllBut198 Effect
H = Contrast SSCP Matrix for AllBut198
E = Error SSCP Matrix

S=2 M=0.5 N=7

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.05241672	13.47	8	32	<.0001
Pillai's Trace	1.50919639	13.07	8	34	<.0001
Hotelling-Lawley Trace	7.36349381	14.27	8	20.667	<.0001
Roy's Greatest Root	5.36723533	22.81	4	17	<.0001

NOTE: F Statistic for Roy's Greatest Root is an upper bound.
NOTE: F Statistic for Wilks' Lambda is exact.

```
proc reg;
     title2 'Multivariate on length10 and weight with proc reg';
     model length10 weight = mcg198 mcg205 mcg213 mcg221 mcg223 mcg225 / noint;
     AllBut198: mtest mcg205=mcg213, mcg213=mcg221,
                      mcg221=mcg223, mcg223=mcg225;
```

Multivariate on length10 and weight with proc reg

The REG Procedure
Model: MODEL1
Dependent Variable: length10 Mean Length on Day 10

Number of Observations Read	24
Number of Observations Used	23
Number of Observations with Missing Values	1

NOTE: No intercept in model. R-Square is redefined.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	14263	2377.23618	17586.8	<.0001
Error	17	2.29792	0.13517		
Uncorrected Total	23	14266			

Root MSE	0.36766	R-Square	0.9998
Dependent Mean	24.85652	Adj R-Sq	0.9998
Coeff Var	1.47912		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value
mcg198		1	27.77500	0.18383	151.09
mcg205		1	25.33750	0.18383	137.83
mcg213		1	24.46667	0.21227	115.26
mcg221		1	22.95000	0.18383	124.84
mcg223		1	24.35000	0.18383	132.46
mcg225		1	24.16250	0.18383	131.44

Parameter Estimates

Variable	Label	DF	Pr > |t|
mcg198		1	<.0001
mcg205		1	<.0001
mcg213		1	<.0001
mcg221		1	<.0001
mcg223		1	<.0001
mcg225		1	<.0001

The REG Procedure
Model: MODEL1
Dependent Variable: weight Sclerotial Weight

Number of Observations Read	24
Number of Observations Used	23
Number of Observations with Missing Values	1

NOTE: No intercept in model. R-Square is redefined.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	9.13420	1.52237	1081.55	<.0001
Error	17	0.02393	0.00141		
Uncorrected Total	23	9.15813			

Root MSE	0.03752	R-Square	0.9974
Dependent Mean	0.62836	Adj R-Sq	0.9965
Coeff Var	5.97077		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value
mcg198		1	0.60653	0.01876	32.33
mcg205		1	0.67815	0.01876	36.15
mcg213		1	0.69017	0.02166	31.86
mcg221		1	0.65363	0.01876	34.84
mcg223		1	0.54818	0.01876	29.22
mcg225		1	0.60895	0.01876	32.46

Parameter Estimates

Variable	Label	DF	Pr > |t|
mcg198		1	<.0001
mcg205		1	<.0001
mcg213		1	<.0001
mcg221		1	<.0001
mcg223		1	<.0001
mcg225		1	<.0001

The REG Procedure
Model: MODEL1
Multivariate Test: AllBut198

Multivariate Statistics and F Approximations

S=2 M=0.5 N=7

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.05241672	13.47	8	32	<.0001
Pillai's Trace	1.50919639	13.07	8	34	<.0001
Hotelling-Lawley Trace	7.36349381	14.27	8	20.667	<.0001
Roy's Greatest Root	5.36723533	22.81	4	17	<.0001

NOTE: F Statistic for Roy's Greatest Root is an upper bound.
NOTE: F Statistic for Wilks' Lambda is exact.

Compare earlier from proc glm

MANOVA Test Criteria and F Approximations for
the Hypothesis of No Overall AllBut198 Effect
H = Contrast SSCP Matrix for AllBut198
E = Error SSCP Matrix

S=2 M=0.5 N=7

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.05241672	13.47	8	32	<.0001
Pillai's Trace	1.50919639	13.07	8	34	<.0001
Hotelling-Lawley Trace	7.36349381	14.27	8	20.667	<.0001
Roy's Greatest Root	5.36723533	22.81	4	17	<.0001

NOTE: F Statistic for Roy's Greatest Root is an upper bound.
NOTE: F Statistic for Wilks' Lambda is exact.