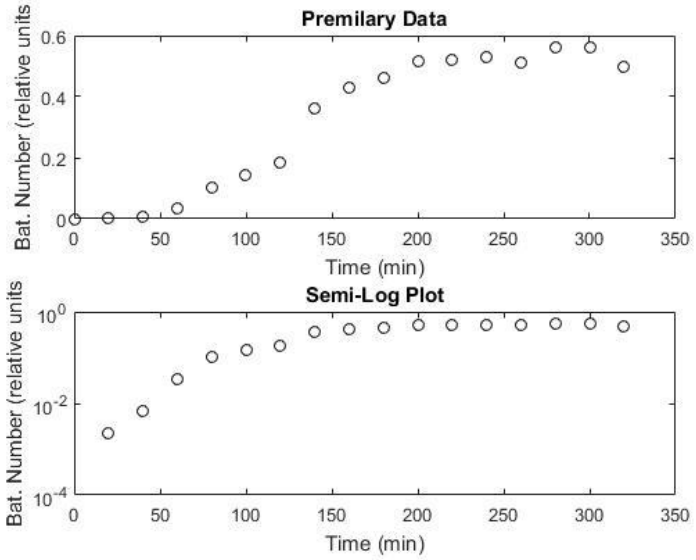
Our Data, Growth

I did some data manipulation to arrive at the following results for our bacteria experiment (Which was nicely done, btw):



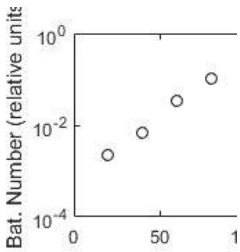
Task 1: This same data has been plotted two different ways. Let's think about what a semi-log plot is. Open up Matlab and do the following:

```
Gamma = 2;
N0    = 10;
tt    = 0:0.01:10;
NN    = N0 * exp(Gamma * tt);

plot (tt, NN)
```

```
Gamma = 2;
N0    = 10;
tt    = 0:0.01:10;
NN    = N0 * exp(Gamma * tt);

semilogy (tt, NN)
```

What do these code snippet do? Are they different? How so? What is interesting about the code on the right?

Task 2: Zooming in on our data, we see something amazing… What is going on here?



Task 3: In physics we try to model data with a governing equation or law. This is not magic. We reasonably think through the process. The governing equation here is:

$$\frac{\Delta N}{\Delta t} = \Gamma \, \mathrm{N}$$

Don't be fooled by the Greek letter Γ. Its just a Greek letter. Explain what the variables, N , t, and Γ are? What do they refer to? Knowing what you know about reproduction, why does this equation make sense?

Task 4: Many of you have to take calculus (which is good but not necessary). This is an easy problem to solve with a little calculus. I will do it for you. YOU DO NOT NEED TO KNOW THIS:

$$\lim_{\Delta t \to 0} \frac{\Delta N}{\Delta t} = \frac{dN}{dt} = \Gamma \, \mathrm{N}$$

Karate chop and integrate (get all the N stuff on one side of the equation and all the t stuff on the other side):

$$\frac{dN}{N} = \Gamma \, \mathrm{dt} \rightarrow \int_{N_0}^{N} \frac{1}{\mathrm{N}} dN = \Gamma \int_{0}^{t} \mathrm{dt}$$

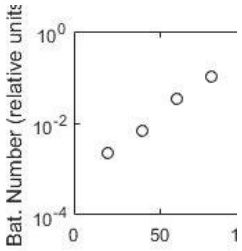
$$\ln N - \ln N_0 = \ln \frac{N}{N_0} = \Gamma \mathrm{t}$$

Which leads to:

$$N = N_0 e^{\Gamma \mathrm{t}}$$

When a pen and paper answer is possible, try to find it. It makes your life a lot easier. However, the thing is that it may not be because nature does whatever it does. So the general method is to numerically compute rate equations, see Tasks 5 & 6.

Knowing what you know now, what is the value of Γ for our data?



Task 5: Algorithm time!!!

$$\frac{\Delta N}{\Delta t} = \Gamma \, \mathrm{N}$$

Explain the following three equations:

$$\frac{N_1 - N_0}{\Delta t} = \Gamma \, \mathrm{N}_0 \qquad \frac{N_2 - N_1}{\Delta t} = \Gamma \, \mathrm{N}_1 \quad \ldots. \qquad \frac{N_{n+1} - N_n}{\Delta t} = \Gamma \, \mathrm{N}_\mathrm{n}$$

What is the significance of rearranging the one of the right in the following manner: (Also, please do the algebra)? Δt is the step step, what do I know about this value? Should it be big or small, why?

$$N_{n+1} = (1 + \Delta t \, \Gamma) \, \mathrm{N}_\mathrm{n}$$

Task 6: Convert this equation to code, try it out:

$$N_{n+1} = (1 + \Delta t\ \Gamma)\ \mathrm{N_n}$$

Can you know tell me what Γ is in our data?