SECTION II: KINETICS AND BIOREACTOR DESIGN:

LESSON 10.2. - Bioreactor design – Design Equations - Examples

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AIMS FOR TODAY'S LESSON

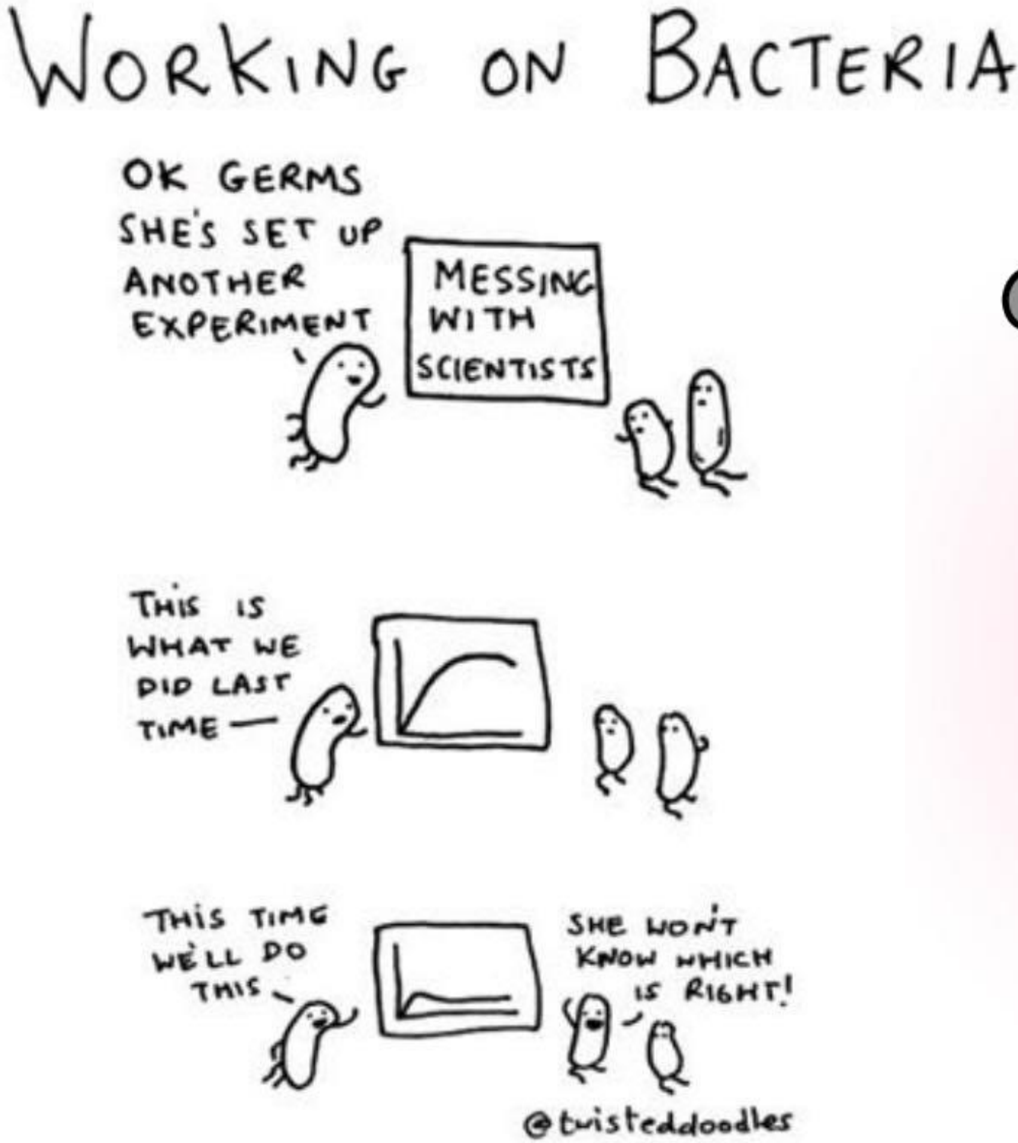
10.1 Design equations

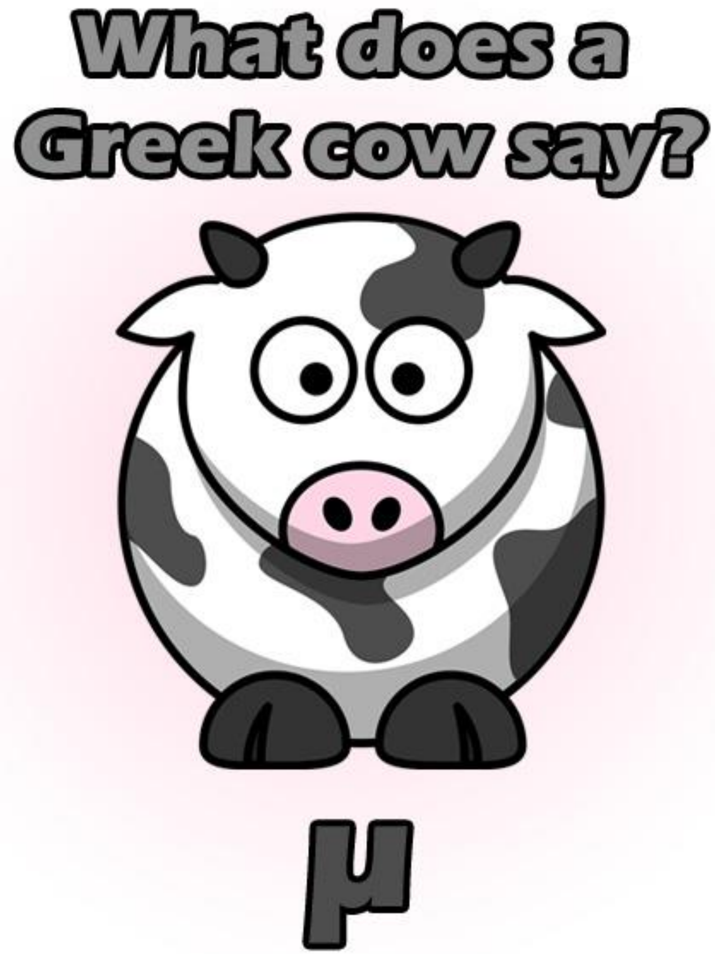
10.2 Exercises

10.3 Tank vs Tubular reactor: Comparing efficiency

10.4 Recycle, By-pass and Purge

10.5 Bioreactor association


WORKING ON BACTERIA
OK GERMS SHE'S SET UP ANOTHER EXPERIMENT
MESSING WITH SCIENTISTS
THIS IS WHAT WE DID LAST TIME —
THIS TIME WE'LL DO THIS
SHE WON'T KNOW WHICH IS RIGHT!
@twisteddoodles


What does a Greek cow say?
μ

Example #1:

An enzymatic process where the following reaction takes place

$$\mathbf{A \rightarrow R},$$

can be described using a first-order kinetic equation:

$$\mathbf{r\ (mole \cdot L^{-1} \cdot h^{-1}) = 1.2 \cdot [A]}$$

This reaction is carried out using a batch reactor where the working temperature is constantly 50°C. The reactant mixture presents an initial concentration of 12 moles/L in A.

What is the reaction time (t_R) needed in order to reach an X_A of 0.80?

Example #2:

One current containing **3 moles/L of substrate** and **0.01 g/L of enzyme** is fed into a **Continuous Stirred Tank Reactor** (CSTR). The kinetic parameters corresponding to the equation describing the process (Michaelis-Menten equation) are:

K_{cat} = 2 moles/(min.gE) and **K_M = 0.1 (mole S)/L**.

Calculate the volume needed to treat a 30 L/min stream so that an output conversion of 99.5% is achieved.

Example #3:

The growth of an aerobic microorganism is carried out within a **3 L** bioreactor working as a **continuous stirred tank** fed with **0,15 L/h**.

If growth can adequately be described using the kinetic model proposed by **Monod**, and **nitrogenous substrate can be considered as limiting nutrient**, calculate both biomass and limiting substrate concentrations when steady state is achieve.

Inlet substrate concentration is 0.4 g/L.

Kinetic parameters for the biological system under the operating conditions are:

$$\mu^{max} = 0.2\ h^{-1},\ K_N = 0.06\ g\ N/L,\ Y_{X/N} = 4.6\ gX / gN.$$

Example #4:

30 g/h of a certain yeast need to be obtained. The kinetic model describing its growth has been obtained, taking into account that it is **limited by the amount of nitrogenous substrate** present in the fermentation broth.

Calculate the volume of the continuous tank reactor required for this production.

Kinetic model:

$$R_X\,(gX/L\cdot h) = \mu_m \cdot [N] \cdot [X]$$

$$R_N\,(gN/L\cdot h) = -Y_{N/X} \cdot R_X$$

where: μ_m = 0.5 L / g N.h; $Y_{N/X}$ = 0.17 gN / gX;

And F = 12 L / h; $[N]_0$ = 0.8 gN / L

Example #5:

A 100 L bioreactor consisting in a continuous stirred tank is fed with a 10 L/h current containing 0,75 g/L of a growth limiting substrate.

The kinetic model describing the system has been previously obtained.

Calculate the amount of product generated per hour.

Data:

Kinetic model:

$$\begin{cases} R_X\left(gX/L\cdot h\right)=0{,}46\cdot\left[N\right]\cdot\left[X\right] \\ R_N\left(gN/L\cdot h\right)=-0{,}15\cdot R_X \\ R_P\left(gP/L\cdot h\right)=0{,}71\cdot R_X \end{cases}$$

Example #6:

A continuous tubular reactor is used in order to carry out the reaction

$$A + B \rightarrow R + S$$

catalyzed by an enzyme. The fed stream contains "A" and "B" in an equimolecular ratio at a 500 L/min flow. The concentration of "A" at the entrance is 0.18 M

In order to achieve an output conversion of 85%, what volume of the reactor is needed?

Although the enzymatic process, the kinetics of the reaction taking place can be expressed as:

$$r = 10 \cdot [A] \cdot [B] \ (\text{mole / L / min})$$

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