

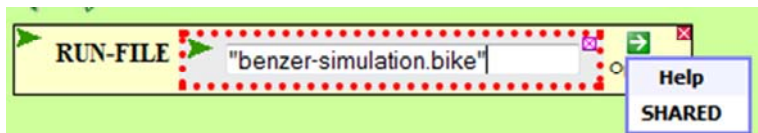
Molecular Biology Through Discovery
Analysis Tool
 Benzer (1959) *On the Topology of the Genetic Fine Structure*
 Proc Natl Acad Sci USA (1959) 45:1607-1620

Benzer analyzed thousands of crosses between T4 phages with different mutations in the rII region to determine if all the mutation sites could be arranged in a simple, unbranching line. Analyzing so much data is a daunting task – there's certainly far more than you can possibly analyze by our usual method of taking it all in and processing it by intuition. What's called for is an algorithm – a systematic approach to solve a problem – and Benzer provided one.

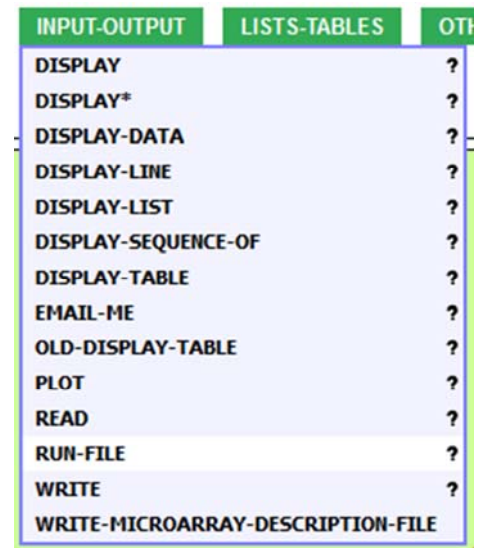
His claim is that if the data in Figure 4 of the article is reorganized such that so that the lines are in what he calls dictionary order. If the reorganization is successful, then for each line, all the zeros to the right of the diagonal will precede all the ones to the right of the diagonal.

Doing the reorganization for a big table can be pretty tedious, however.

I've written some functions that can greatly speed up the process. To use them, get into **CyanoBIKE**, get the RUN-FILE function from the INPUT-OUTPUT menu, and run a file called "benzer-simulation.bike".

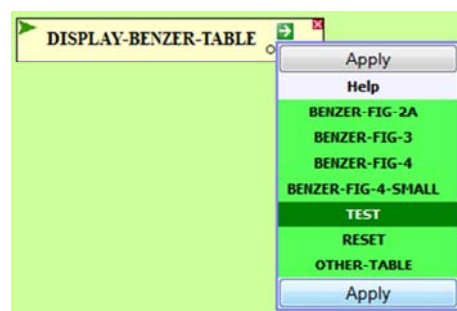


Be sure to press the Enter key after typing in the file name to close the input box (it should not be white). Then go to the Option menu and click SHARED, because the file lives in the shared directory, available to all. Finally, execute the function (either double-click RUN-FILE or use the Action menu through the green wedge).¹



You should find a possibly new FUNCTIONS key on your function palette. Go to that menu and click three functions: DISPLAY-BENZER-TABLE, SWAP-LINES, and MOVE-LINE.

Eventually you're going to want to display and fool around with Benzer's Fig. 4, but let's start small with a test case. Open the Options menu of DISPLAY-BENZER-TABLE, click **Test**, and click Apply. Then execute the function.



Test table

1	0	0	1	0	1	0
2	0	0	1	1	1	1
3	1	1	0	1	0	1
4	0	1	1	0	1	1
5	1	1	0	1	0	1
6	0	1	1	1	1	0

¹ If RUN-FILE fails, then check spelling, and check to see that you're in CyanoBIKE, not PhAnToMe

Is this in dictionary order? Not at all! It fails on the first line, since all the zeros to the right of the diagonal and below the diagonal are not clustered.

You have two functions to rearrange the table to get it into dictionary order (if that is possible). The functions are SWAP-LINES, which allow you to exchange one line with another, and MOVE-LINE, which allows you to move a specified line above or below a specified target line.

Let's see if we can improve matters. Line 3 seems to be a problem, since reading down the first column, I see that it presents a 1 in between two 0's. If I swap lines 3 and 6, that problem will go away, so:



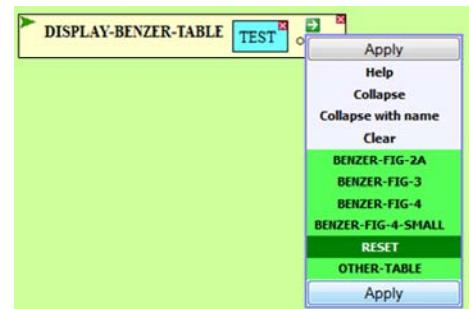
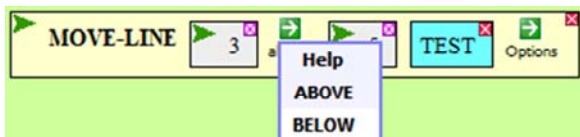
Test table

1	0	0	0	0	1	1
2	0	0	1	1	1	1
6	0	1	0	1	1	1
4	0	1	1	0	1	1
5	1	1	1	1	0	0
3	1	1	1	1	0	0

Note that I chose TEST from the Options menu, to indicate that I want to work on the current state of the test-table. Executing the function yields:

Is this in dictionary order? All the zeros are properly clustered, so yes! I'm through.

Now let's try it again a different way. Reset the table as shown to the right (being sure to click Apply), and execute the completed function. This will get you back to the original test table. Then :



Executing this gives you:

Close! But you need one more step.

Maybe now you're ready to try your hand with Benzer's actual figures.

Enjoy!

Test table

3	1	1	1	0	0	1
1	0	0	0	1	1	0
2	0	0	1	1	1	1
4	0	1	0	1	1	1
5	1	1	1	0	0	1
3	1	1	1	0	0	1
6	0	1	1	1	1	0