1. **Modelling the acquisition of language**. The percentage $p(t)$ of children who can speak at least single words by the age of t months can be modeled by the equation , $p(t) = 100(1 - \frac{12,200}{t^{4.48}})$. Use Desmos[1] to graph this equation.

    a. What is the interpretation of the t-intercept of the graph?

    b. What percentage of children can speak at least single words by the age of 12 months?

    c. By what age are 90% of children speaking at least single words?

2. **Climate change**. The most abundant greenhouse gas is carbon dioxide. According to the UN's "worst-case scenario" prediction the amount of carbon dioxide in the atmosphere (in parts of volume per million) can be approximated by $C(t) \approx 277\,\mathrm{e}^{0.00353t}$ where t is the time in years since 1750.

    a. What does the model predict the amount of carbon dioxide in the atmosphere is now? How accurate is this?

    b. What does the model predict the amount of carbon dioxide in the atmosphere will be in 2025? 2050? 2100?

    c. According to the model when will the level surpass 700 parts per million?

3. **Earthquakes**. The Richter Scale is used to measure the intensity of earthquakes using the formula $R = \frac{2}{3}\left(\log E - 11.8\right)$ where E is the energy released by the earthquake measured in ergs.

    a. The San Francisco earthquake of 1906 registered $R = 8.2$ on the Richter scale. How many ergs of energy were released?

    b. In 1989 another San Francisco earthquake registered $R = 7.1$ on the Richter scale. How many times stronger (in terms of energy released) was the 1906 earthquake than this one?

    c. If one earthquake registers 2 points more than another on the Richter scale how many times more energy does it release?

[1] https://www.desmos.com/calculator

4. **Sunspots**. The activity of the sun (sunspots, solar flares, and coronal mass ejection) fluctuates cyclically. Sunspot activity can be modeled by the function $N(t) = 57.7\sin[0.60(t-1.43)] + 58.8$ where t is the number of years since January1, 1997 and N(t) is the number of sunspots observed at time t. According to the model:

    a. What is the period (length of cycle) of sunspot activity?

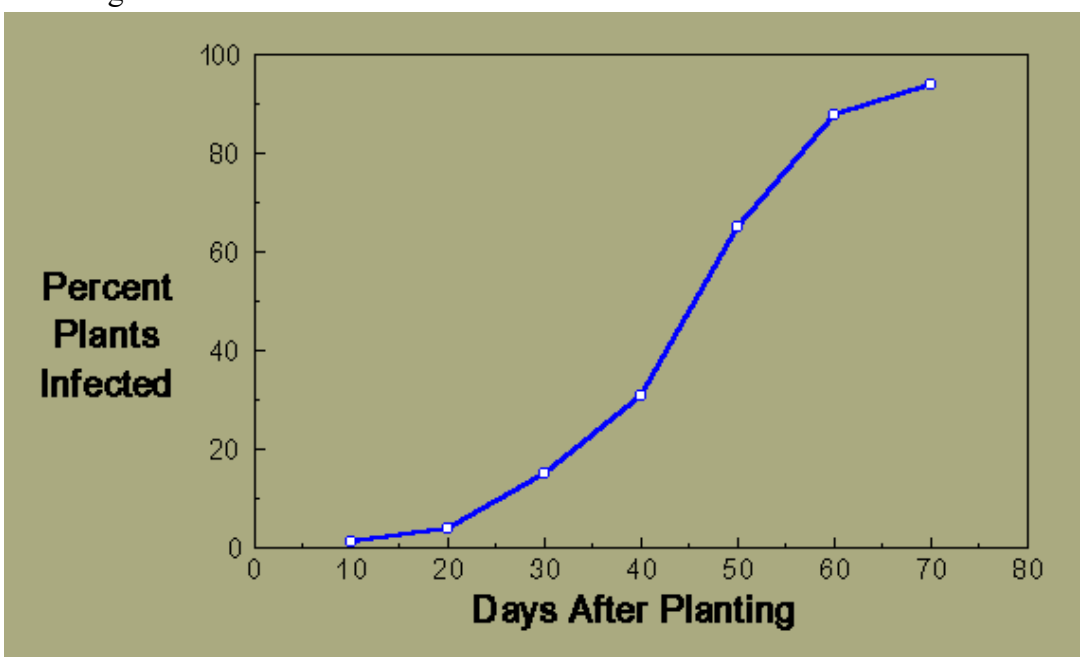
    b. What is the maximum number of sunspots observed?

    c. What is the minimum number of sunspots observed?

    d. In what coming year is sunspot activity next expected to reach a high point?

Plant diseases. Plant diseases follow many different courses, both within a year, and across years. For each of the following graphs[2] suggest the type of model that would be most appropriate, and provide an *approximate* model for the data.[3]

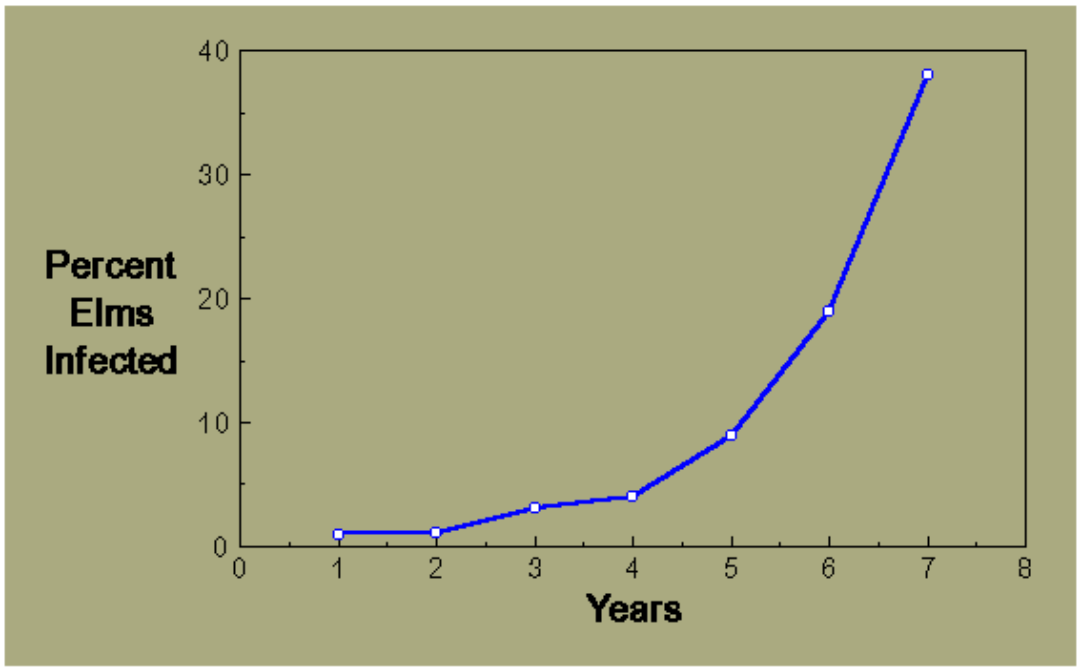
5. Halo blight disease



[2] All graphs from: http://www.apsnet.org/edcenter/advanced/topics/EpidemiologyTemporal/Pages/Disease%20Progress.aspx

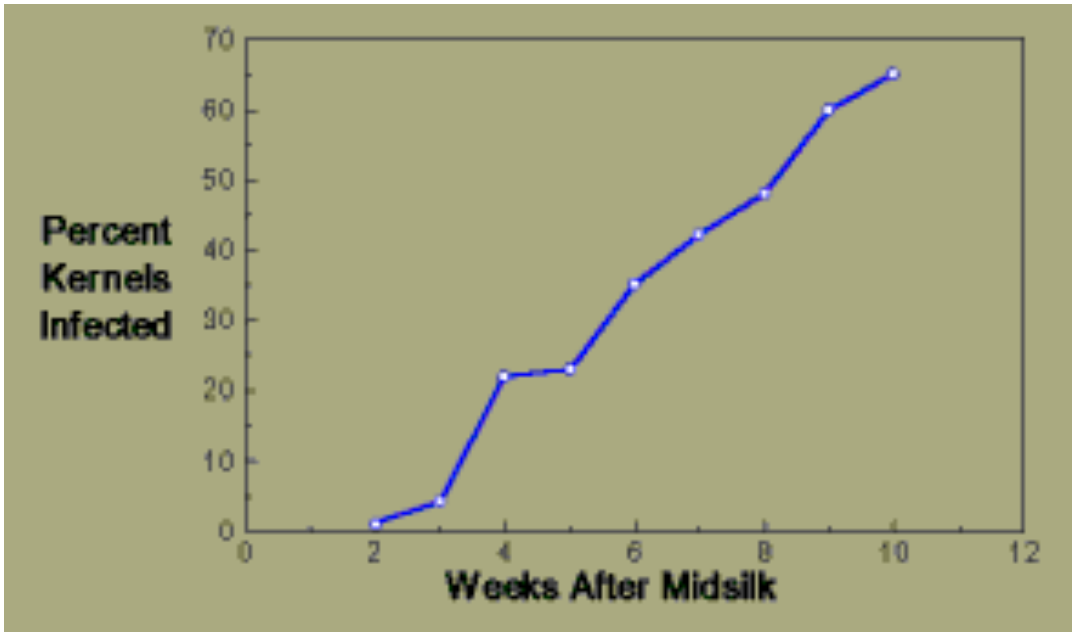
[3] I've prepared a Desmos worksheet with the data sets at https://www.desmos.com/calculator/wsdkfoldu6 You will need to log in to the Desmos app to save your models. If you have a gmail address that is an easy way to log in.

6. Dutch Elm Disease

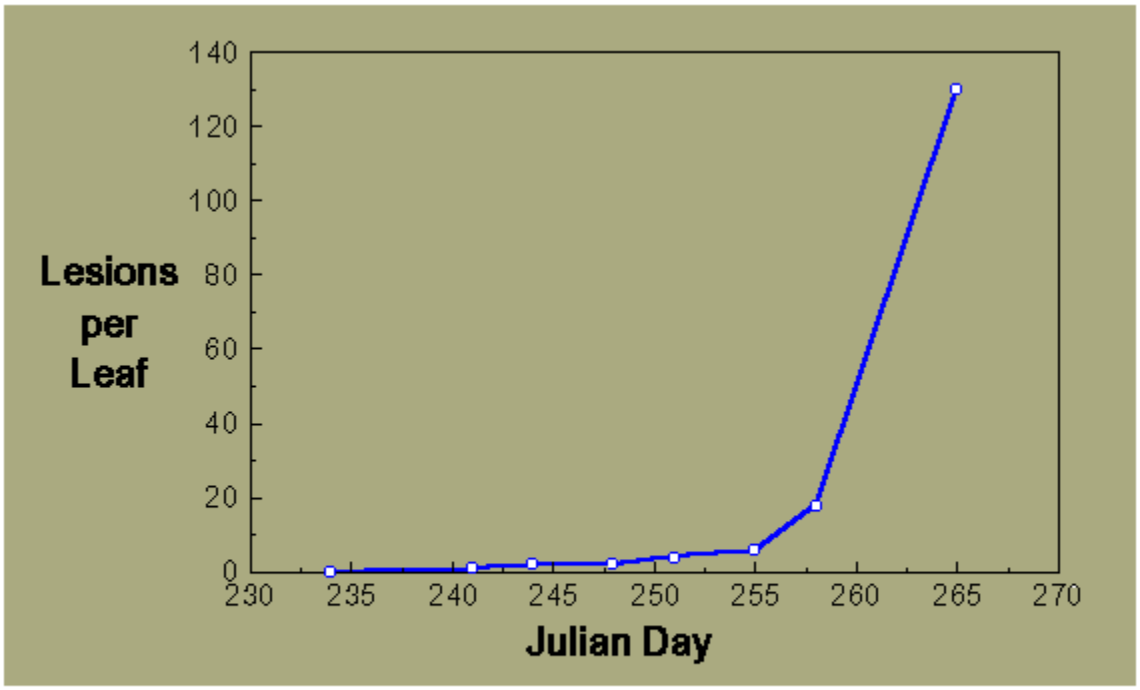


Polyetic Epidemic: Dutch elm disease
Redrawn from: Van Sickle, G. A. and Sterner, T. E. 1976. Sanitation: A practical protection against Dutch elm disease in Frederickton, New Brunswick. Plant Disease Reporter 60:336-338.

7. Fusarium kernel rot of maize

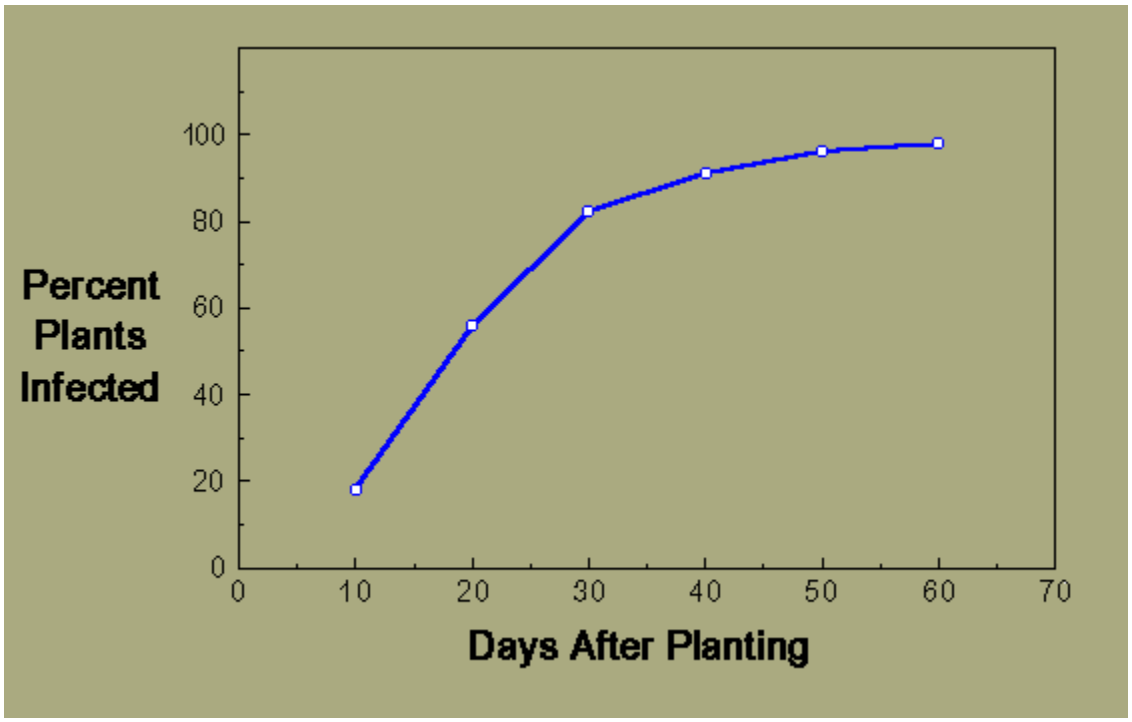
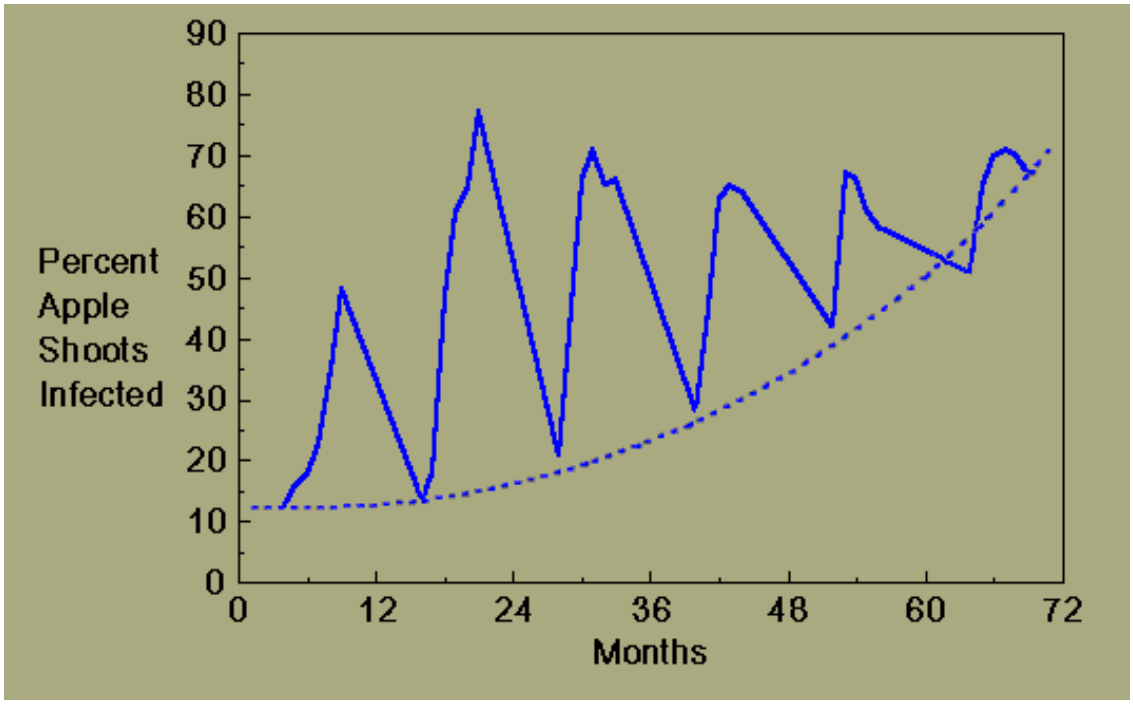


8. Gray leafspot on maize



Gray Leafspot on Maize.
Redrawn from: Rupe, J. C., Siegel, M. R., and Hartman, J. R. 1982. Influence of environment and plant maturity on grey leaf spot of corn caused by *Cercospora zeae-maydis*. Phytopathology 72:1587-1591.

9. Flax Wilt



10. Polyetic Epidemic: Apple Powdery Mildew