Discrete Difference Equation Models

Potential Entry Point Models

Possible Entry Point Models

Single Equation Models

Linear Models

- ***Exponential Growth/Decay***

$$x_{t+1} = a x_t$$

  - Cell culture growth
  - Drug decay
  - Cohort mean annual survival (life tables)

- ***Linear Difference Equation***

$$x_{t+1} = a x_t + b$$

  - Drug dosing
  - Harvesting/fisheries maximum sustainable yield
  - Continent-island model (one-way gene flow)

Nonlinear Models

- ***Population Growth with Resource Constraints***
  - Logistic Difference Equation

$$x_{t+1} = x_t + r x_t \left(1 + \frac{x_t}{K}\right)$$

  - Beverton-Holt Difference Equation

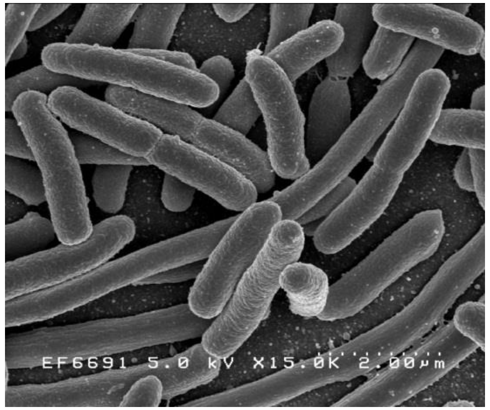
$$x_{t+1} = \frac{rKx_t}{K + (r-1)x_t}$$

- ***Natural Selection Model***

$$q_{t+1} = \frac{w_2(1-q_t)q_t + w_3 q_t^2}{w_1(1-q_t)^2 + 2w_2(1-q_t)q_t + w_3 q_t^2}$$

  - Comparing different modes of selection

Optical Density of *E. coli* cell culture



Scanning electron micrograph of *E. coli*

Table gives the optical density of an *Escherichia coli* cell culture measured every 30 minutes for 3 hours. The culture was grown in a nutrient solution at 37°C.

Time (hours)	0.0	0.5	1.0	1.5	2.0	2.5	3.0
Cell Density (OD_{600})	0.055	0.120	0.231	0.360	0.516	0.821	1.300

$x_0 = 0.055,\ x_1 = 0.120,\ x_2 = 0.231,\ x_3 = 0.360,\ x_4 = 0.561,$
$x_5 = 0.821,\ x_6 = 1.300$

n	$x_{n+1} - x_n$	x_{n+1}/x_n
0	0.065	2.18
1	0.111	1.93
2	0.129	1.56
3	0.156	1.43
4	0.305	1.59
5	0.479	1.58

$$x_{n+1} = 1.712 x_n \text{ (model 1)}$$

Arithmetic mean of ratios

$$x_{n+1} = 1.693 x_n \text{ (model 2)}$$

Geometric mean of ratios

$$x_{n+1} = 1.585 x_n \text{ (model 3)}$$

Median of ratios

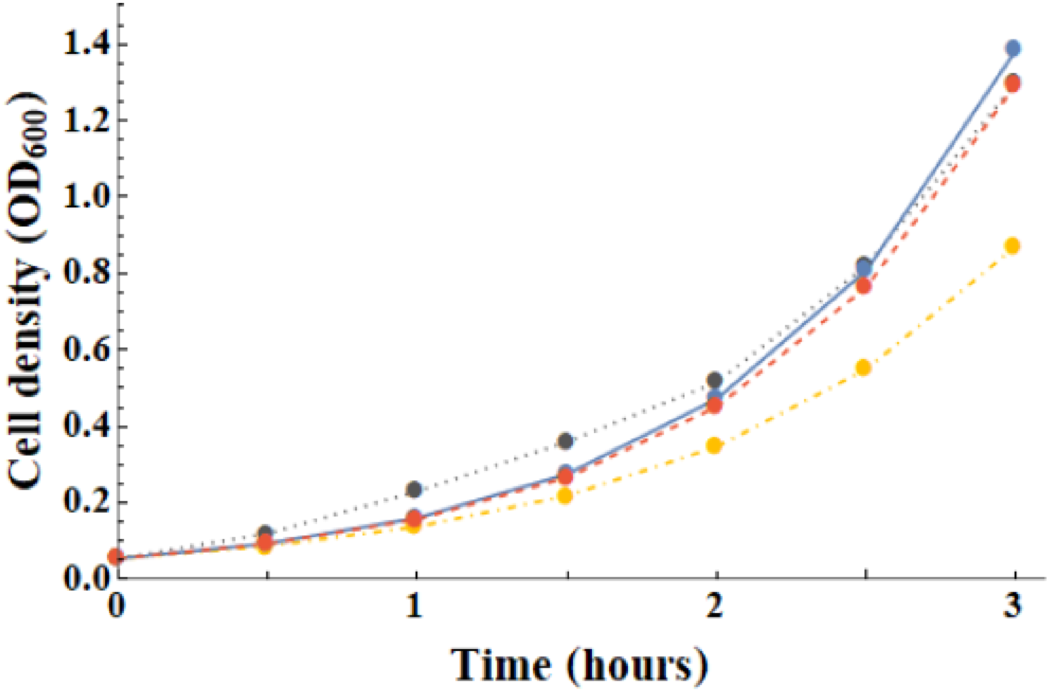


Figure 2: Optical density of the *E. coli* cell culture measured every 30 minutes over 3 hours (dotted grey), and estimated optical density using model 1 (solid blue), model 2 (dashed red), and model 3 (dot-dash yellow).