Growth Kinetics

Growth and nutrition: Phases in growth, Growth Curve, Calculation of G-time, Physical and environmental requirements of growth

I. The Growth Curve in batch culture

A. Growth is an increase in cell constituents

B. For most animal cells, growth in indicated by an increase in cell # because cell division accompanies growth

C. Batch culture = cultivation of organisms in 1 batch of liquid medium

D. Growth curve

1. Experimental design
   a) Introduce small number of animal cells into new medium →
   b) monitor # of viable cells as a function of time by spectrophotometry or by diluting aliquot of culture and plate on agar plates (plate counts)
   c) plot on semilogarithmic scale: log for # of cells (or OD) and linear for time)
2. Phases of growth of a population of cells
   a) Lag
      (1) No increase in cell # when cells are introduced into fresh media
      (2) Reasons
         (a) Cells may be depleted of a variety of factors that may need to be resynthesized
         (b) Medium may be different that previous one and thus new enzymes may be needed for growth
         (c) Cells may be injured and need time to recover
   b) Exponential phase
      (1) Cells are growing at maximal rate possible for the particular conditions
      (2) Growth rate is constant
      (3) Growth is exponential – cell growth doubles every x min (generation time)

Time	# of cells
0	1
0.5	2
1	4
1.5	8
2	16
2.5	32
3	64
3.5	128
4	256
4.5	512
5	1024
5.5	2048

c) Stationary phase
   (1) No net increase in cell #
   (2) Mostly due to cessation of cell division
      (a) depletion of nutrients
      (b) accumulation of waste
   (3) Also due to balance between cell death and cell division
   (4) For cells typically at 10^9 cells/ml

d) Death phase
   (1) Decrease in viable cell #
   (2) Causes are extended nutrient deprivation and accumulation of toxic waste

E. Generation time
1. Generation time (g) is the time it takes a culture or animals cells to double in number (doubling time)
2. Determination g using mathematics
   a) g = t/n where:
      (1) t = time of exponential growth
      (2) n = # of generations in time t as calculated:

exponential growth = 2^n

N_o = # of cells in population initially N_t = # of cells in population at time t

$$N_t = N_o \times 2^n$$

$$\log N_t = \log N_o + n\log 2$$

$$\frac{\log N_t - \log N_o}{n \log 2} =$$

b) For example: What is the generation time if 100 animal cells growing logarithmically for 5 hours produced 1.7×10^6 cells?

$$n = \frac{\log(1.7 \times 10^6) - \log 100}{\log 2} = 14 \text{ generations in 5 hours}$$

g = 5 hours/14 generations = 0.357 generations/hour

3. Determination of g using growth curve data
    a) Plot time on X axis and cells/ml on Y axis (log scale)
    b) Pick a point on the Y axis in log growth
    c) Draw a line from the Y axis point in (b) to the plotted graph and then down to the X axis to determine the time at which the population was at that cell density (b)
    d) Multiple the point that you picked in (b) by 2 (because we want to know when the population doubles)
    e) Draw a line from the Y axis point determined in (d) to the plotted graph and then down to the X axis to determine the time at which the population was at that cell density (d)
    f) The generation time is the difference between the X values from (e) and (c)