

Simplified Balance:

$$\dot{n}X_{acc,j} = \dot{n}X_{gen,j} \quad (j=1,2,\dots,M)$$

$$\frac{d}{dt} \int_B X_j dB = \int_B (\dots) dB$$

Well mixed assumption:

$$\frac{d}{dt} (X_j B) = (\dots) B$$

$$\dot{X}_j = (\dots) - X_j \underbrace{B^{-1} \dot{B}}$$

$$B^{-1} \dot{B} = \cancel{X^{-1} \dot{X}} + \cancel{V_R^{-1} \dot{V}_R}$$

0 b/c

0 b/c V_R const.

cell-free

(no growth)

$$\Rightarrow \dot{X}_j = (\dots) \quad \text{NO DILUTION}$$

$$\begin{aligned} \dot{m} &= r_X u - \theta_m m + \lambda \\ \dot{p} &= r_L w - \theta_p p \end{aligned}$$