Introduction to Fractals

Fractals can be thought of as fractions or parts of a whole. A point represents a particular location and is represented by a dot. All points are zero-dimensional. A straight line consists of two or more points, which are connected. All lines are one-dimensional. Multiple lines construct a plane, which is three-dimensional. A fractal is not in a particular dimension, instead it is between dimensions. Fractals are rough geometric shapes, which are subdivided. The main shape is repeated infinitely many times and occupies the area of the fundamental structure. In this way, a fractal occupies a finite space as its perimeter approaches infinity. Fractals can be interpreted as fractions, or smaller parts of a whole, known as subdivisions.

An example of a fractal is Sierpinski's triangle.

1) Begin with a basic triangle.

2) Find the midpoints of each line and connect them to form a smaller upside down triangle using the inverse color.

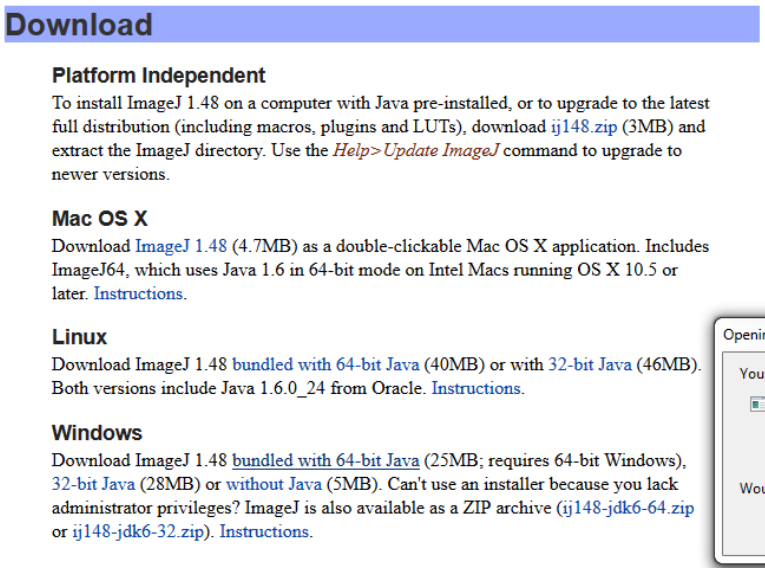
Note: Currently there are three black triangles and one white triangle. The starting triangle is still present. The smaller triangles are fractals or subdivisions of the original triangle. Keep repeating the instructions to eventually obtain the image below.

Fractals have real world applications. For example, in physics fractals describe the roughness of the surface. Two or more fractals contribute a rough surface because you aren't adding whole number dimensions. Another example is in computer science. Fractals can be compressed, manipulated, and studied on computer programs such as ImageJ.

Fractal Image Analysis using ImageJ & FracLac

Installing ImageJ

1. Google ImageJ and select the first link: http://imagej.nih.gov/ij/
2. Click the "**Download**" link
3. Select the download for the appropriate platform (i.e. mac osx or windows)



Download

Platform Independent

To install ImageJ 1.48 on a computer with Java pre-installed, or to upgrade to the latest full distribution (including macros, plugins and LUTs), download ij148.zip (3MB) and extract the ImageJ directory. Use the *Help>Update ImageJ* command to upgrade to newer versions.

Mac OS X

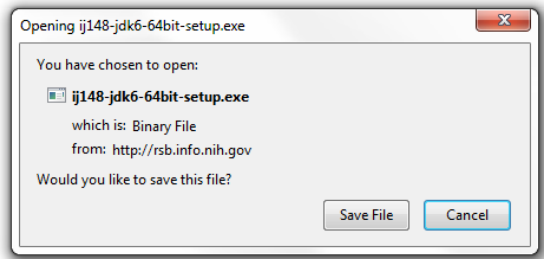
Download ImageJ 1.48 (4.7MB) as a double-clickable Mac OS X application. Includes ImageJ64, which uses Java 1.6 in 64-bit mode on Intel Macs running OS X 10.5 or later. Instructions.

Linux

Download ImageJ 1.48 bundled with 64-bit Java (40MB) or with 32-bit Java (46MB). Both versions include Java 1.6.0_24 from Oracle. Instructions.

Windows

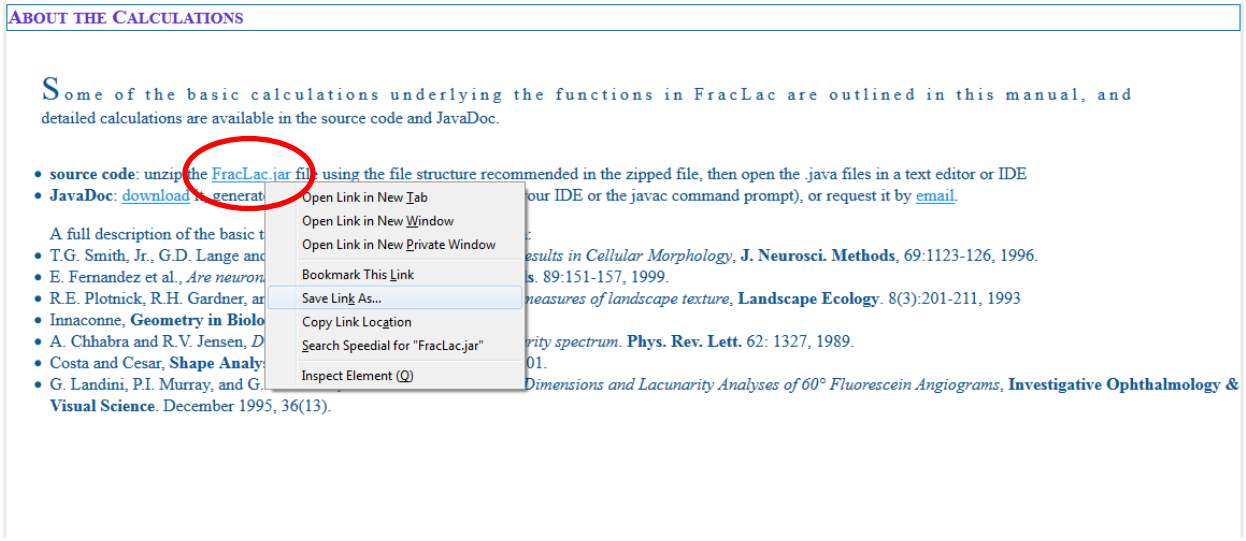
Download ImageJ 1.48 bundled with 64-bit Java (25MB; requires 64-bit Windows), 32-bit Java (28MB) or without Java (5MB). Can't use an installer because you lack administrator privileges? ImageJ is also available as a ZIP archive (ij148-jdk6-64.zip or ij148-jdk6-32.zip). Instructions.



4. A pop up window will open, click "**save file**"
5. On a mac go to the download folder on the bottom right of the screen
   On a PC go to the download arrow in the top right corner of the screen
6. Select the downloaded ImageJ setup program
7. Click "**run**" in the pop up tab that appears
8. Click **next** in the startup program several times, then hit **install**, and wait for ImageJ to finish installation

Installing FracLac

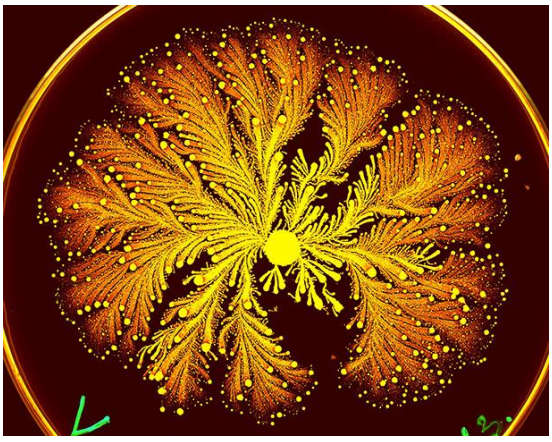
1. Google FracLac and select the first link: http://imagej.nih.gov/ij/plugins/fraclac/FLHelp/Introduction.htm
2. Scroll down to the "About the Calculations" section
3. Right click "FracLac.jar" and select "**save link as**"

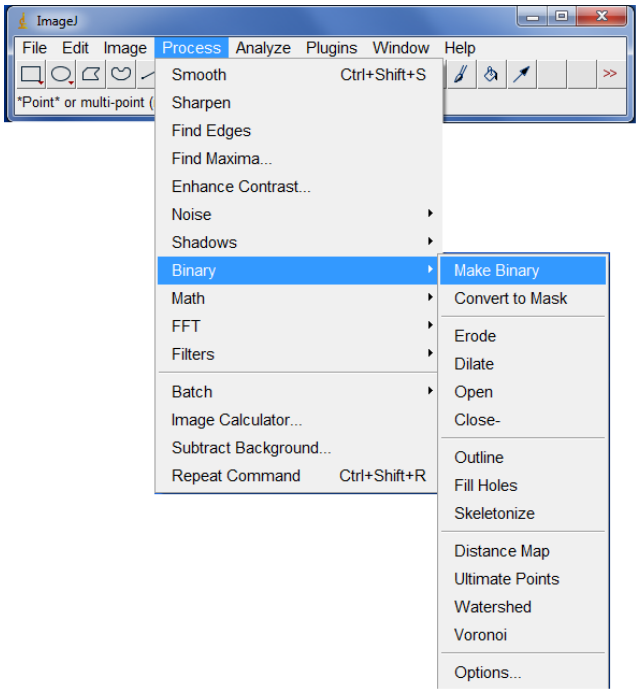


4. Click **recent places**, then **ImageJ**, then **Plugins**, and save FracLac.jar in the plugins folder

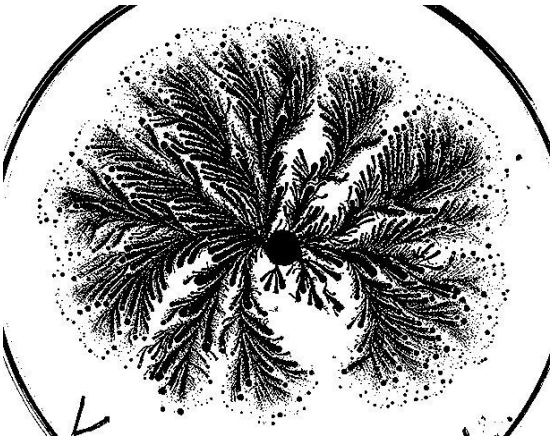
Preforming your Analysis:

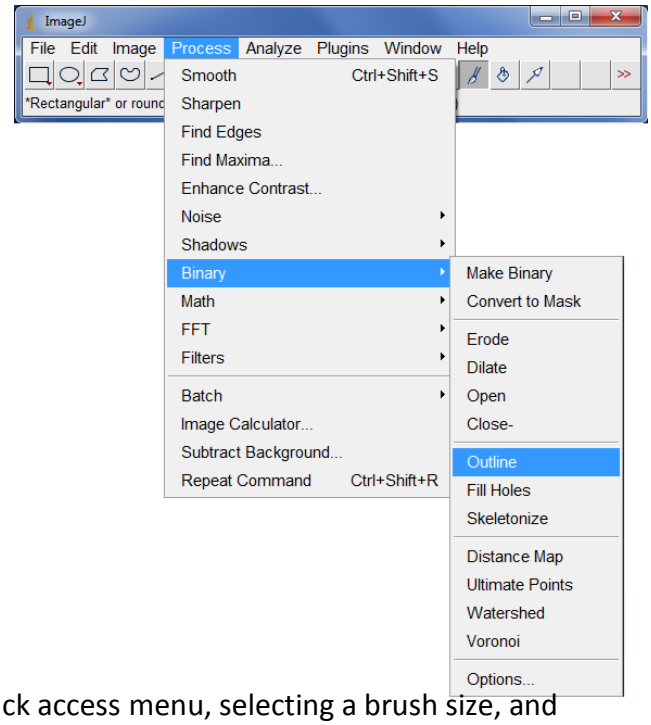
1. Find a fractal image that you wish to analyze and right click to save it in your pictures folder (fractal examples: snowflake, lightning bolt, fern, tree, bacteria)
2. Launch Image J from the start up menu
3. In ImageJ click **File**, **Open**, and open the image you saved
    - In order for FracLac to analyze a fractal image the image must be converted to a binary (black & white) outline. On paper, we can select only the boxes that touch the outline of the image. In order for the computer to do this, we must reduce the image to only its outline.
4. On the ImageJ toolbar select process, go down to Binary, and select Analyze.



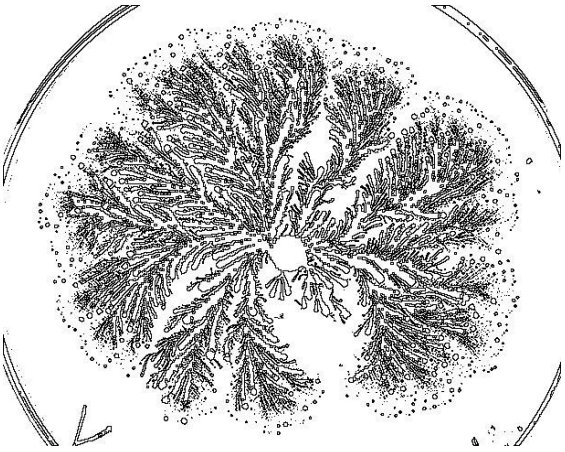


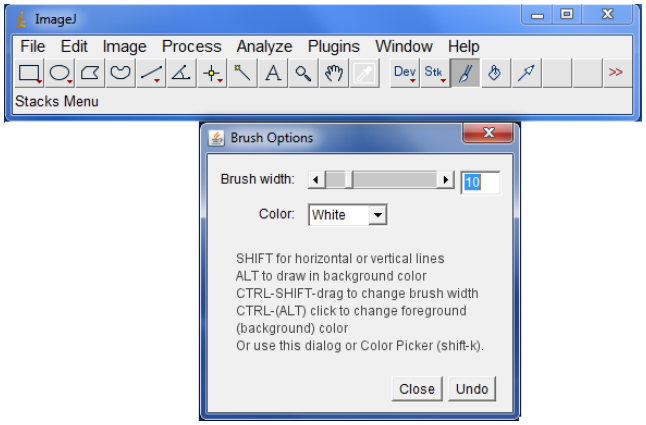
5. Again select Process on the toolbar, go down to Binary and now select outline to outline the image.



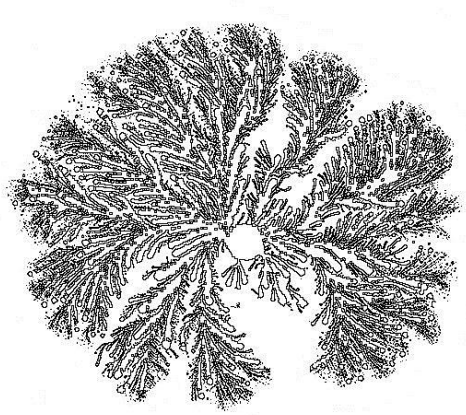


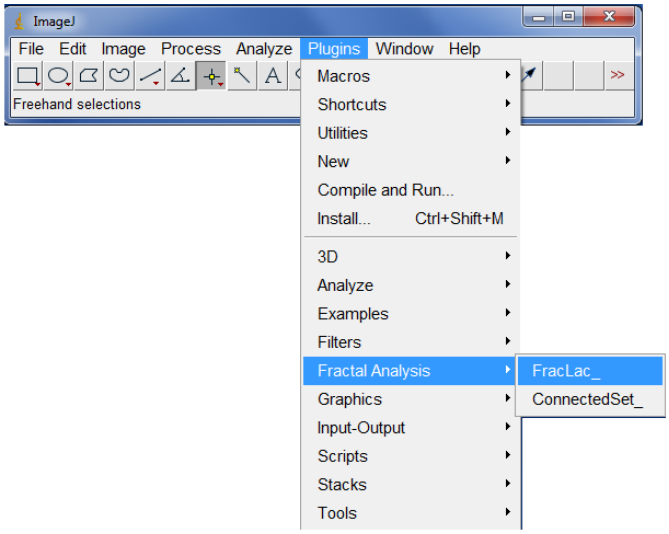
6. By double clicking the paint brush on the quick access menu, selecting a brush size, and changing the brush color to white we can process the image down into only the fractal pattern.





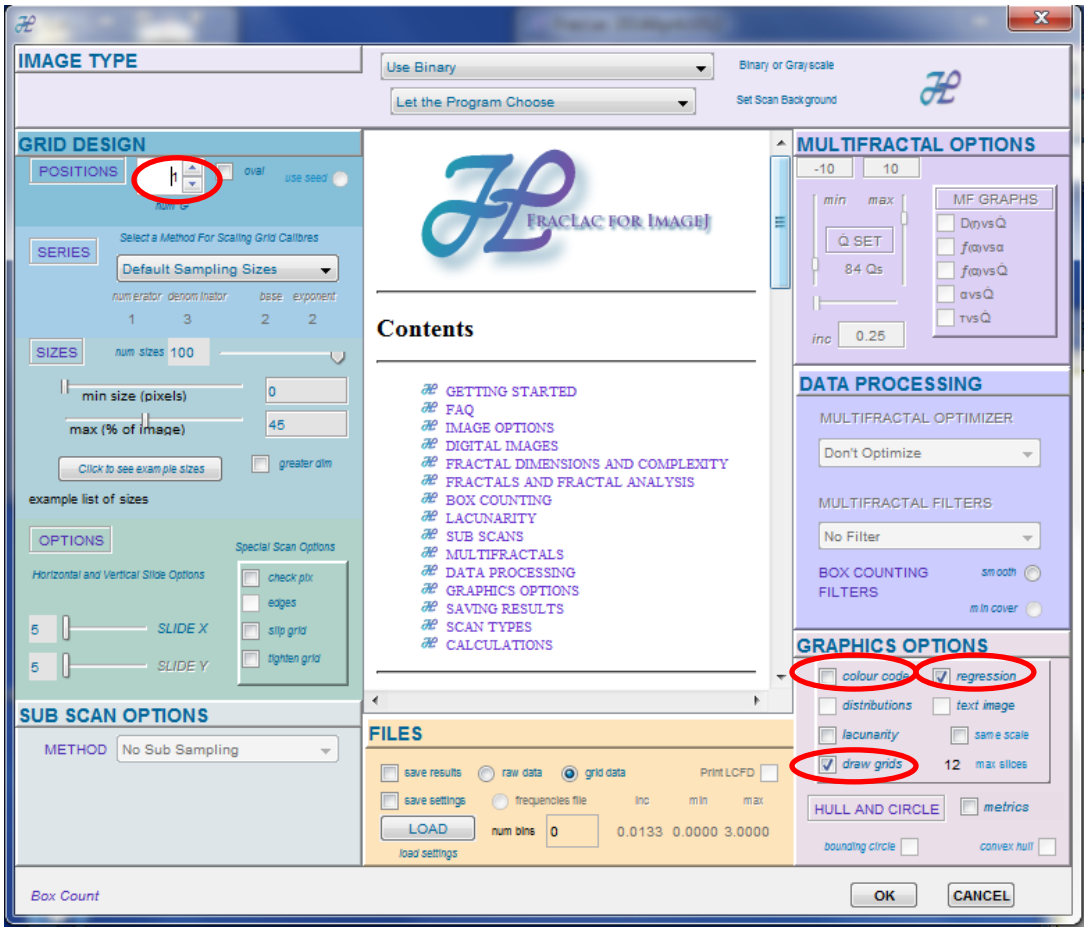
7. The image is now ready to be analyzed. In the toolbar, select plugins, go down to fractal analysis, and open FracLac.



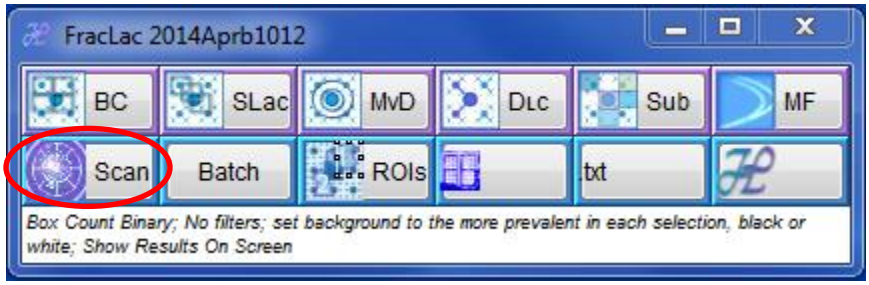


8. Select “BC” to set up the box counting analysis.

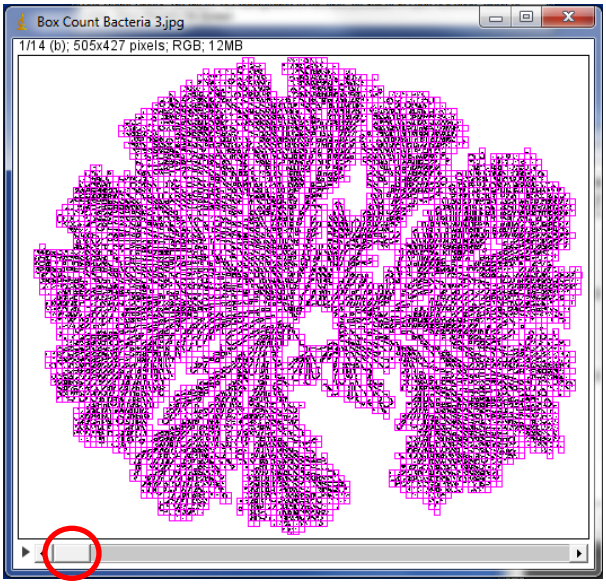
9. In the FracLac analysis window shown below under GRID DESIGN set number of positions to 1. Under GRAPHICS OPTIONS turn off “colour code” and turn on the “draw grids” and “regression” options. Click ok, the program is now set to scan.

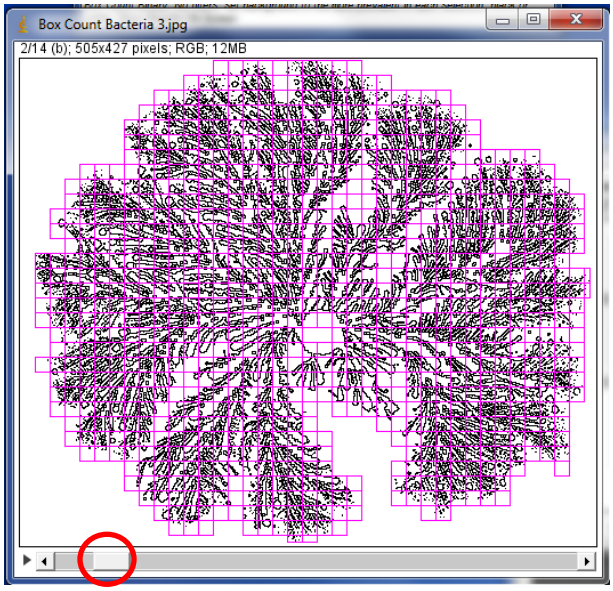


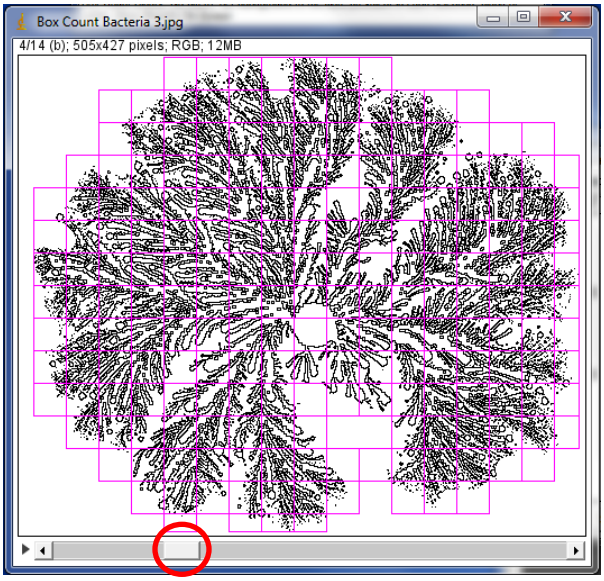
10. Click the scan button on the FracLac toolbar.

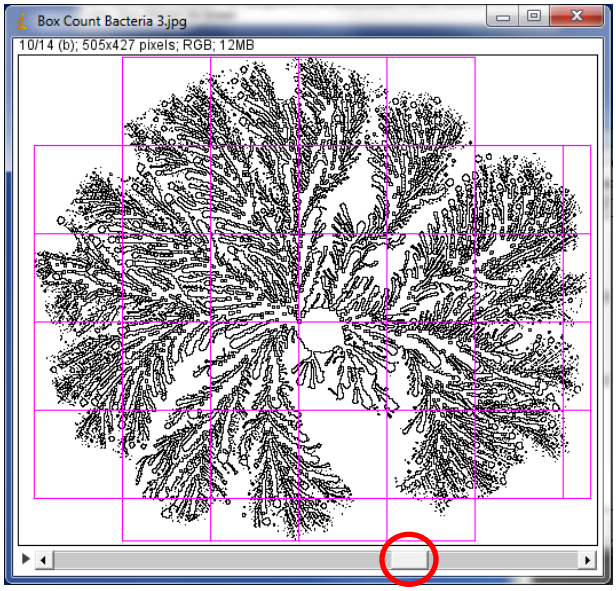


11. The scan will open up several windows. One contains the image with grid lines drawn. By using the scroll bar at the bottom of the window the program visualizes the different sample scales used in the analysis.

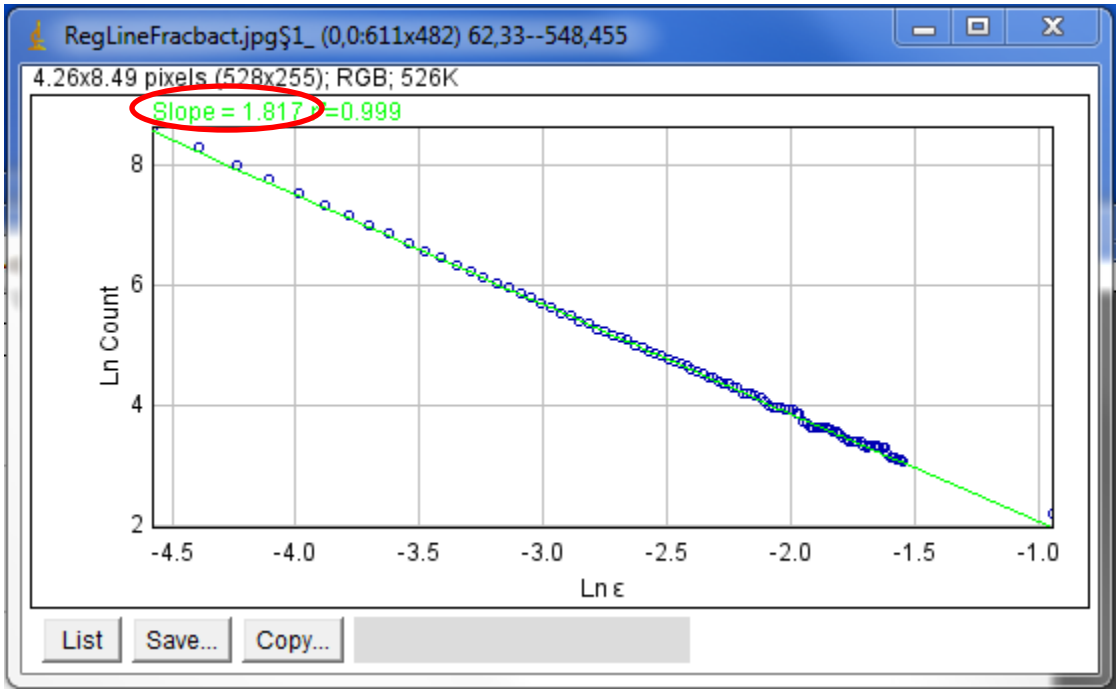






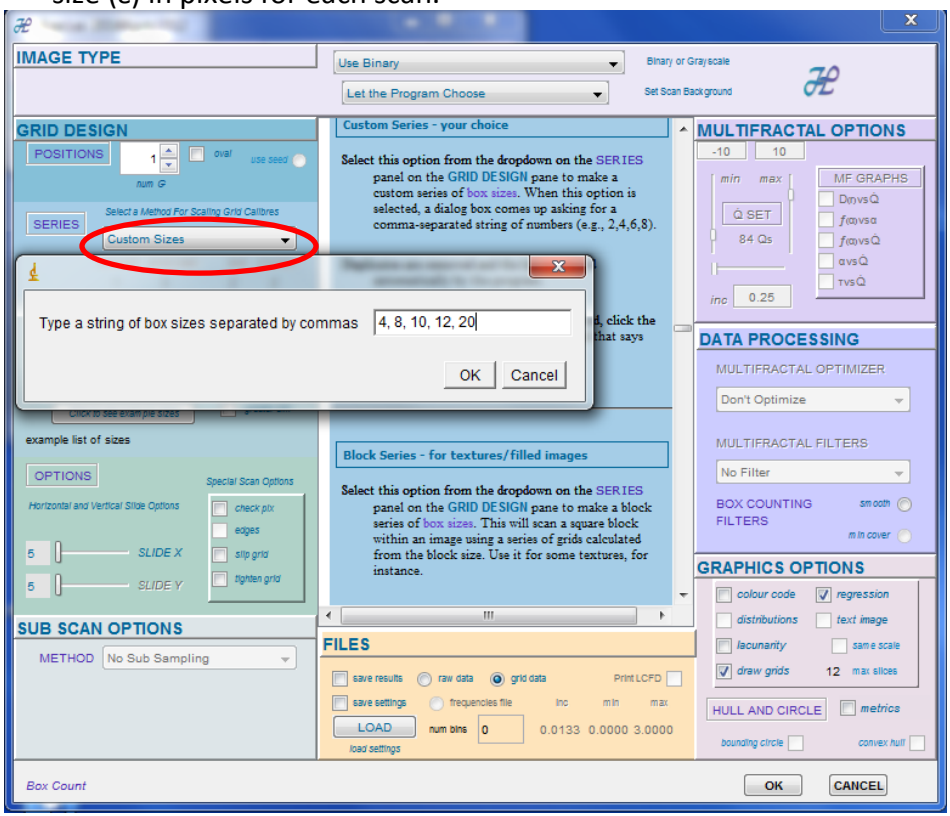


12. The other window that will appear contains a graph of ln(Count) vs. ln(ε). The slope of the line given at the top of the graph tells us based on our analysis how much of the plane our image covers or its relative dimension.

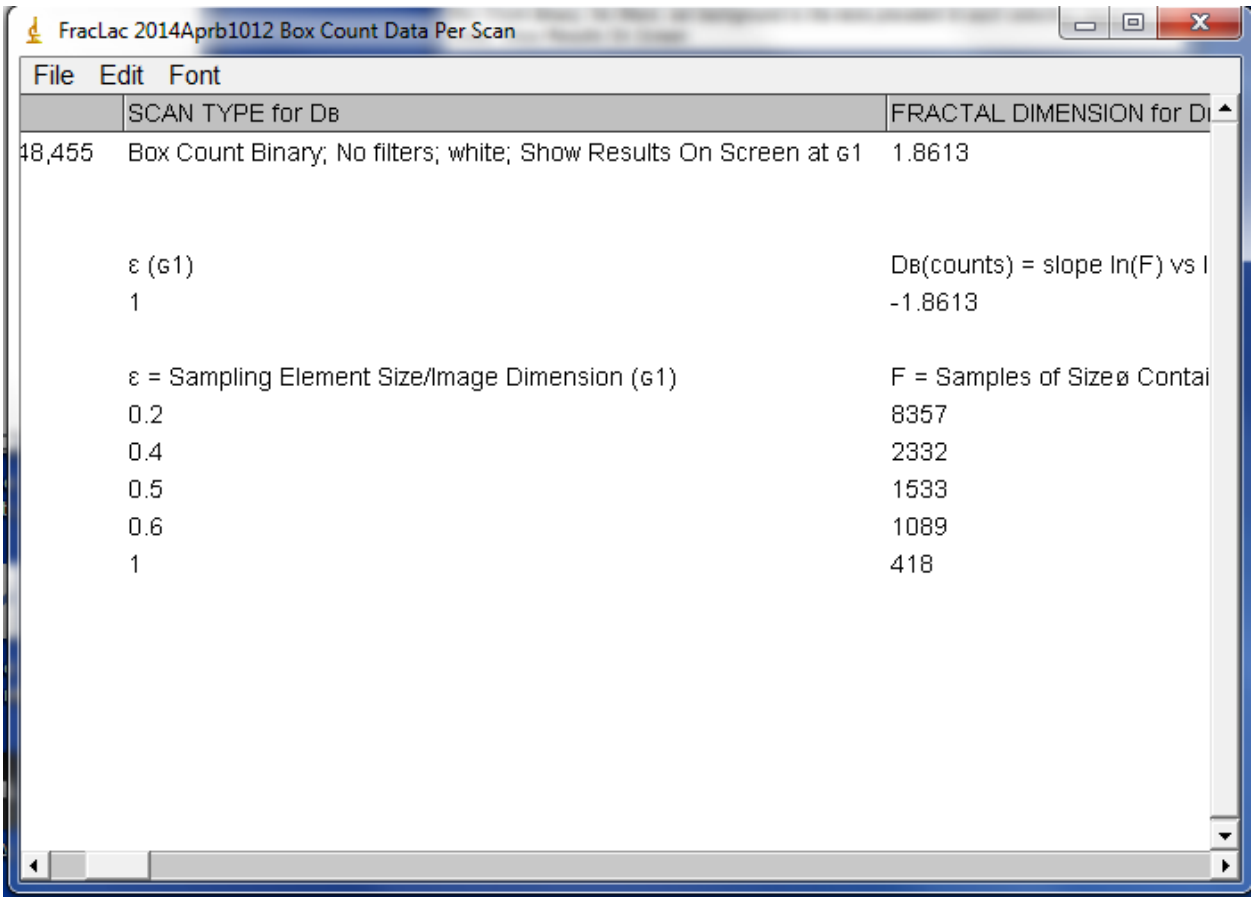


Custom Analysis & Log Log Graphing in Excel:

1. Users can also create a custom scan series in which they choose their own relative box size (ε) in pixels for each scan.



2. One of the windows resulting from the custom scan allows you to obtain the number of boxes and the relative box size (ε) in that particular scan.

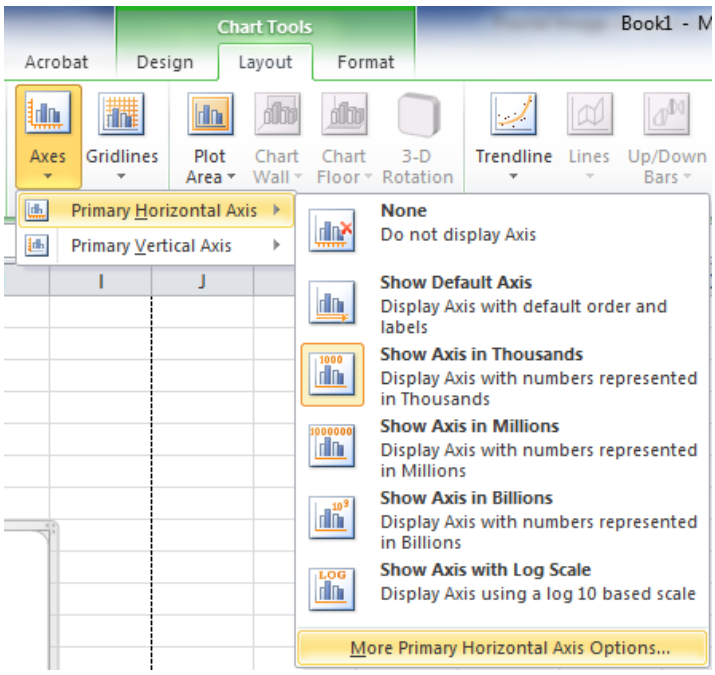


3. We can then input this data into excel to create our own log vs. log graph.

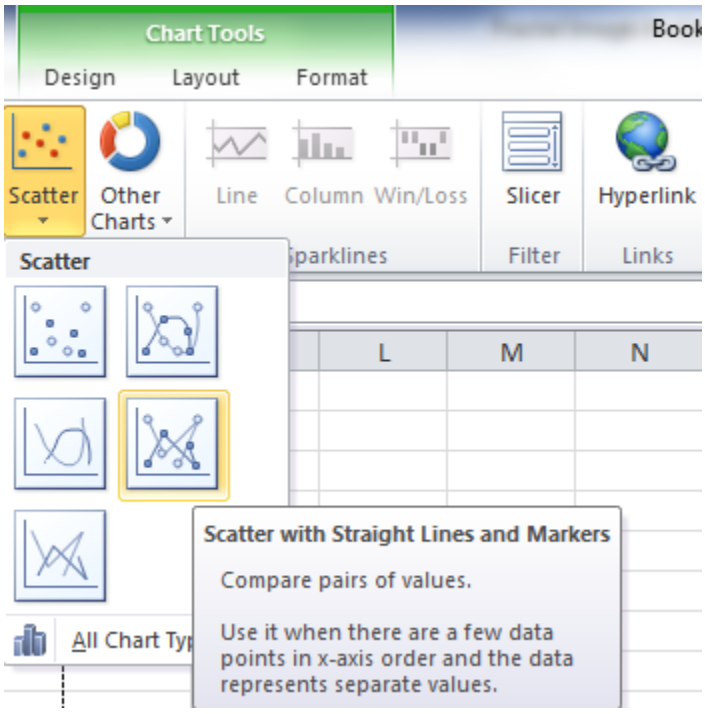
Data:

0.2	8357
0.4	2332
0.5	1533
0.6	1089
1	418

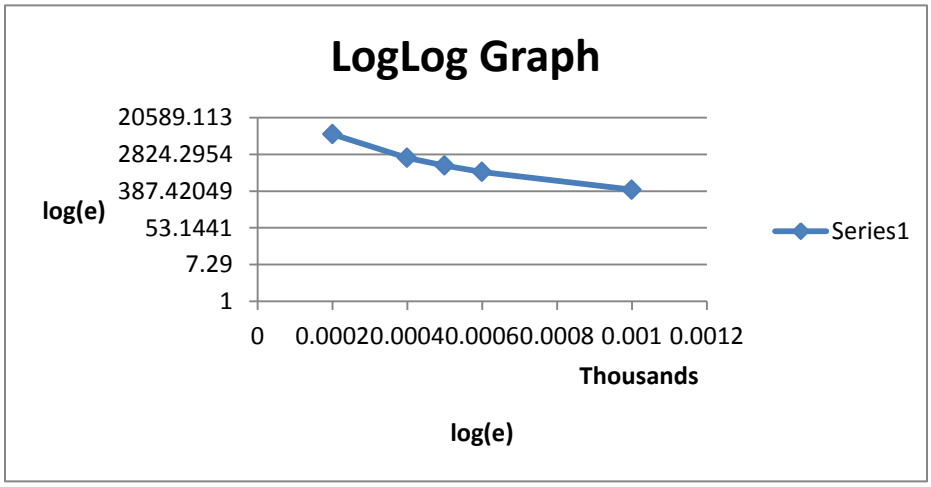
4. Highlight all the cells that include the data. Create a scatter plot by clicking on the little arrow under scatter plot and click the second option from the top in the right column.



5. In order to change the graph to a LogLog graph click under vertices and click the option entitled Logarithmic for both the “X” and “Y” axis. Set the scale to the thousandths place for four decimal place accuracy.



6. After altering the axis you can change the legends for the X and Y axis and you will obtain the following graph.



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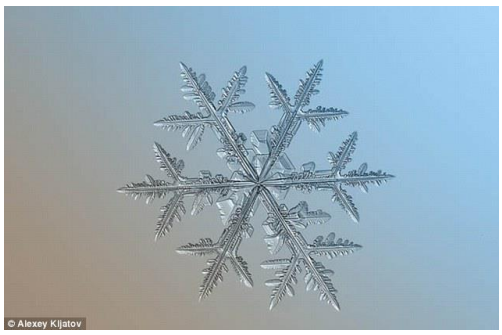
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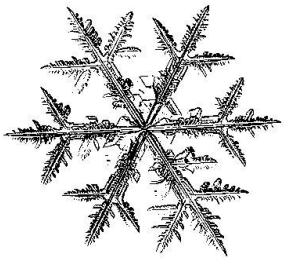
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