

The tubes data: A completely randomized design

	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

```
/****** 305tubes1.sas *****/
options linesize=79 noovp formdlim='_' ;
title 'Little Fungus Tube data';

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

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

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

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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	4	length10	4	25.0625000	1.2030344
		weight	4	0.6682000	0.0501647
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

Recall how dummy variables were set up for the math data.

```

if course=. then c1=.; else if course=1 then c1=1; else c1=0;
if course=. then c2=.; else if course=2 then c2=1; else c2=0;
if course=. then c3=.; else if course=3 then c3=1; else c3=0;

/***** 305tubes2.sas *****/
options linesize=79 noovp formdlim='_' nodate;
title 'Little Fungus Tube data';

data mould;
  infile 'littletubes.data' firstobs=2; /* Skip the header */
  input tube mcg length10 weight;
  /* Make dummy variables */
  /* Indicators, for use with or without intercept */
  mcg198=(mcg=198)=1; mcg205=(mcg=205)=1; mcg213=(mcg=213)=1;
  mcg221=(mcg=221)=1; mcg223=(mcg=223)=1; mcg225=(mcg=225)=1;
  /* Fix up missing values (there are none here) */
  array dummy{6} mcg198 -- mcg225;
  if mcg=. then do i = 1 to 6;
    dummy{i} = . ;
  end;
  /* Effect coding */
  array fungus{5} fungus1-fungus5;
  do i = 1 to 5;
    if mcg=225 then fungus{i} = -1;
    else fungus{i}=dummy{i};
  end;

proc freq;
  title2 'Check dummy variable creation';
  tables mcg*(mcg198--fungus5) / norow nocol nopercnt missing;

```

```

proc means maxdec=3;
  title2 'Mean, N, SD of length10 broken down by Fungus Type';
  class mcg;
  var length10;

proc reg;
  title2 'With Intercept: MCG198 is reference';
  model length10 = mcg205 mcg213 mcg221 mcg223 mcg225;
  /* Creating new SAS data set mold2, with St. deleted residuals */
  output out=mold2 rstudent = delstudres
         predicted = yhat;

proc sort;
  by delstudres;
proc print;
  title2 'Look at Studentized deleted residuals';
  var tube mcg length10 yhat delstudres;

proc plot;
  plot length10*mcg /haxis = 198 205 213 221 223 225;

/* They said that tube 9 was contaminated. */

proc means maxdec=3;
  title2 'Mean, N, SD of length10 by Fungus Type';
  title3 'With tube 9 eliminated';
  where tube ne 9;
  class mcg;
  var length10;

proc reg;
  title2 'Regression with tube 9 eliminated';
  where tube ne 9;
  model length10 = mcg205 mcg213 mcg221 mcg223 mcg225 / clb;
  /* 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;
  output out=mold2 rstudent = delstudres
         predicted = yhat;

proc iml;
  title2 'Critical value of t for tests and CIs';
  title3 'df = 23 - 6 = 17';
  alpha = 0.05;
  critvalue = tinv(1-alpha/2,17);
  print "Critical value of t:" critvalue;

/*****
> # 95% CI for beta1, by "hand"
> cv = 2.1098156; b1 = -2.43750; se = 0.25997;
> low = b1 - cv*se; low
[1] -2.985989
> up = b1 + cv*se; up
[1] -1.889011
*****/

```

Little Fungus Tube data
Check dummy variable creation

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The FREQ Procedure

Table of mcg by mcg198

mcg	mcg198		Total
Frequency	0	1	
198	0	4	4
205	4	0	4
213	4	0	4
221	4	0	4
223	4	0	4
225	4	0	4
Total	20	4	24

Table of mcg by mcg205

mcg	mcg205		Total
Frequency	0	1	
198	4	0	4
205	0	4	4
213	4	0	4
221	4	0	4
223	4	0	4
225	4	0	4
Total	20	4	24

skipping ...

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

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The MEANS Procedure

Analysis Variable : length10

mcg	N	Obs	N	Mean	Std Dev	Minimum	Maximum
198	4	4	4	27.775	0.310	27.500	28.200
205	4	4	4	25.338	0.309	24.950	25.700
213	4	4	4	25.063	1.203	24.350	26.850
221	4	4	4	22.950	0.456	22.300	23.350
223	4	4	4	24.350	0.187	24.100	24.550
225	4	4	4	24.163	0.551	23.550	24.700

Little Fungus Tube data
 With Intercept: MCG198 is reference

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The REG Procedure

Model: MODEL1

Dependent Variable: length10

Number of Observations Read 24
 Number of Observations Used 24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	52.49177	10.49835	28.81	<.0001
Error	18	6.55813	0.36434		
Corrected Total	23	59.04990			

Root MSE 0.60361 R-Square 0.8889
 Dependent Mean 24.93958 Adj R-Sq 0.8581
 Coeff Var 2.42027

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > t
Intercept	1	27.77500	0.30180	92.03	<.0001
mcg205	1	-2.43750	0.42681	-5.71	<.0001
mcg213	1	-2.71250	0.42681	-6.36	<.0001
mcg221	1	-4.82500	0.42681	-11.30	<.0001
mcg223	1	-3.42500	0.42681	-8.02	<.0001
mcg225	1	-3.61250	0.42681	-8.46	<.0001

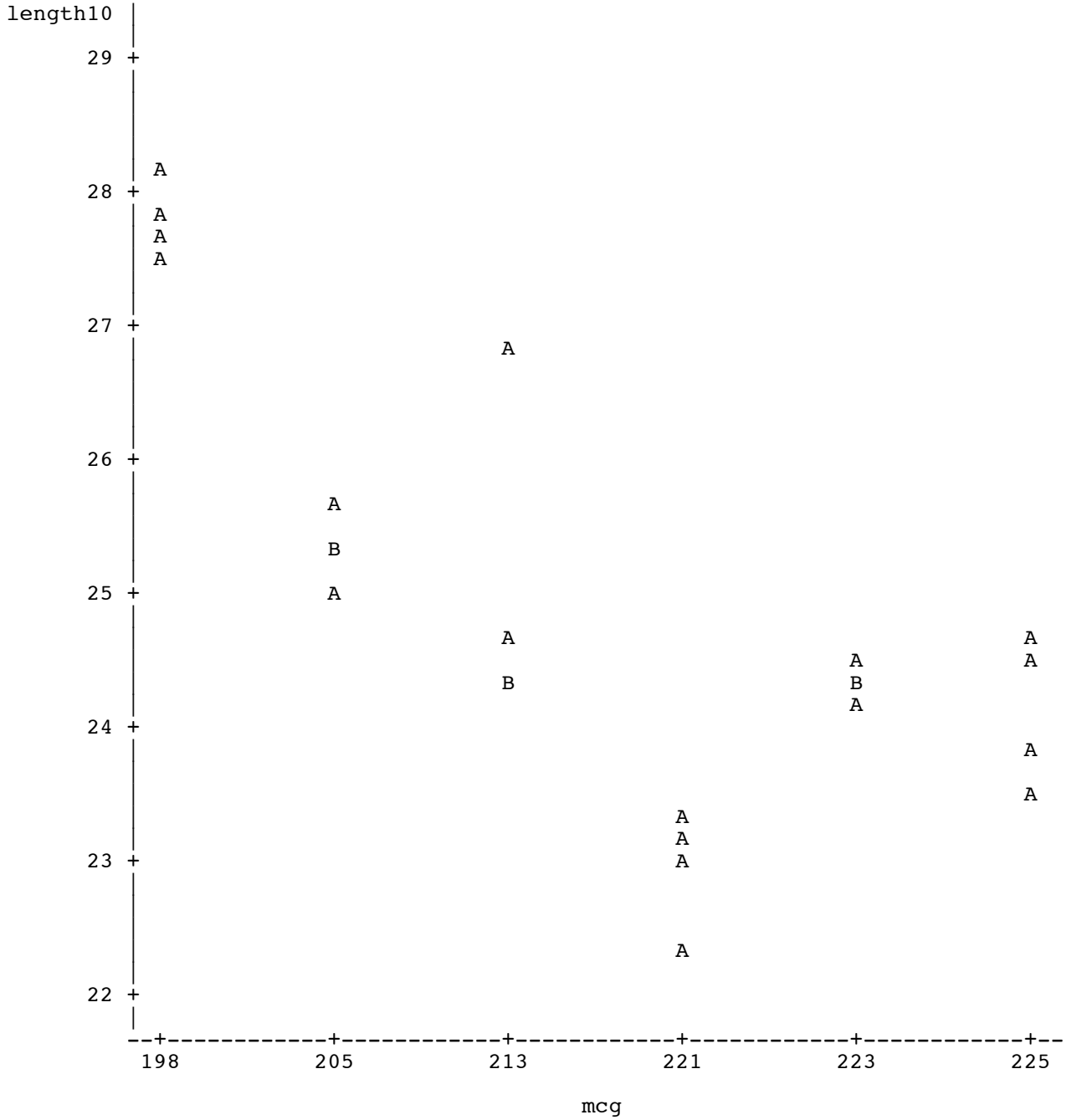
Little Fungus Tube data
Look at Studentized deleted residuals

9

Obs	tube	mcg	length10	yhat	delstudres
1	10	213	24.35	25.0625	-1.39876
2	12	213	24.35	25.0625	-1.39876
3	15	221	22.30	22.9500	-1.26392
4	21	225	23.55	24.1625	-1.18478
5	5	205	24.95	25.3375	-0.73166
6	11	213	24.70	25.0625	-0.68311
7	24	225	23.85	24.1625	-0.58683
8	4	198	27.50	27.7750	-0.51523
9	17	223	24.10	24.3500	-0.46776
10	3	198	27.60	27.7750	-0.32636
11	8	205	25.30	25.3375	-0.06973
12	19	223	24.35	24.3500	0.00000
13	1	198	27.80	27.7750	0.04648
14	14	221	23.00	22.9500	0.09298
15	20	223	24.40	24.3500	0.09298
16	7	205	25.40	25.3375	0.11624
17	16	221	23.15	22.9500	0.37334
18	18	223	24.55	24.3500	0.37334
19	6	205	25.70	25.3375	0.68311
20	22	225	24.55	24.1625	0.73166
21	13	221	23.35	22.9500	0.75604
22	2	198	28.20	27.7750	0.80504
23	23	225	24.70	24.1625	1.02998
24	9	213	26.85	25.0625	5.61400

Little Fungus Tube data
Look at Studentized deleted residuals

Plot of length10*mcg. Legend: A = 1 obs, B = 2 obs, etc.



Little Fungus Tube data
 Mean, N, SD of length10 by Fungus Type
 With tube 9 eliminated

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The MEANS Procedure

Analysis Variable : length10

mcg	N	Obs	Mean	Std Dev	Minimum	Maximum
198	4	4	27.775	0.310	27.500	28.200
205	4	4	25.338	0.309	24.950	25.700
213	3	3	24.467	0.202	24.350	24.700
221	4	4	22.950	0.456	22.300	23.350
223	4	4	24.350	0.187	24.100	24.550
225	4	4	24.163	0.551	23.550	24.700

Little Fungus Tube data
 Regression with tube 9 eliminated

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The REG Procedure
 Model: MODEL1
 Dependent Variable: length10

Number of Observations Read 23
 Number of Observations Used 23

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	DF	Parameter Estimate	Standard Error	t Value	Pr > t
Intercept	1	27.77500	0.18383	151.09	<.0001
mcg205	1	-2.43750	0.25997	-9.38	<.0001
mcg213	1	-3.30833	0.28080	-11.78	<.0001
mcg221	1	-4.82500	0.25997	-18.56	<.0001
mcg223	1	-3.42500	0.25997	-13.17	<.0001
mcg225	1	-3.61250	0.25997	-13.90	<.0001

Parameter Estimates

Variable	DF	95% Confidence Limits	
Intercept	1	27.38716	28.16284
mcg205	1	-2.98599	-1.88901
mcg213	1	-3.90077	-2.71589
mcg221	1	-5.37349	-4.27651
mcg223	1	-3.97349	-2.87651
mcg225	1	-4.16099	-3.06401

Little Fungus Tube data 13
 Regression with tube 9 eliminated

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		

Little Fungus Tube data 14
 Regression with tube 9 eliminated

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		

Little Fungus Tube data 15
 Regression with tube 9 eliminated

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		

Little Fungus Tube data 16
 Critical value of t for tests and CIs
 df = 23 - 6 = 17

critvalue

Critical value of t: 2.1098156

```

/***** 305tubes3.sas *****/
options linesize=79 noovp formdlim='_' ;
title 'Little Fungus Tube data, without tube 9';

data mould;
  infile 'littletubes.data' firstobs=2; /* Skip the header */
  input tube mcg length10 weight;
  /* Make dummy variables */
  /* Indicators, for use with or without intercept */
  mcg198=(mcg=198)=1; mcg205=(mcg=205)=1; mcg213=(mcg=213)=1;
  mcg221=(mcg=221)=1; mcg223=(mcg=223)=1; mcg225=(mcg=225)=1;
  /* Fix up missing values (there are none here) */
  array dummy{6} mcg198 -- mcg225;
  if mcg=. then do i = 1 to 6;
    dummy{i} = . ;
  end;
  /* Effect coding */
  array fungus{5} fungus1-fungus5;
  do i = 1 to 5;
    if mcg=225 then fungus{i} = -1;
    else fungus{i}=dummy{i};
  end;
  if tube ne 9; /* Otherwise, delete the case. */

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;

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 */
  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=78.34' 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 single 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
"-----";

```

305tubes3.lst

Little Fungus Tube data, without tube 9
No Intercept: Use Test statement for contrasts

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The REG Procedure
Dependent Variable: length10

Number of Observations Read 23
Number of Observations Used 23

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	DF	Parameter Estimate	Standard Error	t Value	Pr > t
mcg198	1	27.77500	0.18383	151.09	<.0001
mcg205	1	25.33750	0.18383	137.83	<.0001
mcg213	1	24.46667	0.21227	115.26	<.0001
mcg221	1	22.95000	0.18383	124.84	<.0001
mcg223	1	24.35000	0.18383	132.46	<.0001
mcg225	1	24.16250	0.18383	131.44	<.0001

Little Fungus Tube data, without tube 9 2
 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		

Little Fungus Tube data, without tube 9 3
 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		

Little Fungus Tube data, without tube 9 4
 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		

Little Fungus Tube data, without tube 9 5
 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 23
		Number of Observations Used 23

Little Fungus Tube data, without tube 9
One-Factor ANOVA: Just the defaults

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The GLM Procedure

Dependent Variable: length10

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

Little Fungus Tube data, without tube 9
 With contrasts and multiple comparisons

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The GLM Procedure

Class Level Information

Class	Levels	Values
mcg	6	198 205 213 221 223 225

Number of Observations Read 23
 Number of Observations Used 23

Little Fungus Tube data, without tube 9
 With contrasts and multiple comparisons

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The GLM Procedure

Dependent Variable: length10

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 0.958402
 Coeff Var 1.479116
 Root MSE 0.367657
 length10 Mean 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

Little Fungus Tube data, without tube 9
 With contrasts and multiple comparisons

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The GLM Procedure

Level of mcg	N	-----length10----- Mean	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

Little Fungus Tube data, without tube 9
 With contrasts and multiple comparisons

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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	

Little Fungus Tube data, without tube 9
 With contrasts and multiple comparisons

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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	

Little Fungus Tube data, without tube 9
 With contrasts and multiple comparisons

12

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	

Little Fungus Tube data, without tube 9
 With contrasts and multiple comparisons

13

The GLM Procedure

Dependent Variable: length10

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=78.34	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

