HOW TO USE

NUTRITIONAL RESPONSE MODELS

Verson 1.0

A workbook to fit data from nutritional experiments to several models

UNIVERSITY OF GEORGIA
EXTENSION

This PowerPoint presentation shows you how to use the ***NRM 1.0.xls*** Excel Workbook to fit several regression models to experimental data.

The models may be used to estimate nutritional requirements *or* the most economical feeding levels of critical nutrients.

NUTRITIONAL RESPONSE MODELS

Verson 1.0

A workbook to fit data from nutritional experiments to several models

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Athens, Georgia 30602

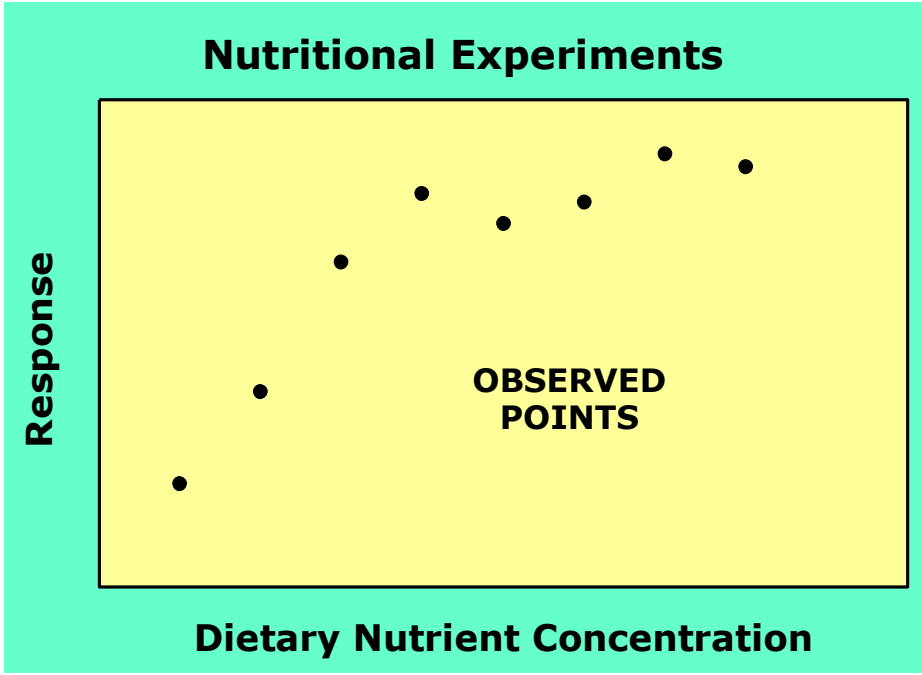
All you need is MicroSoft Excel, the NRM 1.0.xls file, and some input / output data.

First, a short explanation of the types of models that NRM 1.0.xls fits.

Experiments designed to estimate nutritional requirements result in a series of ordered pairs of data, the observed points.

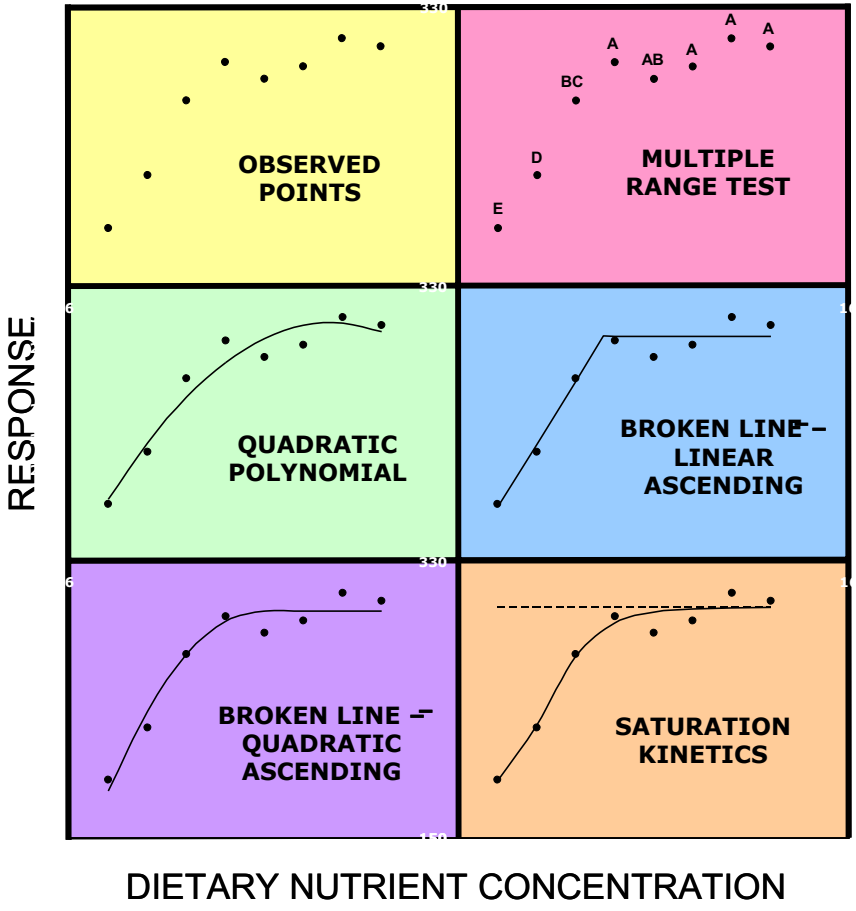
The points come from feeding several concentrations of the limiting nutrient, with all other nutrients present in adequate amounts.

The measured responses may include growth, feed efficiency, carcass lean accumulation, egg and milk production, etc.



Several different interpretations of nutritional response data are sometimes made:

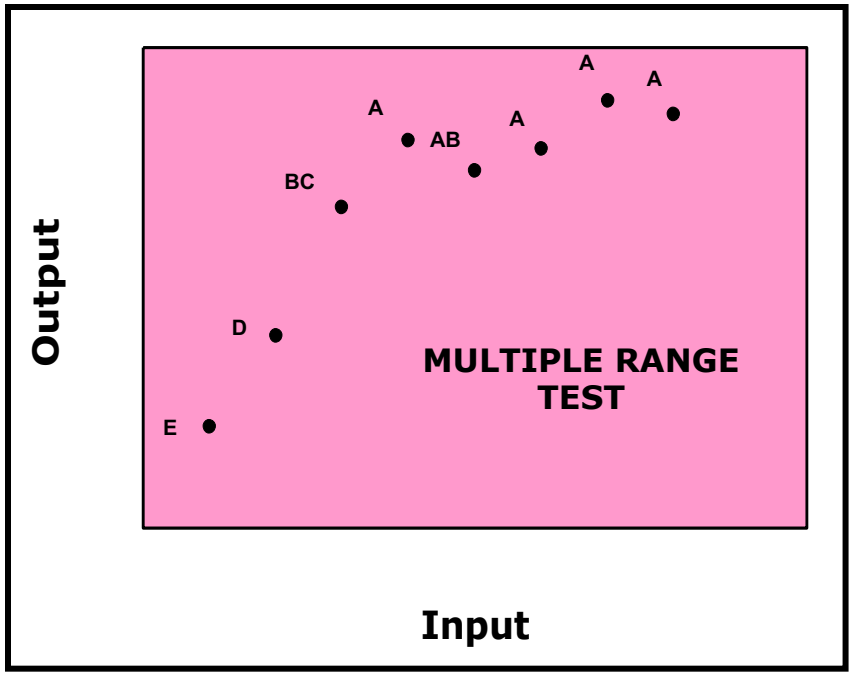
- Multiple Range Tests
- "Broken-Line" or Spline Models
- Non-Linear, Continuous Models
  - Quadratic Polynomials
  - Saturation Kinetics
  - Many Others



There are several multiple range tests that may be used to determine which responses are significantly different from the maximum response.

*More **conservative** multiple range tests will only indicate that large differences are 'significantly different', and therefore suggest that lower input levels result in maximum responses.*

The result is lower requirement estimates with more conservative multiple range tests. But higher requirement estimates are generally considered more conservative by nutritionists.



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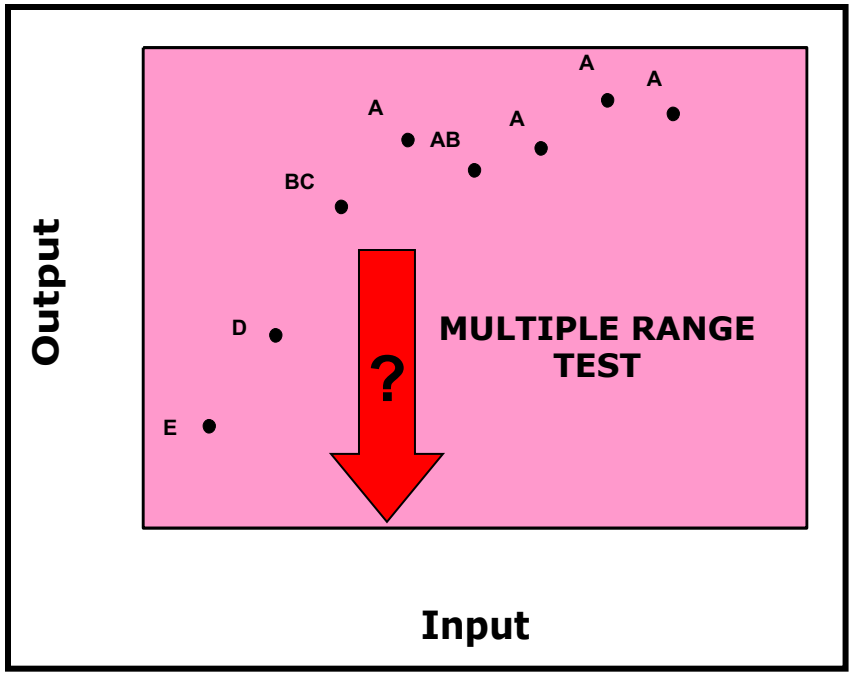
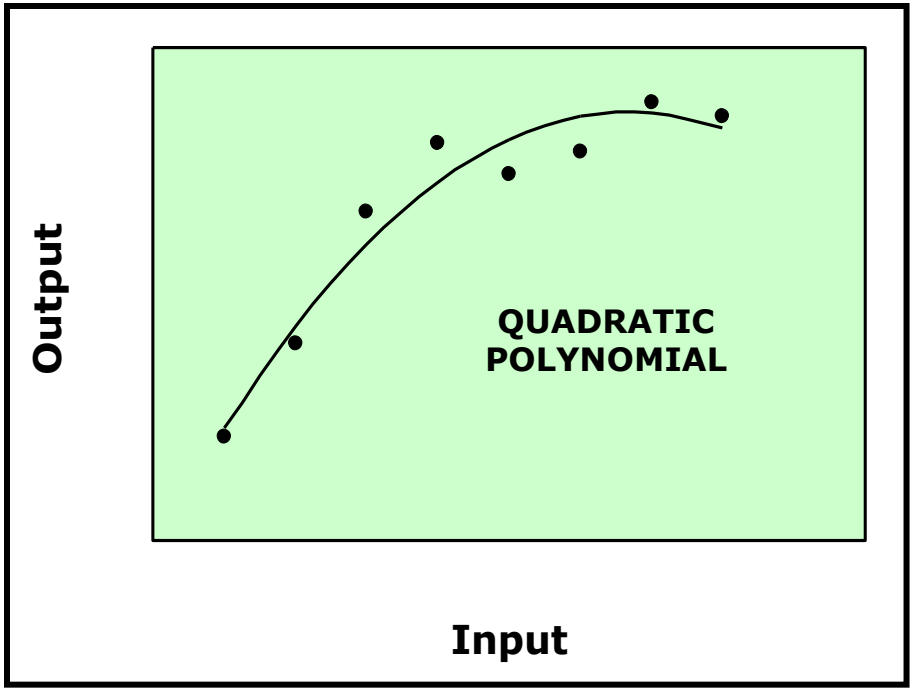


The "requirement" is between the input levels that give maximum and sub-maximum responses

Quadratic, or second order, polynomials are easy to fit to input-output data sets using ordinary least squares methods. They fit most data sets fairly well.

Quadratic polynomials have no ability to represent a plateau. A higher order polynomial should fit data with a plateau better.



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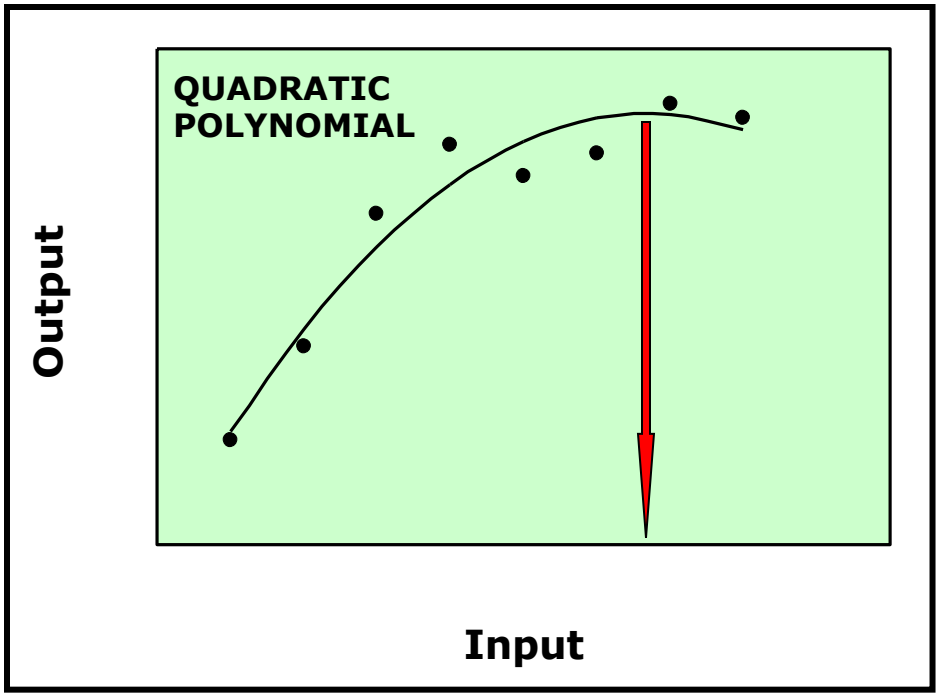


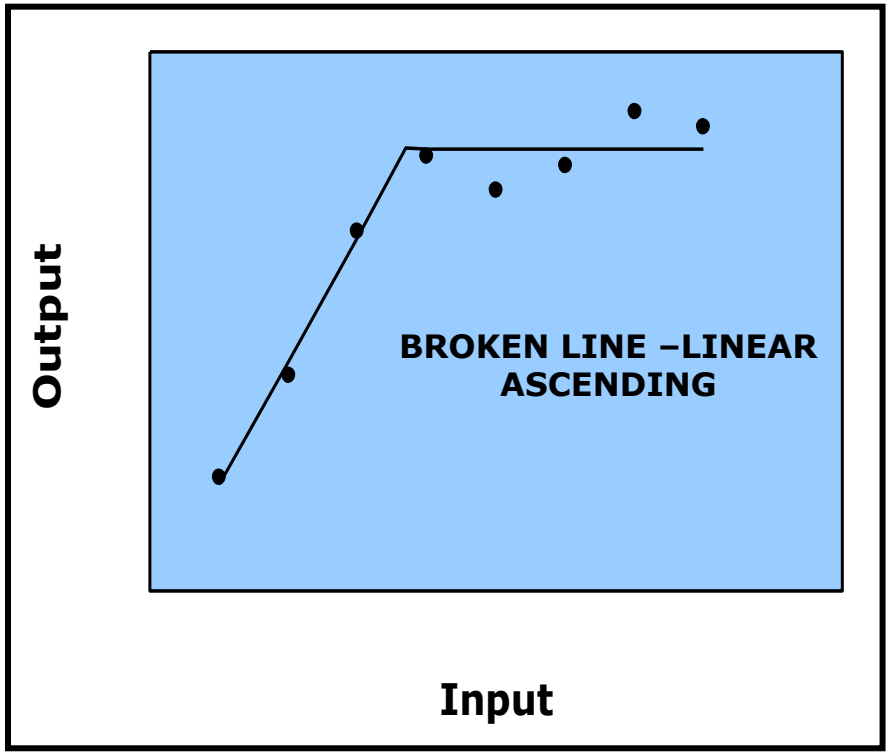
The "requirement" is the nutrient input level that gives the maximum output level, or response.

Broken-Line Models are commonly fitted to nutritional response data.

These models are also called “spline” models where one segment has a slope = 0.

Broken-Line Models have a feature for a plateau, but no feature for toxic levels should the nutrient input level become excessive.

The ascending segment is a first order, or straight line.



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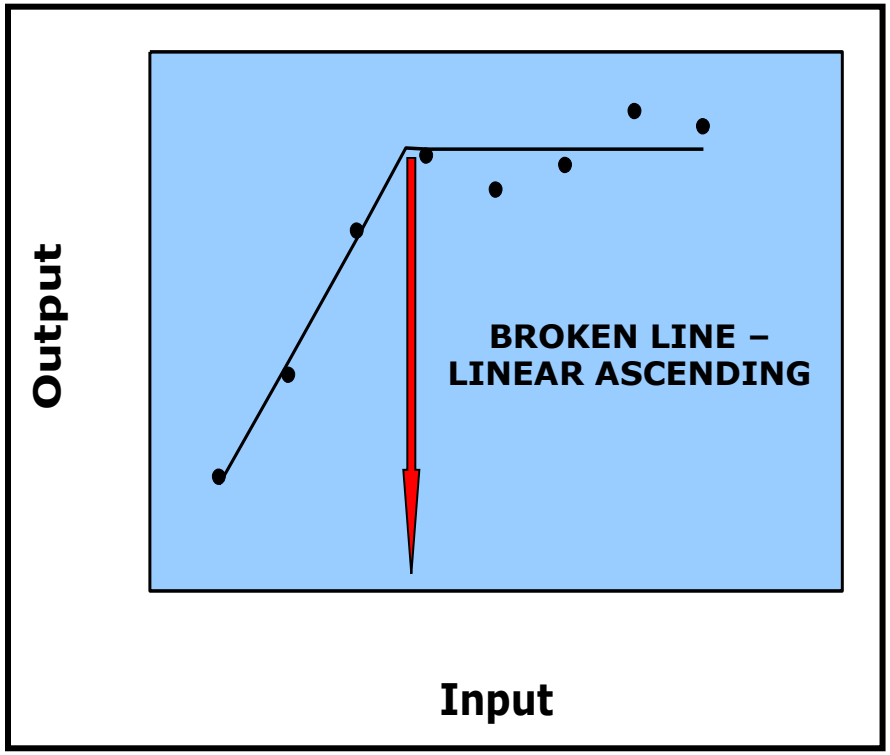
Broken-Line Models have a feature for a plateau, but not toxic levels should the nutrient input level become excessive.

The ascending segment is most often a first order, or straight line.

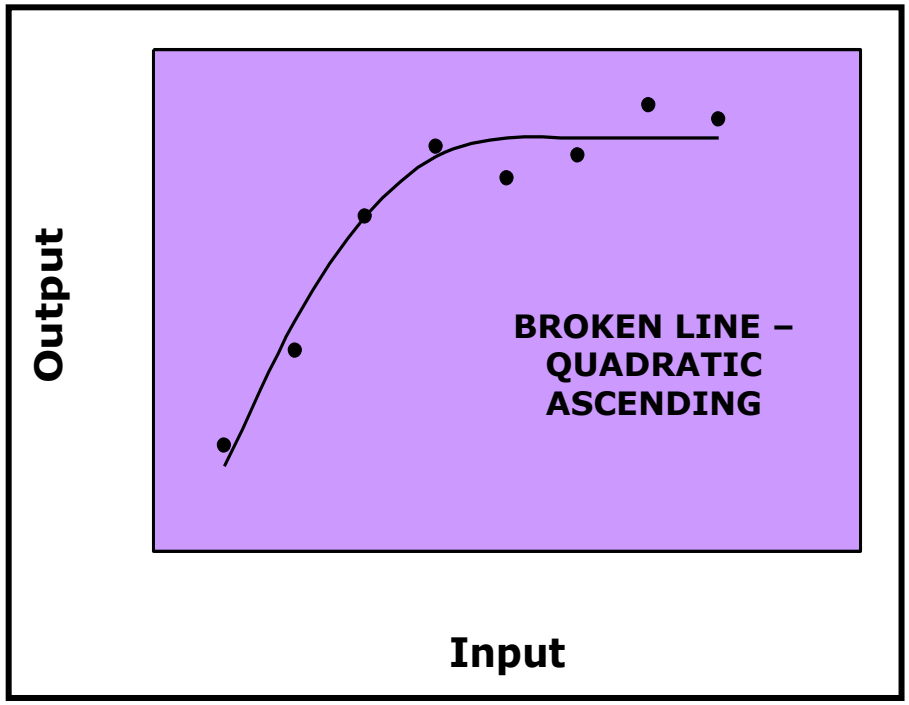


The “requirement” is the lowest nutrient input level that gives the maximum output level, or response.

Another form of spline model has a second order polynomial for the ascending segment.

It has the same features as the first order model except for the curved ascending segment.

The curved ascending segment more realistically represents biological responses.



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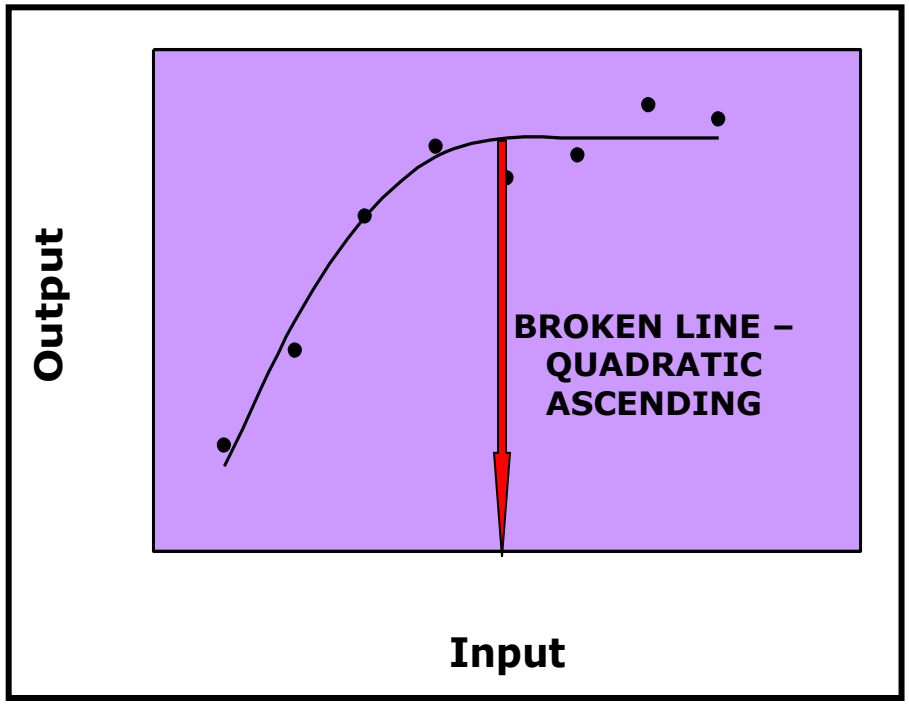


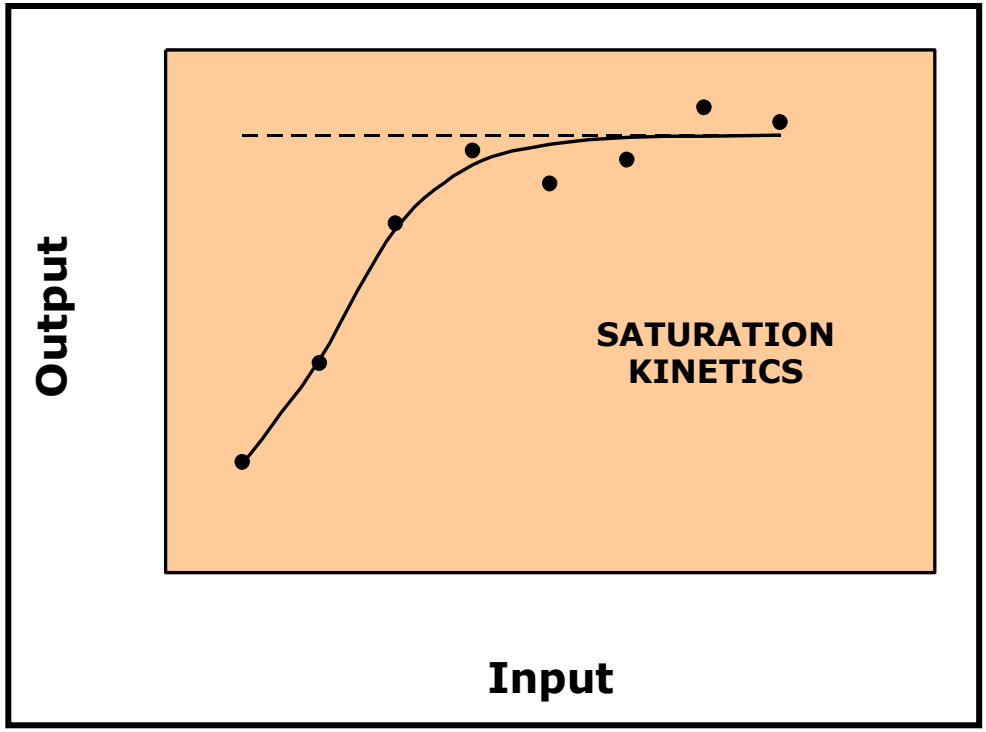
The “requirement” is the lowest nutrient input level that gives the maximum output level, or response.

There are a large number of possible non-linear response models that can be fitted to nutritional response data.

The NRM.xls Workbook fits several logistics, compartmental and exponential models.

The example shown here is the Saturation Kinetics Model.

This model asymptotically approaches the maximum, so the maximum is never reached.



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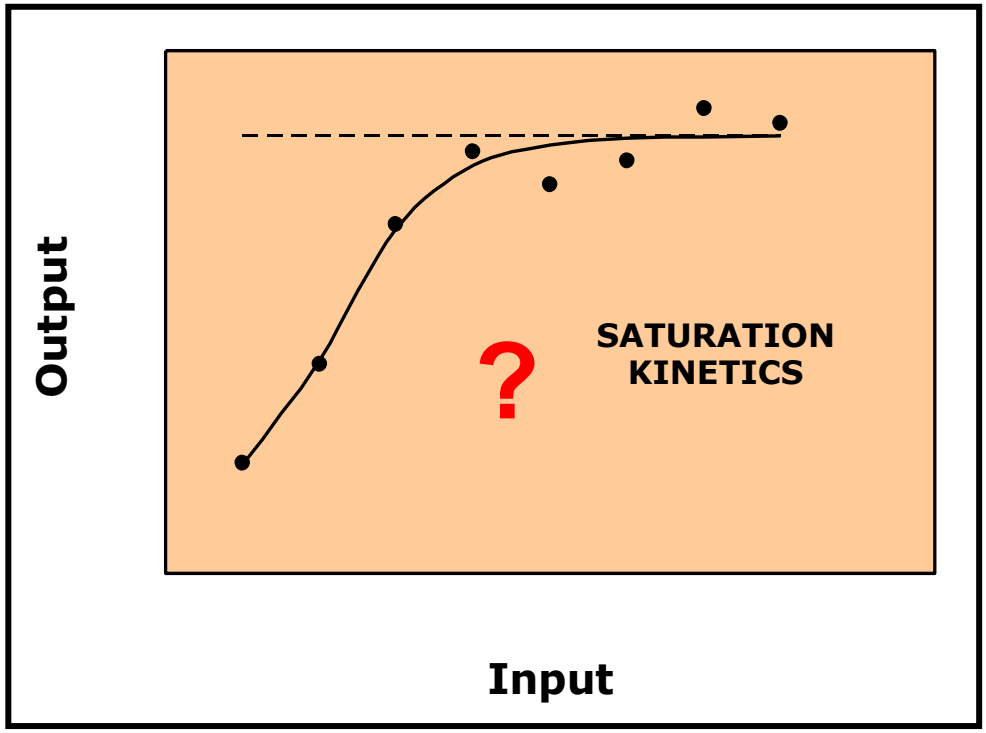
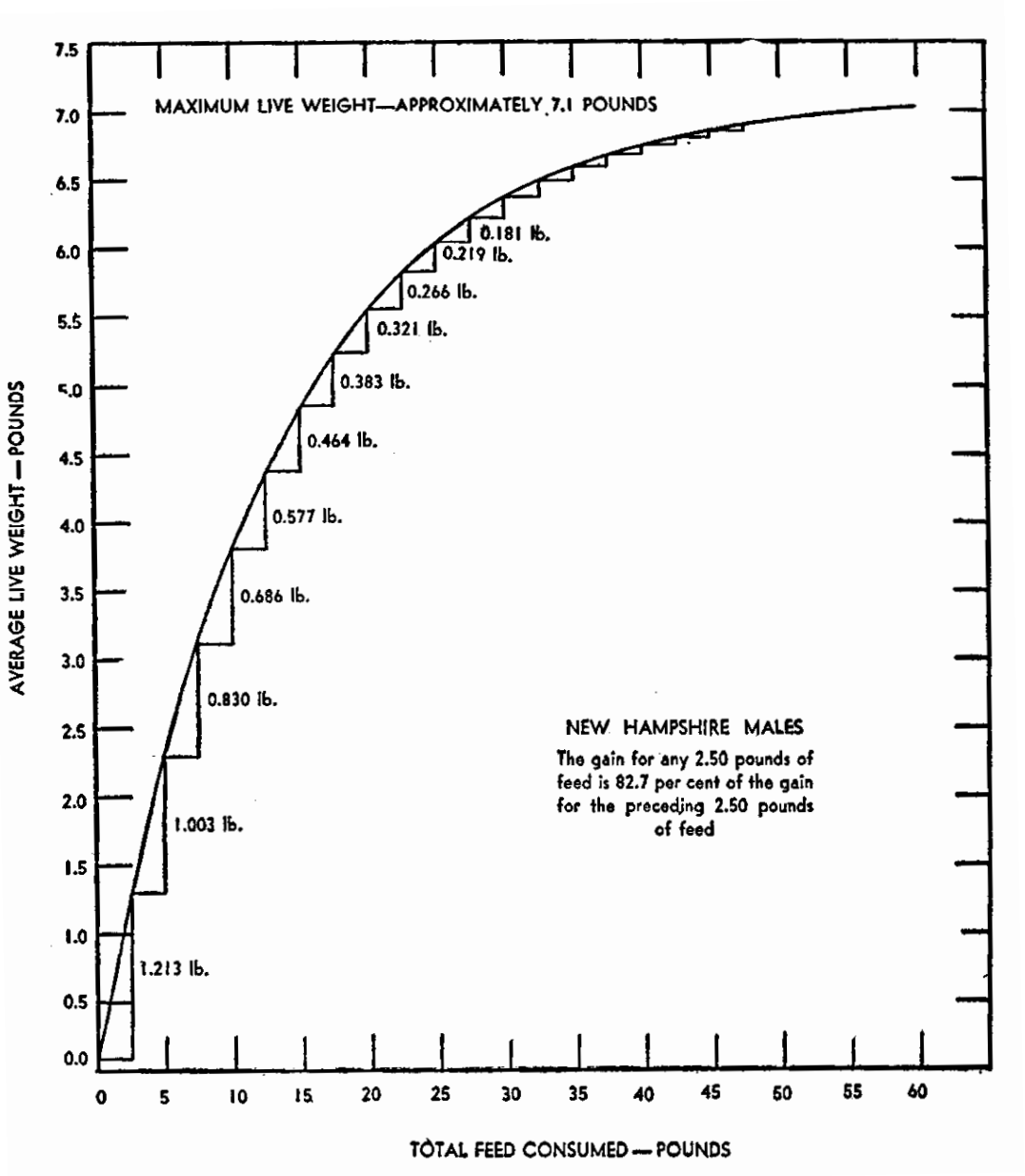


The "requirement" for maximum output is not defined with models that approach, but never attain, a maximum.

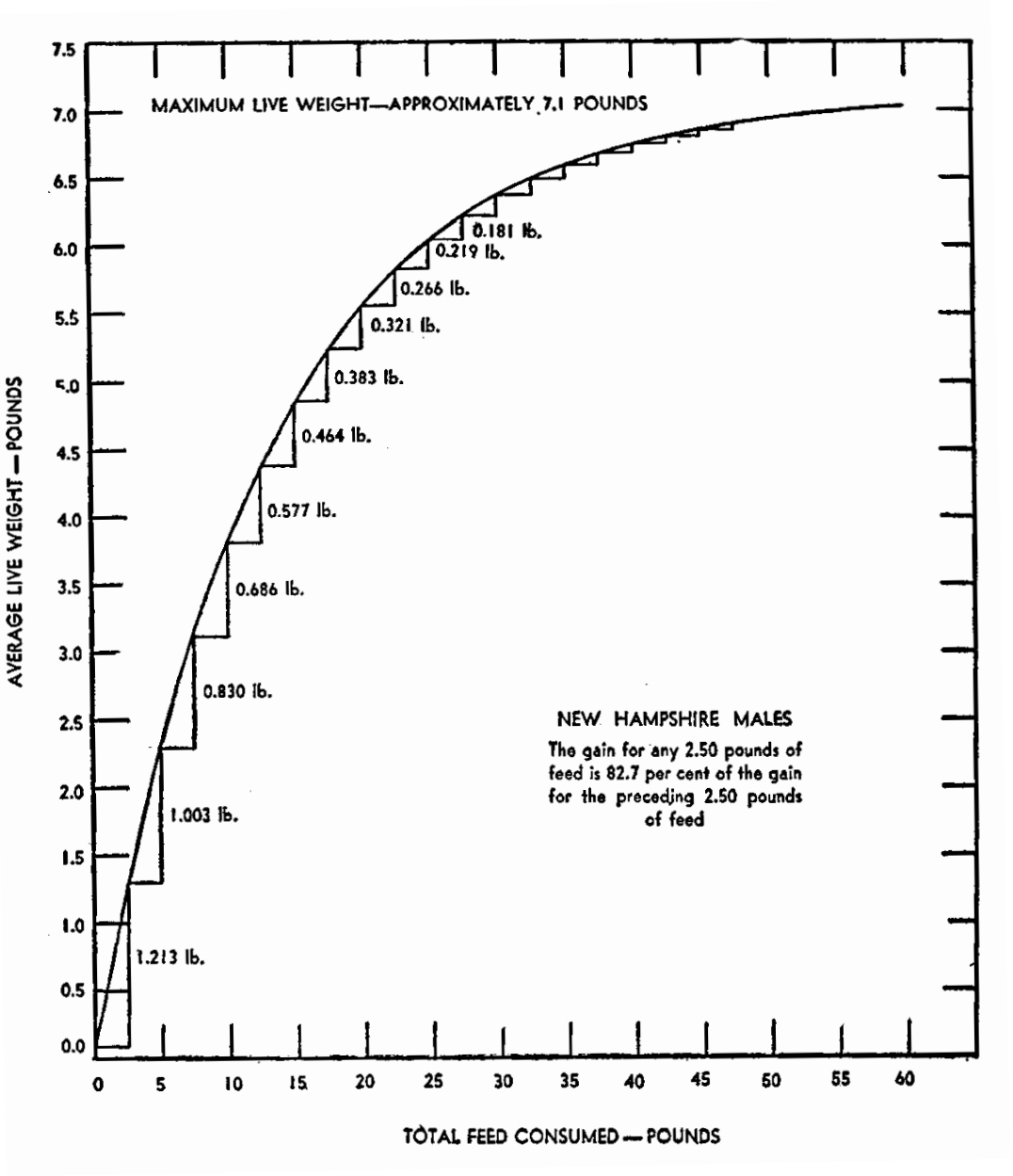
Many non-linear models exhibit "*The law of diminishing returns*" or "*The law of diminishing marginal productivity*".

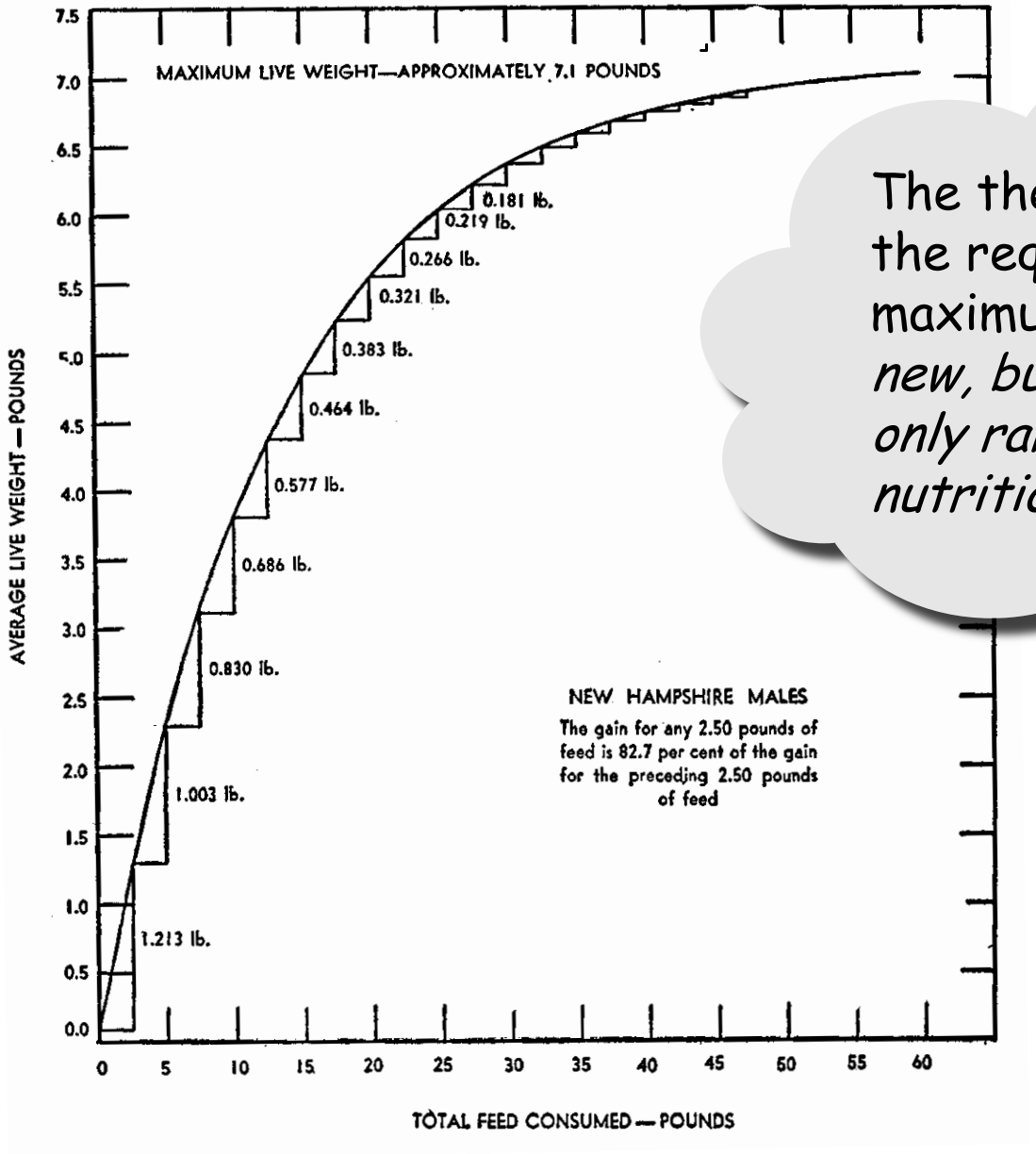
Economic theory must be applied to these models to find the feeding level (Input) that maximizes profits (not necessarily the maximum output level).

This example is from a 1955 book "The Scientific Feeding of Chickens"



With diminishing returns models, the *"requirement"* is for maximizing profits instead of maximum performance





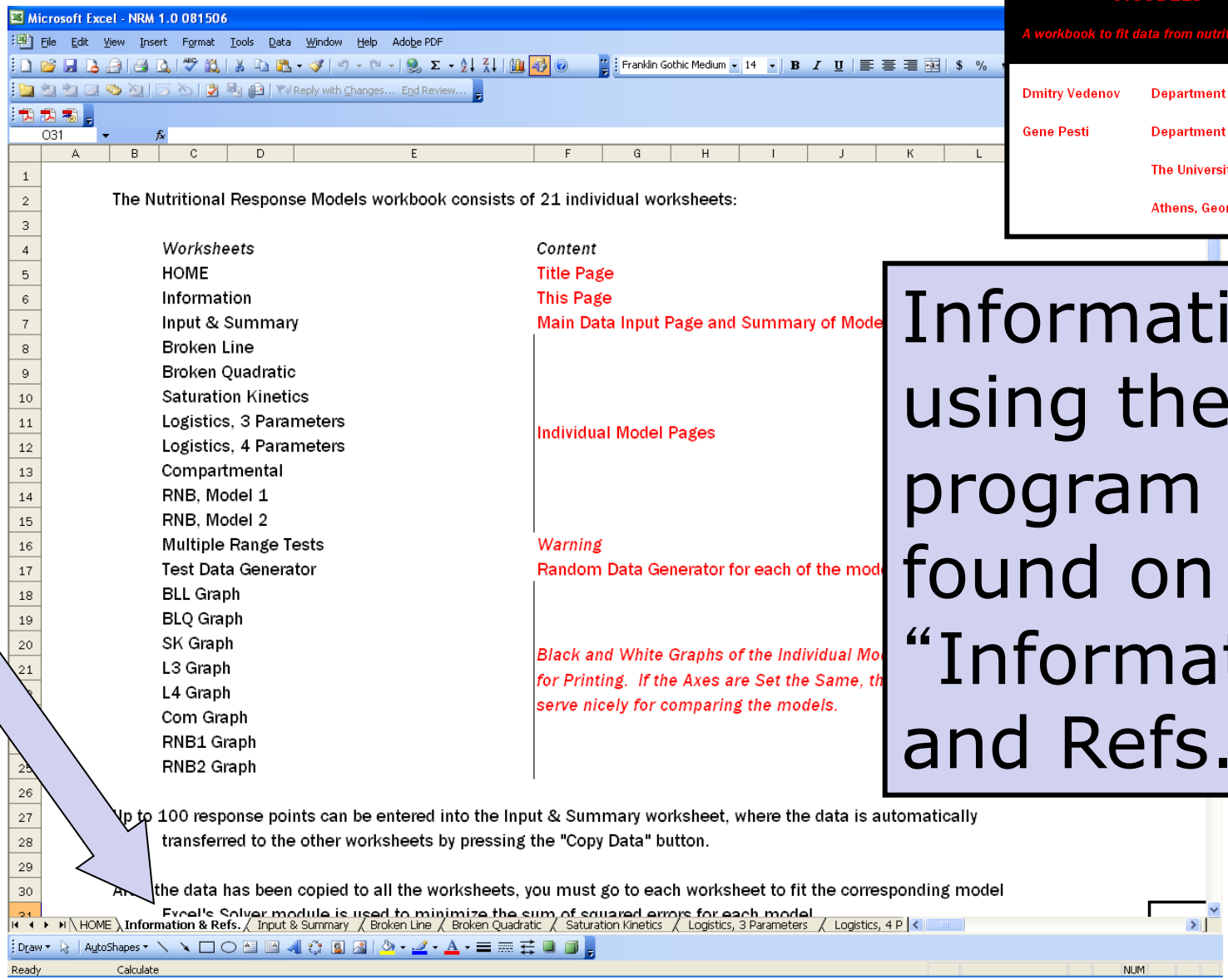
The theories of determining the requirements for maximum profits *"are not new, but have been employed only rarely by workers in nutrition"*

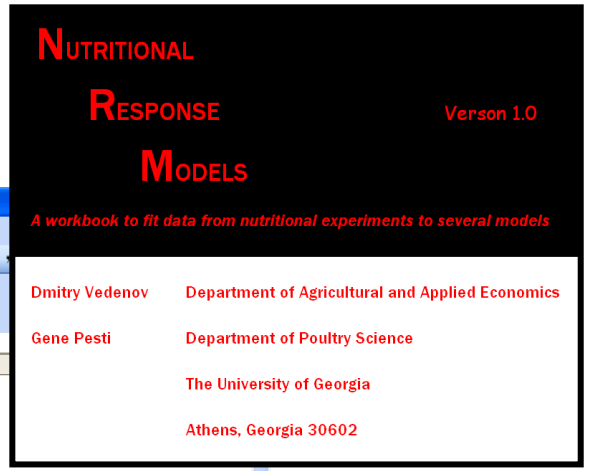
H.J. Almquist
Poultry Science 32:1001(1953)

Application of The Law of Diminishing Returns to Estimation of B-vitamins Requirements of Growth

- "The principles described are not new, but have been employed only rarely by workers in nutrition"
- "The several examples to be given below will further emphasize the broad utility of the principles in the estimation of requirements..."

Using the Program

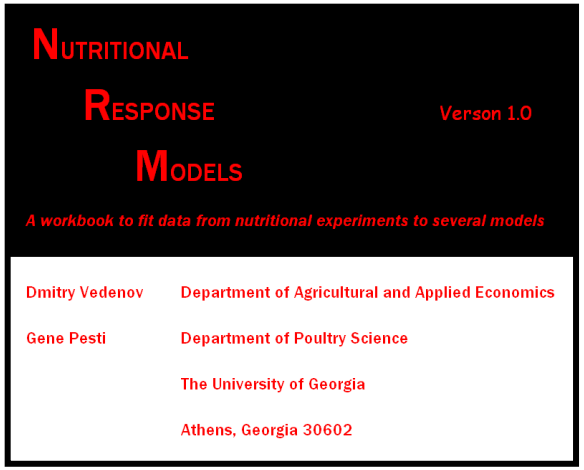




Information on using the program is found on the "Information and Refs." page

NRM 1.0.xls can fit several models to nutritional response data

- Broken Line
- Broken Quadratic
- Saturation Kinetics
- Logistics, 3 Parameters
- Logistics, 4 Parameters
- Compartmental
- Robbins, Norton & Baker, Model 1
- Robbins, Norton & Baker, Model 2



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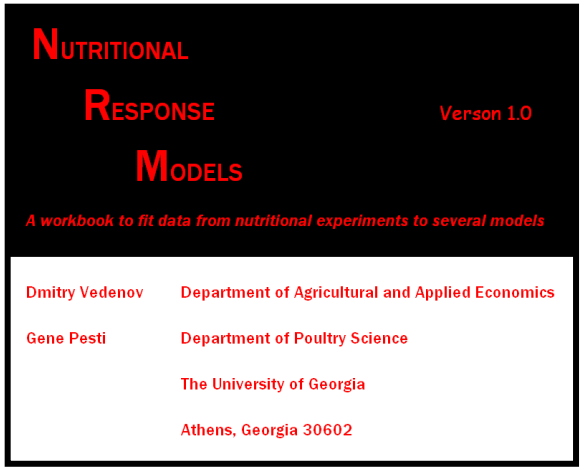
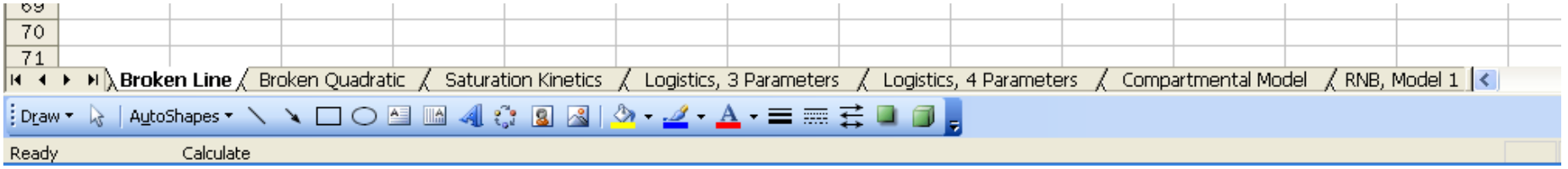


Each has a spreadsheet in the workbook



File Edit View Insert Format Tools Data Window Help Adobe PDF

Point	Input	Output
1	0.5	114.9
2	0.5	131.5
3	0.5	136.4
4	0.6	180.2
5	0.6	213.3
6	0.6	184.3
7	0.7	222.2
8	0.7	199.3
9	0.7	196.0
10	0.8	234.0
11	0.8	229.0
12	0.8	222.8
13	0.9	233.6
14	0.9	239.2
15	0.9	261.7
16	1	207.8
17	1	239.2
18	1	211.5
19	1.1	234.0
20	1.1	236.0
21	1.1	234.0
22	1.2	234.00
23	1.2	228.00
24	1.2	263.00
25		
26		
27		
28		
29		

INSTRUCTIONS

0. Press the button below to clear the data range

[Data Range]

1. Enter your data into columns B and C.
   Column B, Input, should contain the
   Column C, Output, should contain
2. Press the button below to automa

[Copy Data]

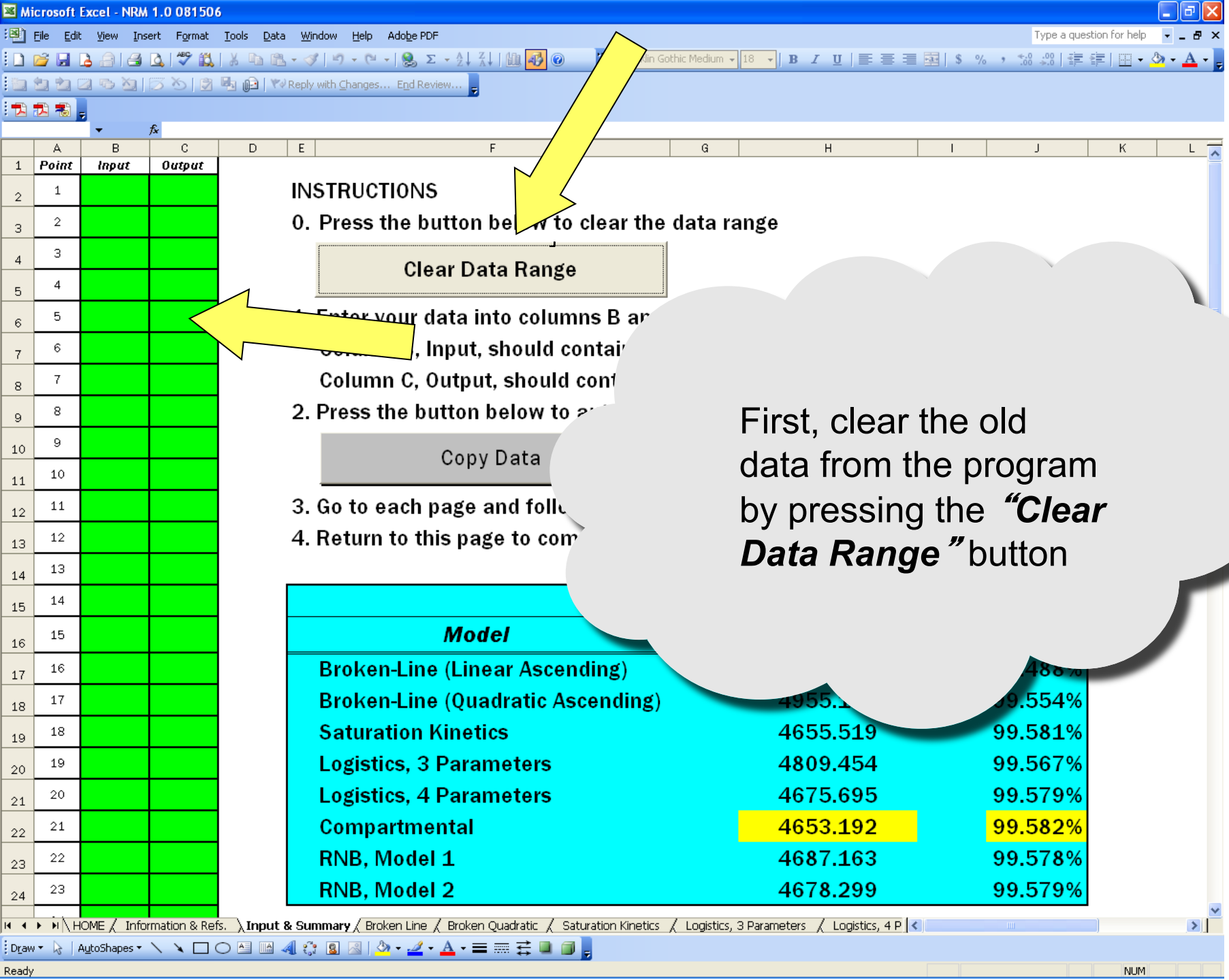
3. Go to each pag nd follow
4. Return to this o comp

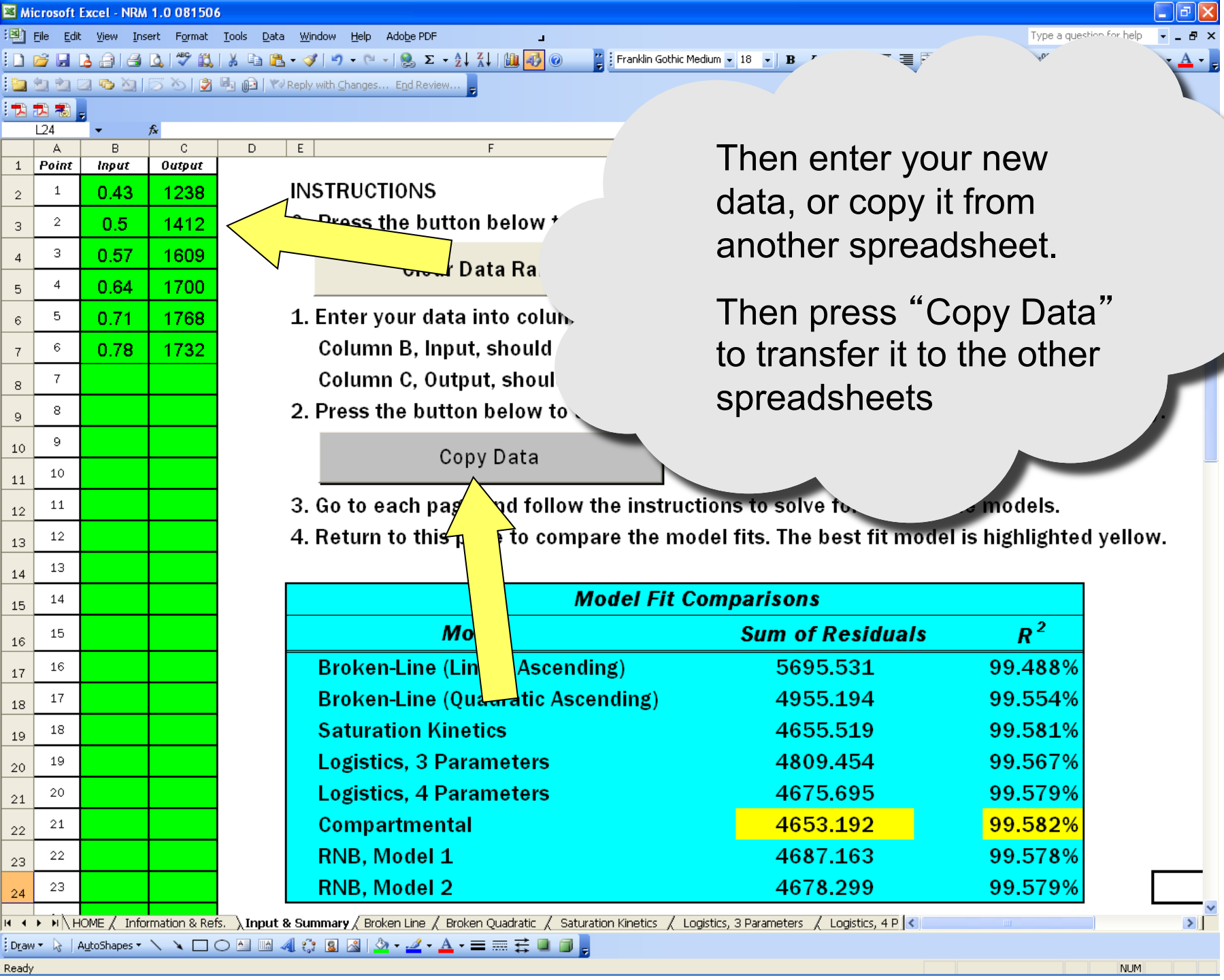
M		
Mo		
Broken-Line (Lin Ascending)		
Broken-Line (Qua tic Ascending)		4%
Saturation Kinetics	4655.519	.581%
Logistics, 3 Parameters	4809.454	99.567%
Logistics, 4 Parameters	4675.695	99.579%
Compartmental	4653.192	99.582%
RNB odel 1	4687.163	99.578%
RN lodel 2	4678.299	99.579%

Input / Output data is entered on the ***Input & Summary*** page and transferred to the other spreadsheets by pressing the **"Copy Data"** button.

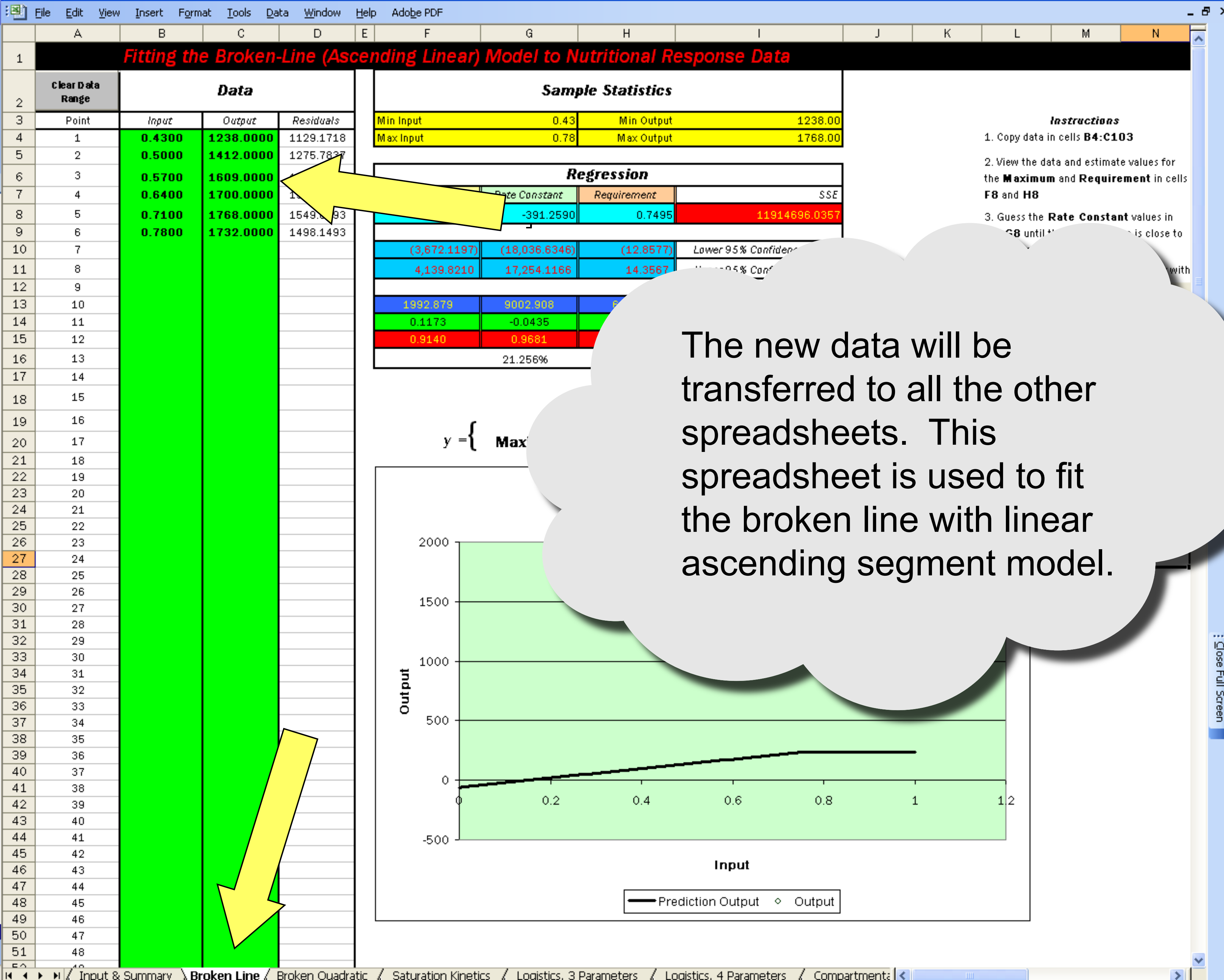
HOME | Information & Refs. | **Input & Summary** | Broken Line | Broken Quadratic | Saturation Kinetics | Logi

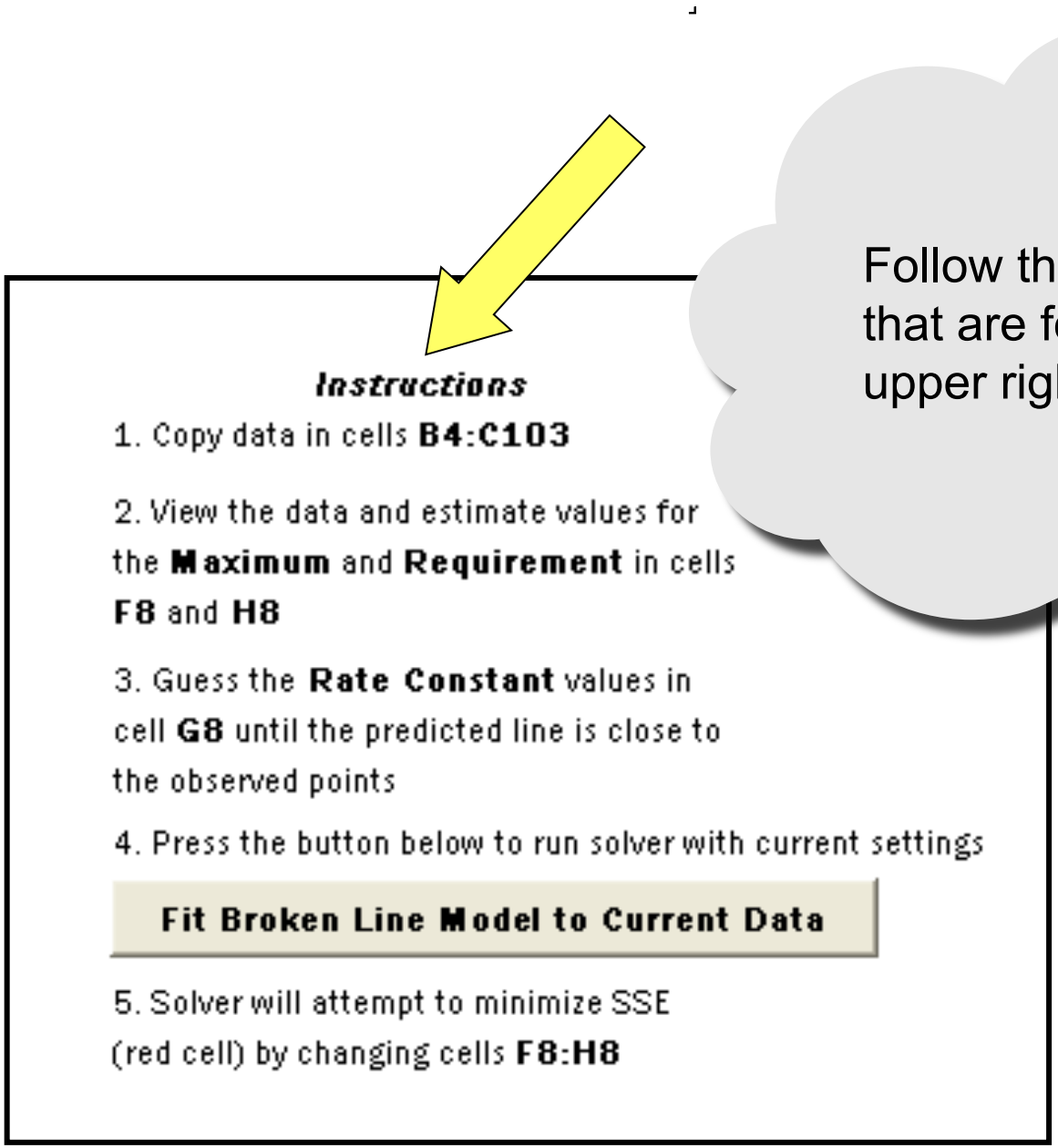
Close Full Screen


Microsoft Excel - NRM 1.0 081506
File Edit View Insert Format Tools Data Window Help Adobe PDF
Type a question for help
Reply with Changes... End Review...
Point Input Output
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
INSTRUCTIONS
0. Press the button be w to clear the data range
Clear Data Range
Input, should contai
Column C, Output, should con
2. Press the button below to a
Copy Data
3. Go to each page and follo
4. Return to this page to com
Model
Broken-Line (Linear Ascending)
Broken-Line (Quadratic Ascending)
Saturation Kinetics 4655.519 99.581%
Logistics, 3 Parameters 4809.454 99.567%
Logistics, 4 Parameters 4675.695 99.579%
Compartmental 4653.192 99.582%
RNB, Model 1 4687.163 99.578%
RNB, Model 2 4678.299 99.579%
First, clear the old data from the program by pressing the "Clear Data Range" button
HOME Information & Refs. Input & Summary Broken Line Broken Quadratic Saturation Kinetics Logistics, 3 Parameters Logistics, 4 P
Draw AutoShapes
Ready
NUM


Microsoft Excel - NRM 1.0 081506
Then enter your new data, or copy it from another spreadsheet.
Then press “Copy Data” to transfer it to the other spreadsheets
INSTRUCTIONS
Copy Data
Model Fit Comparisons
Sum of Residuals
Broken-Line (Ascending) 5695.531 99.488%
Broken-Line (Quadratic Ascending) 4955.194 99.554%
Saturation Kinetics 4655.519 99.581%
Logistics, 3 Parameters 4809.454 99.567%
Logistics, 4 Parameters 4675.695 99.579%
Compartmental 4653.192 99.582%
RNB, Model 1 4687.163 99.578%
RNB, Model 2 4678.299 99.579%

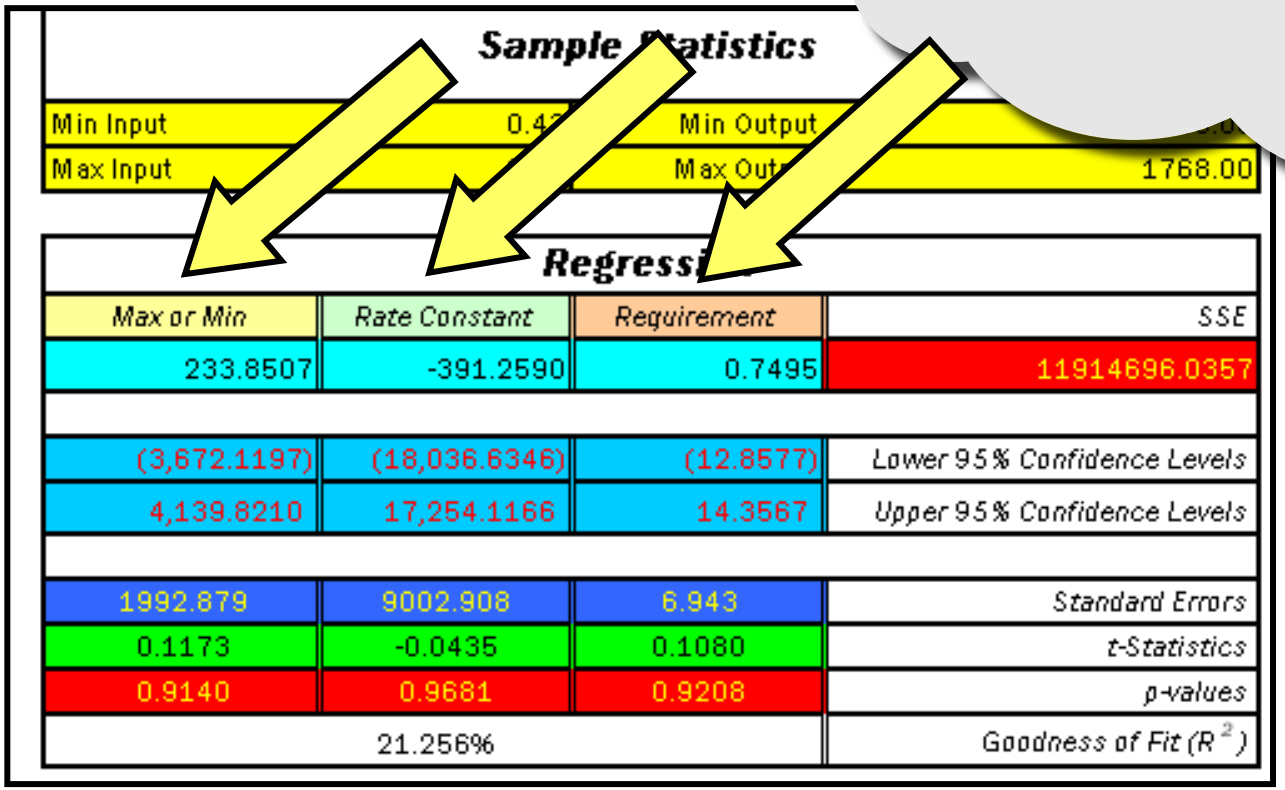
The new data will be transferred to all the other spreadsheets. This spreadsheet is used to fit the broken line with linear ascending segment model.





Follow the instructions that are found in the upper right of each page.

You will need to guess at the parameters for the new data set before the program can solve for the best solution



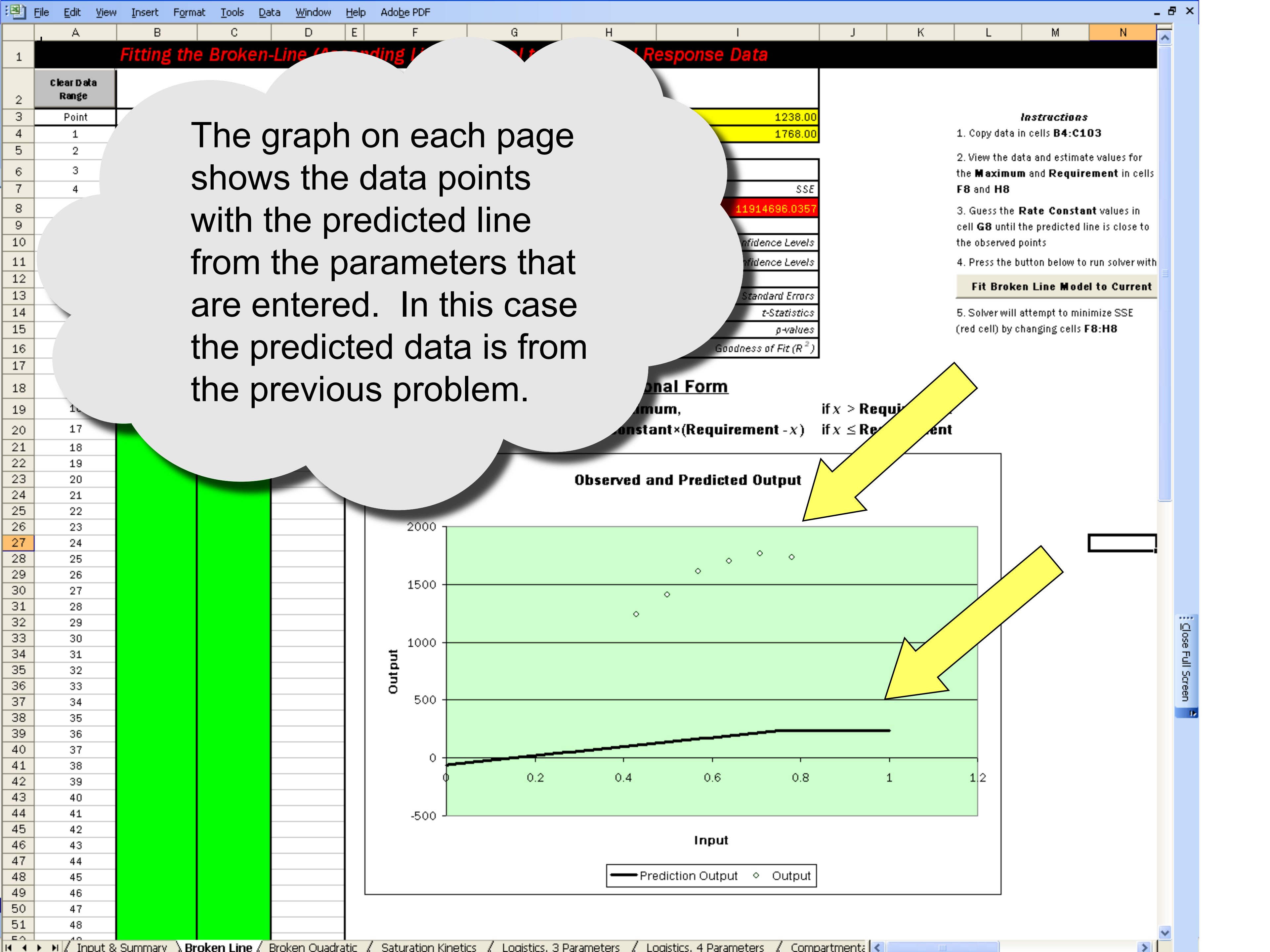
Sample Statistics

Min Input	0.4	Min Output	
Max Input		Max Output	1768.00

Regressi

Max or Min	Rate Constant	Requirement	SSE
233.8507	-391.2590	0.7495	11914696.0357
(3,672.1197)	(18,036.6346)	(12.8577)	Lower 95% Confidence Levels
4,139.8210	17,254.1166	14.3567	Upper 95% Confidence Levels
1992.879	9002.908	6.943	Standard Errors
0.1173	-0.0435	0.1080	t-Statistics
0.9140	0.9681	0.9208	p-values
21.256%			Goodness of Fit (R^2)

The graph on each page shows the data points with the predicted line from the parameters that are entered. In this case the predicted data is from the previous problem.



If one of the parameters is changed, the graph will change to show how good the fit is.

Regres			
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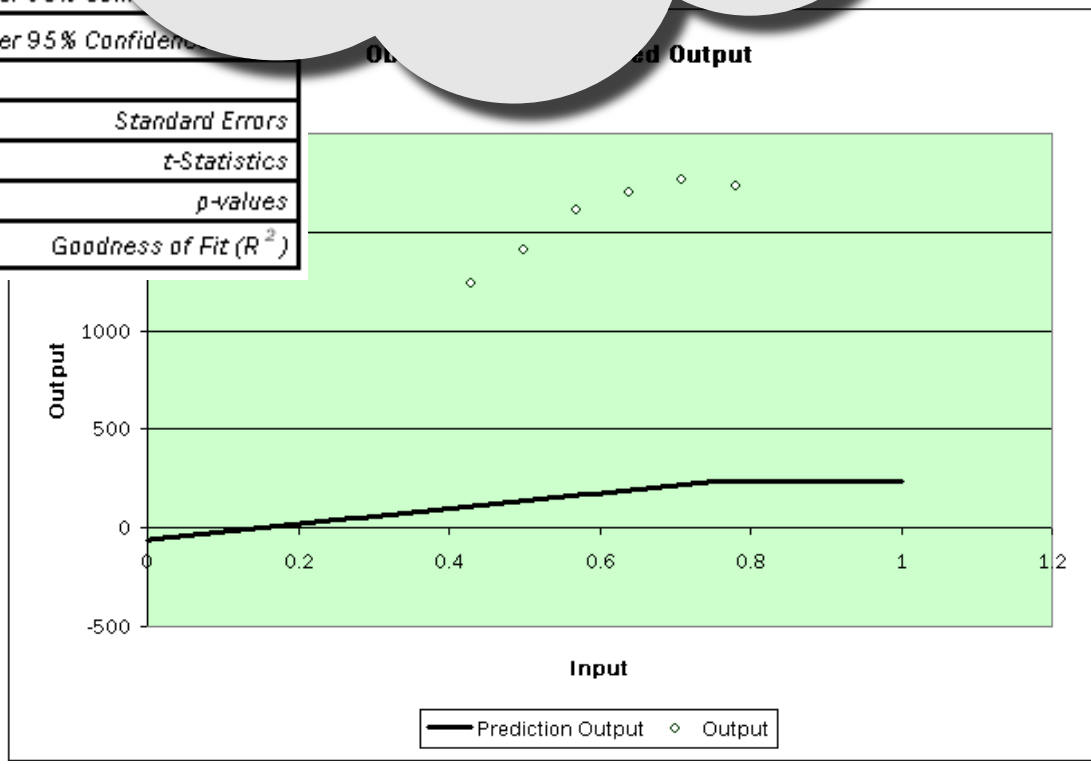
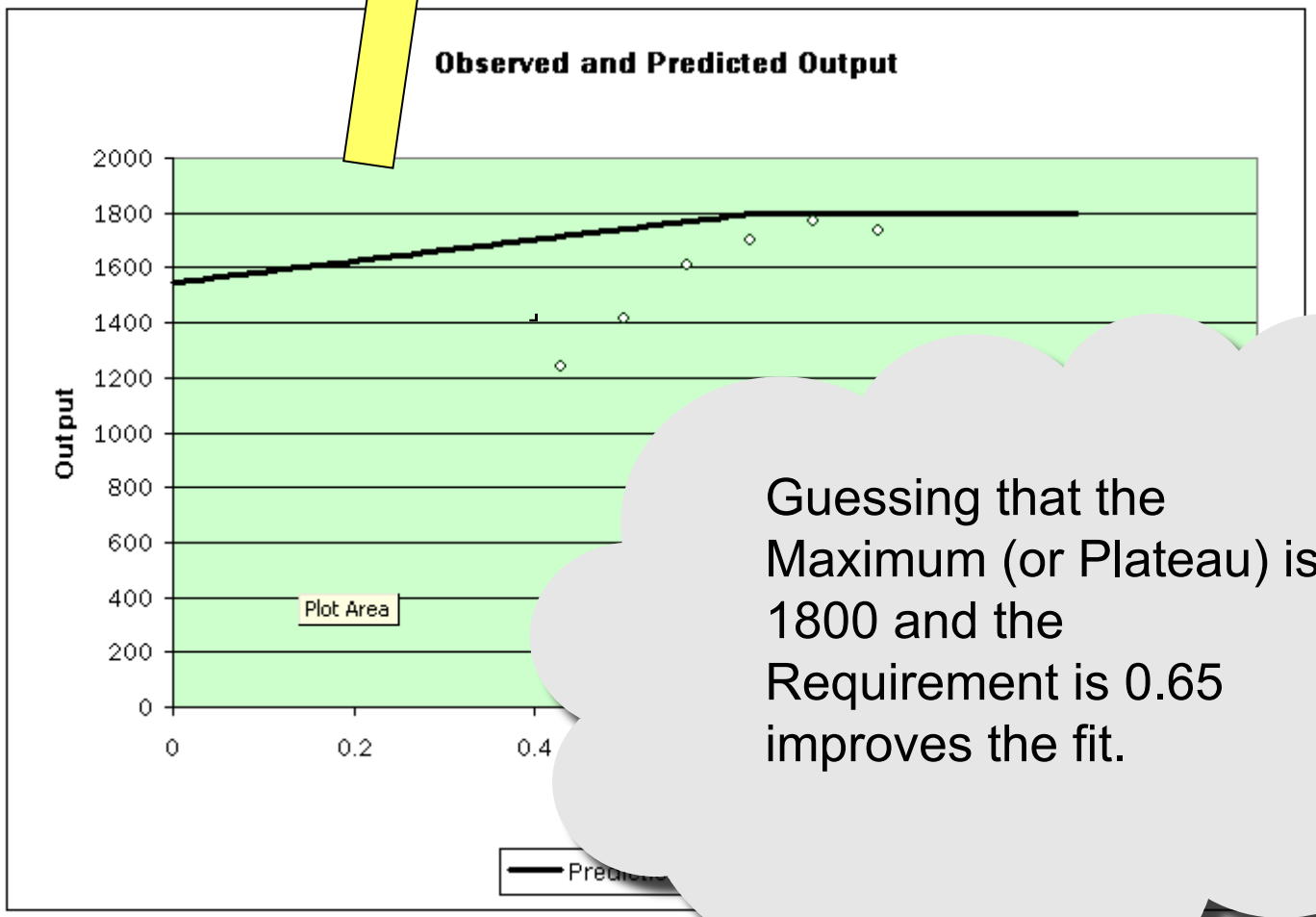


Regression

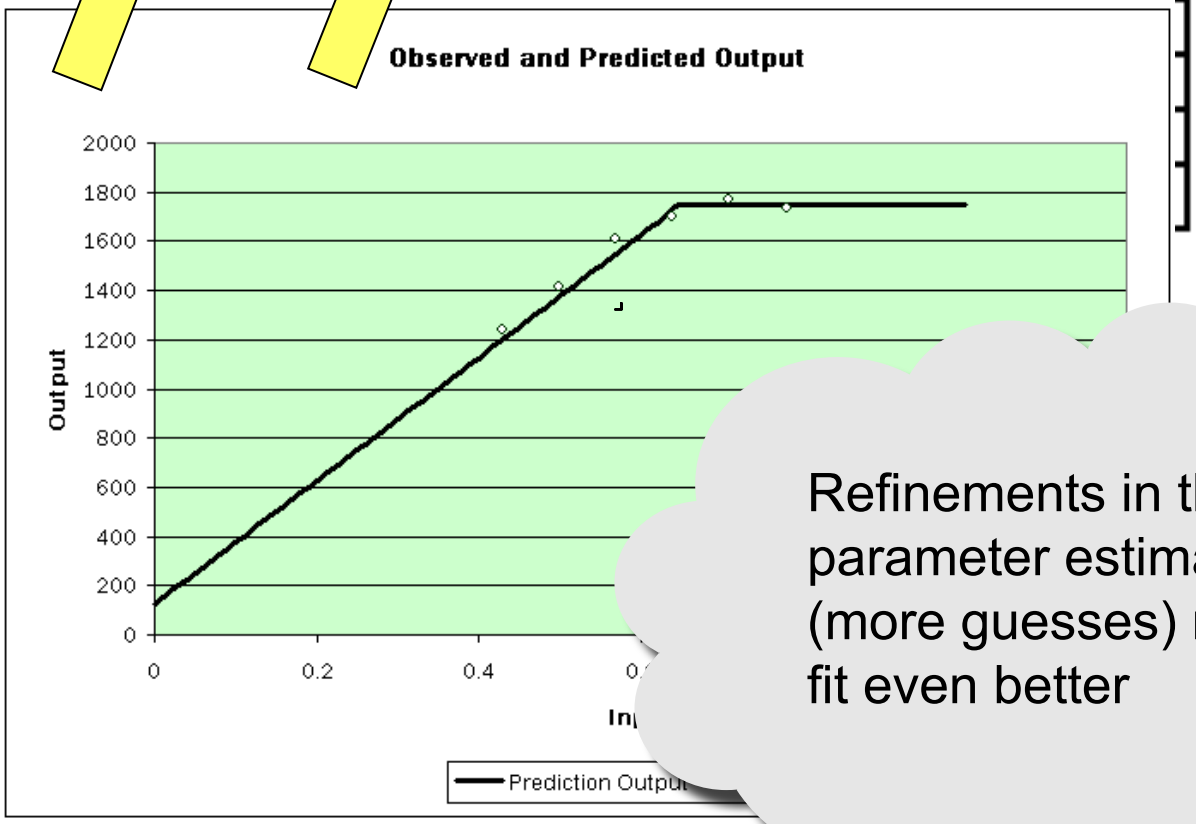
Max or Min	Rate Constant	Requirement	SSE
1800.0000	-391.2590	0.6500	375333.2122
1,3 7914	(4,820.3328)	(1.3623)	Lower 95% Confidence Levels
2,2 2086	4,037.8148	2.6623	Upper 95% Confidence Levels
25 11			
7 68			
55			



Guessing that the Maximum (or Plateau) is 1800 and the Requirement is 0.65 improves the fit.

Regression

Max or Min	Rate Constant	Requirement	SSE
1750.0000	-2500.0000	0.6500	7567.0000
1,[illegible]960	([illegible]8.8778)	0.6053	Lower 95% Confidence Levels
1[illegible]9.6040	([illegible]871.1222)	0.6947	Upper 95% Confidence Levels
[illegible]513			
[illegible].2779			
0.0000			



Refinements in the parameter estimates (more guesses) make the fit even better

Now it's time to let Excel's Solver function make the final fit by further adjusting the parameter estimates to minimize the value in cell I9.

Press this button.

Instructions

1. Copy data in cells **B4:C103**

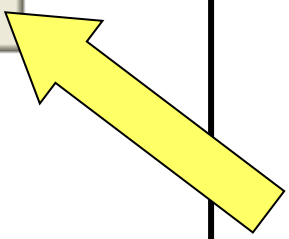
2. View the data and estimate values for the **Maximum** and **Requirement** in cells **F8** and **H8**

3. Guess the **Rate Constant** values in cell **G8** until the predicted line is close to the observed points

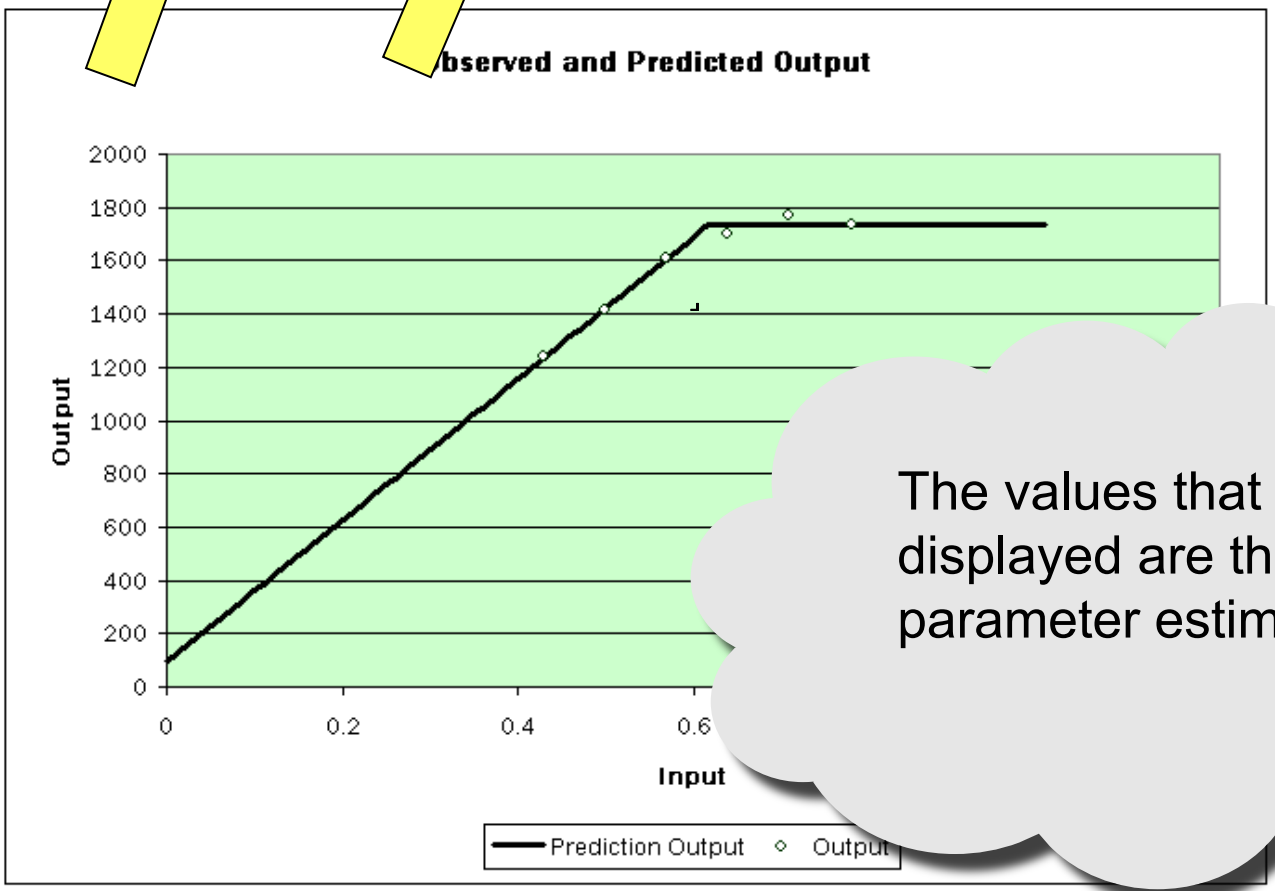
4. Press the button below to run solver with current settings

Fit Broken Line Model to Current Data

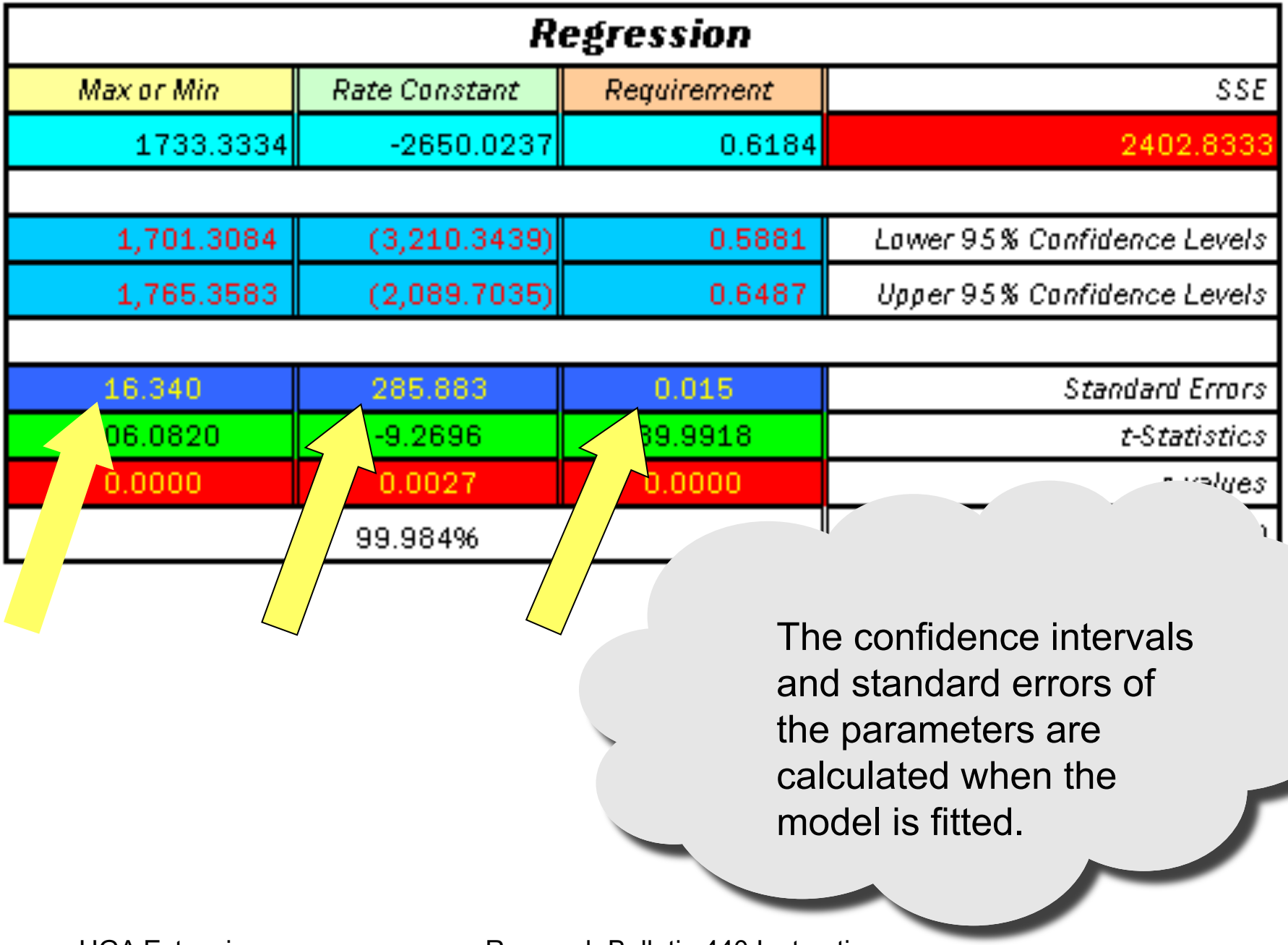
5. Solver will attempt to minimize SSE (red cell) by changing cells **F8:H8**

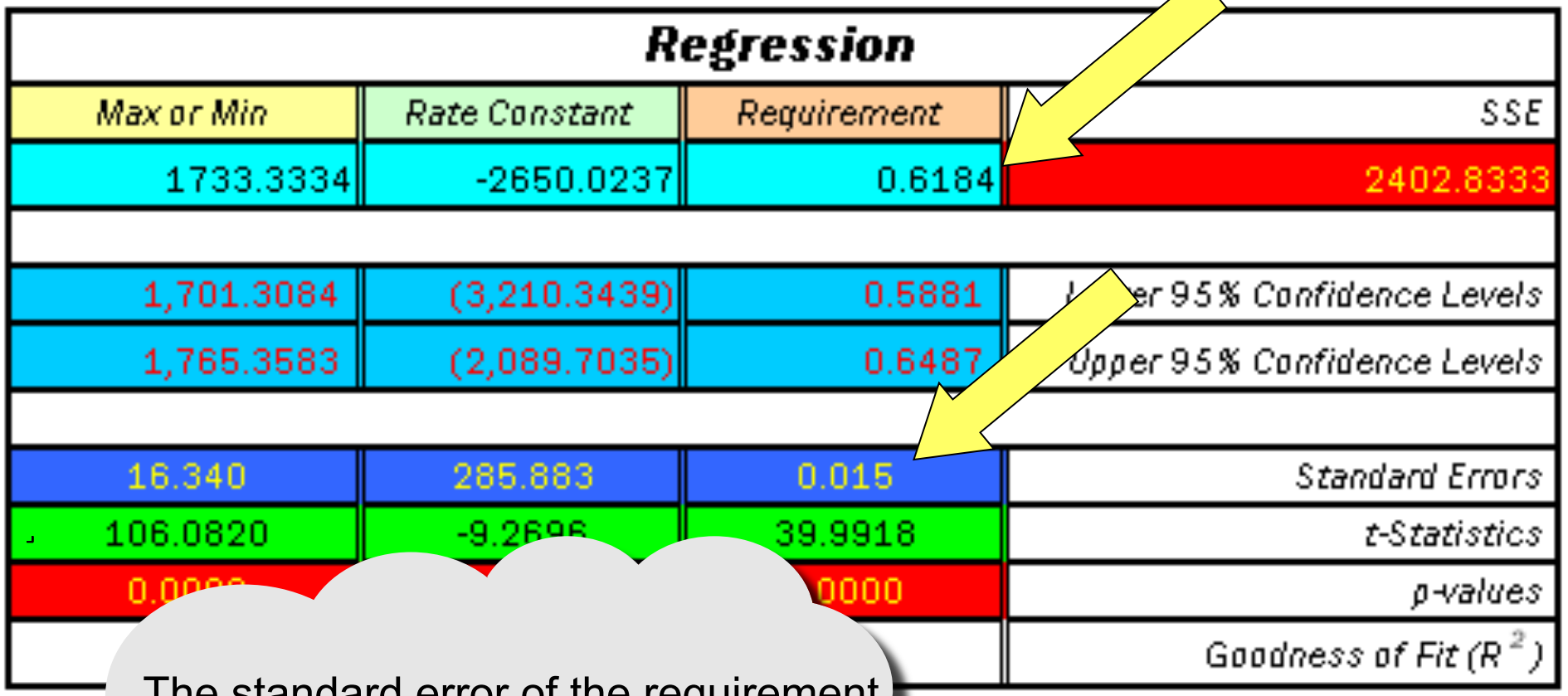


Regression			
Max or Min	Rate Constant	Requirement	SSE
1733.3334	-2650.0237	0.6184	2402.8333
,701.3084	,210.3439)	0.5881	Lower 95% Confidence Levels
1,765.3583	(2,089.7035)	0.6487	Upper 95% Confidence Levels
16.249	985.883	0.015	Standard Errors
106.			
0.0			



The values that are displayed are the final parameter estimates.

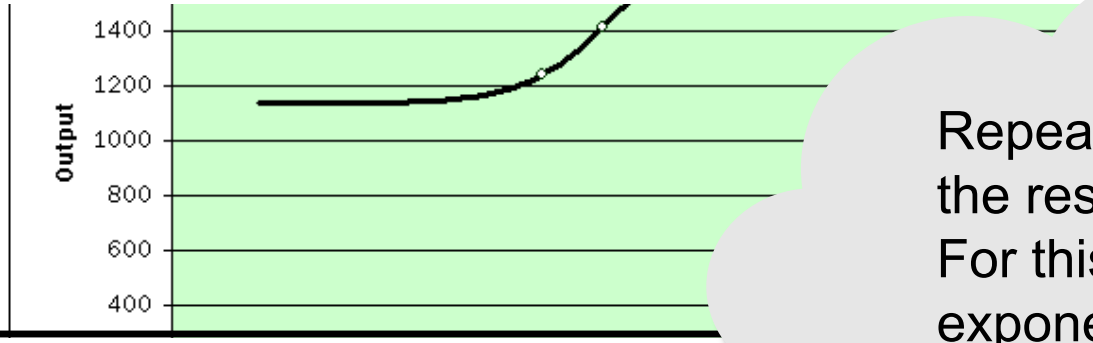

Regression
Max or Min
Rate Constant
Requirement
SSE
1733.3334
-2650.0237
0.6184
2402.8333
1,701.3084
(3,210.3439)
0.5881
Lower 95% Confidence Levels
1,765.3583
(2,089.7035)
0.6487
Upper 95% Confidence Levels
16.340
285.883
0.015
Standard Errors
06.0820
-9.2696
39.9918
t-Statistics
0.0000
0.0027
0.0000
99.984%
The confidence intervals and standard errors of the parameters are calculated when the model is fitted.



Regression			
Max or Min	Rate Constant	Requirement	SSE
1733.3334	-2650.0237	0.6184	2402.8333
1,701.3084	(3,210.3439)	0.5881	Lower 95% Confidence Levels
1,765.3583	(2,089.7035)	0.6487	Upper 95% Confidence Levels
16.340	285.883	0.015	Standard Errors
106.0820	-9.2696	39.9918	t-Statistics
0.0060		0000	p-values
			Goodness of Fit (R^2)

Regression

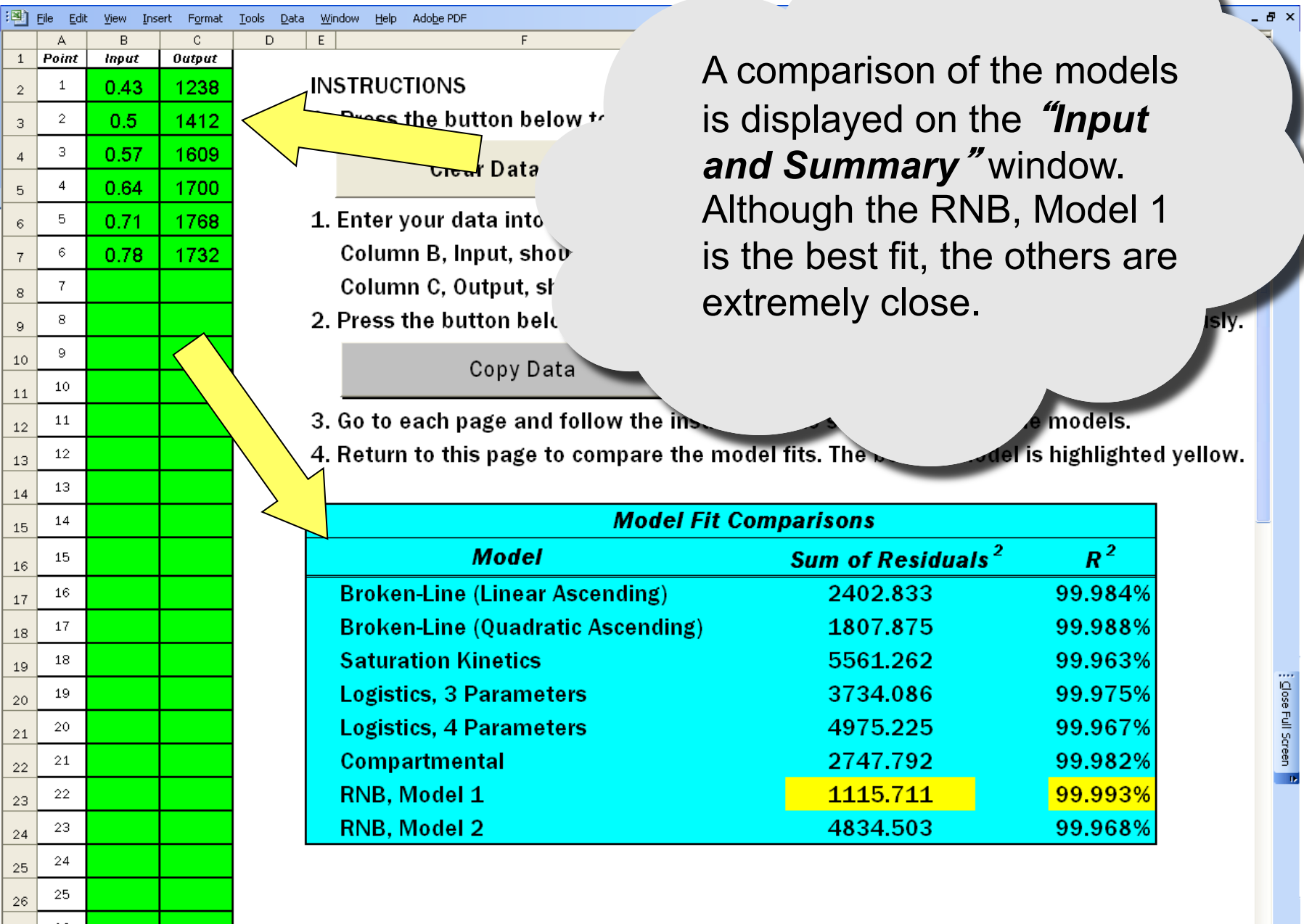
Lower Asymptote	Range	r	s	SSE
1135.9834	616.7528	10.2185	-20.0073	1115.7114
949.0751	407.5242	4.1732	(30.6673)	Lower 95% Confidence Levels
1,322.8917	825.9813	16.2638	(9.3474)	Upper 95% Confidence Levels
95.361	106.749	3.084	5.439	Standard Errors
11.9124	5.7776	3.3130	-3.6787	t-Statistics
0.0070	0.0287	0.0803	0.0666	p-values
99.993%				Goodness of Fit (R^2)



Functional Form

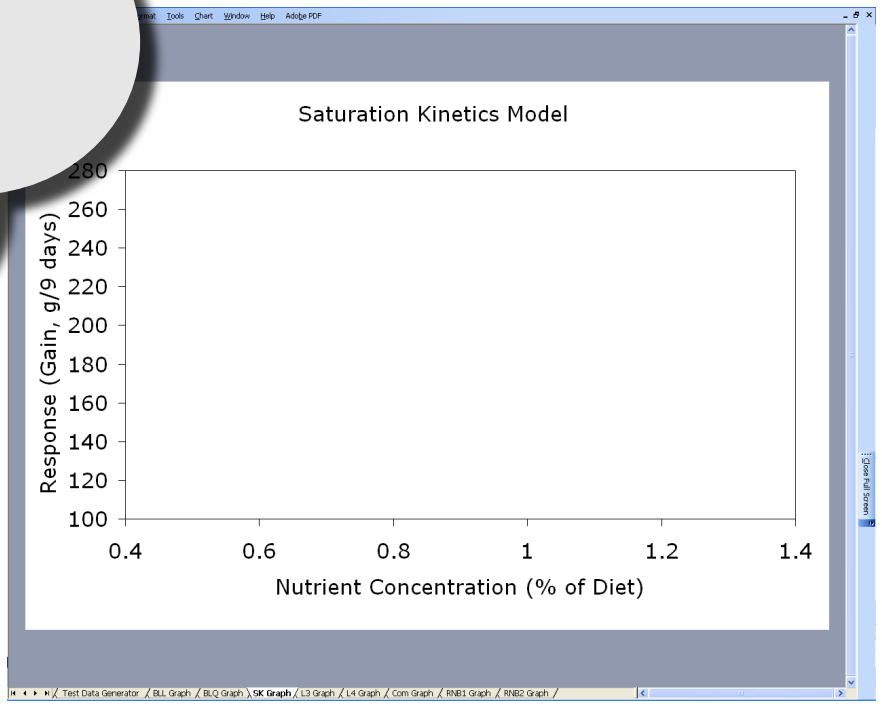
$$y = \text{Lower Asymptote} + \frac{\text{Range}}{1 + e^{r + s \times X}}$$

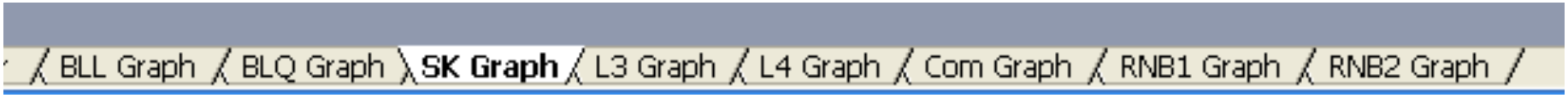
Repeat the process for the rest of the models. For this data, the exponential Model #1 of Robbins, Norton and Baker was the best fit.



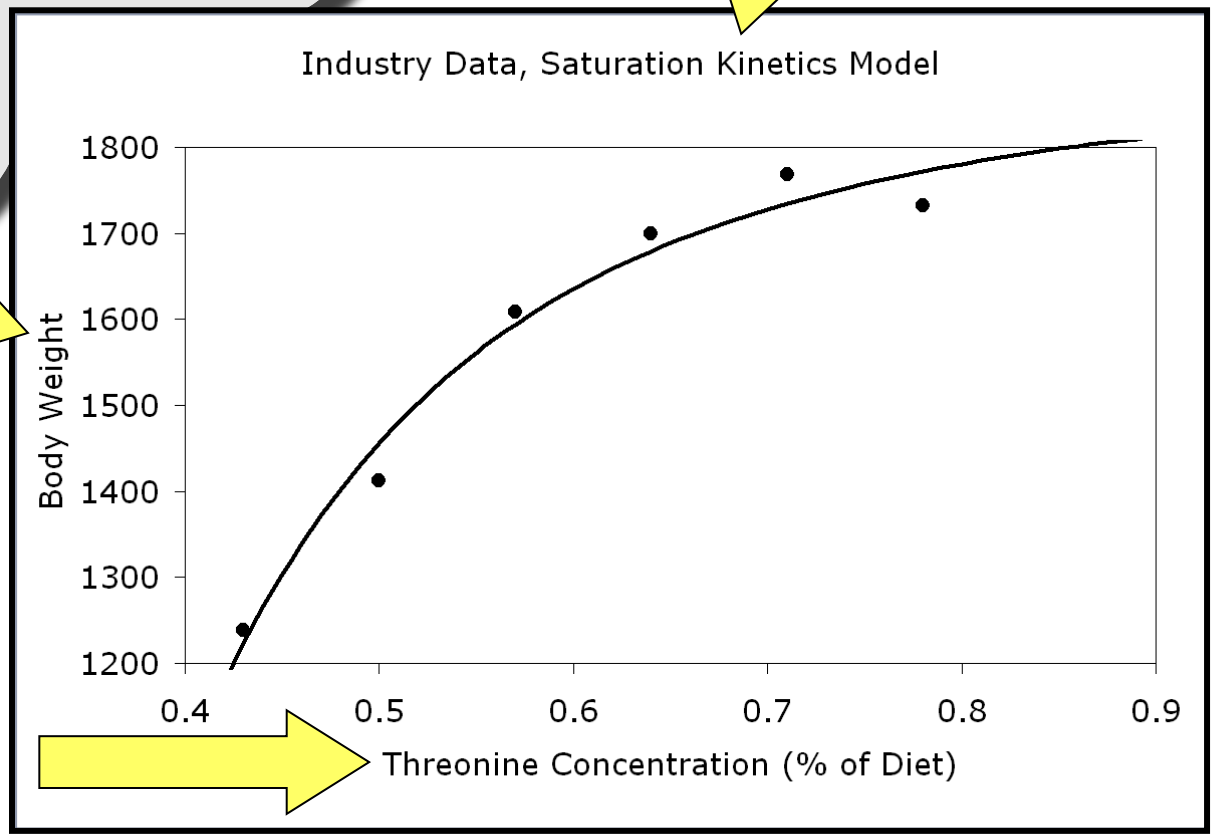
A comparison of the models is displayed on the ***"Input and Summary"*** window. Although the RNB, Model 1 is the best fit, the others are extremely close.

For each model there is also a graph for printing in black and white.





When the axes are set to the right scale and titles are added, nice graphs are easy to print.



There is also a page that tells when it is appropriate to use Multiple Range Tests to determine nutritional requirements.

All of these regression models may be helpful to describe simple input / output relationships to estimate nutrient requirements.

The big challenge for producers is to decide whether the requirement is for maximum performance or maximum profits.

Even when nutritional requirements are well known, nutritionists don't necessarily know how much to supplement to feeds.

Because of ingredient variability, nutritionists may decide to add a margin of safety to cover the risk of feeding the 50% of feeds that are below average for any nutrient.

We hope this program is of value to you

Gene Pesti

Dmitry Vedenov

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