FDE 328
INDUSTRIAL MICROBIOLOGY

Microbial Growth

Microbial Growth Kinetics

- **Growth kinetics**; describe the growth and product formation of microorganisms with mathematical equations.
- This includes not only active cell growth, but also the activities of cells in stationary or death phase.
- Because many commercially important fermentation products occur after cell growth is completed.
- In some industrial productions, the enzymes released after the cell dies perform the necessary biotransformation and provide product formation.

Microbial Growth Kinetics

- Unlimited growth can be considered after optimizing all growth parameters (physical, chemical, biological).

- In order to optimize the conditions, that is, for an unrestricted growth;

  - The required nutrients should be more than the demanded ones in the environment.
  - There should be no insoluble elements in the environment.
  - Cells must be active.
  - There should not be growth-limiting inhibitors in the environment.

Microbial Growth Kinetics

- Mathematically, the exponential growth can be described by 2 methods;
  - One is related to biomass (X)
  - The other is related to cell numbers (N)

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- $\frac{dX}{dt} = \mu X$

- $\frac{dN}{dt} = \mu_n N$

X : Concentration of biomass (g/L)

N: Cell number (cells/mL)

t : Time (h)

μ : Specific growth rate (per hour) (h^{-1}) (cell mass)

μ_n : Specific growth rate (per hour) (h^{-1}) (cell number)

1. The first equation shows the increase in cell mass over time.

2. The second equation shows the increase in cell number over time.

Microbial Growth Kinetics

Taking the integral of this equation, we have;

$$\int_{x1}^{x2} \frac{dX}{X} = \int_{t1}^{t2} \mu \, dt$$

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When $X_2 = 2X_1$;

Δt; $(t_2 - t_1) = t_d$, so it shows **the doubling time** and from here;

$$t_d = \frac{ln(X_2/X_1)}{\mu} = ln\,\frac{2}{\mu} = \frac{0{,}693}{\mu}$$

Microbial Growth Curve (Log/exponential phase)

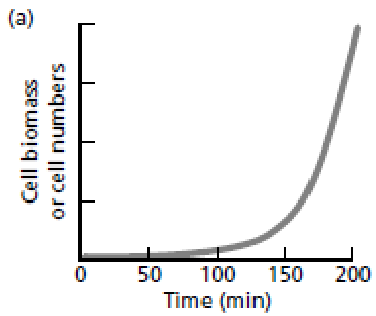
For cell biomass;

- Growth can be considered as an autocatalytic reaction.
- Therefore, the rate of growth is dependent on the biomass concentration, i.e. catalyst, that is present at any given time.
- This can be described as follows:

Rate of change of biomass ⇨ $dx/dt = \mu X$ (Equation 1)

X = concentration of biomass (g/L)
μ = specific growth rate (per hour)
t = time (h)

- When a graph is plotted of cell biomass against time, the product is a curve with a constantly increasing slope.



- Equation 1 can be rearranged to estimate the specific growth rate (μ):

$\mu = 1/X * dx/dt$ (Equation 2)

- During any period of exponential growth, Equation 1 can be integrated to provide the following equation:

$X_t = X_0 * e^{\mu t}$ (Equation 3)

- https://www.youtube.com/watch?v=CfOecDMBrOk