10.5. Consider the 10-l and 10,000-l tanks described in Example 10.4. Suppose that fully continuous operation is to be used, and F was fixed at 5 mg/l-s for both tanks, and $D = 0.2\ h^{-1}$ for each tank with fluid removal from the top. What fraction of the inlet substrate would be consumed in each tank? If the biomass yield coefficient were 0.5 g cells/g substrate and $Y_{P/X}$ = 0.1 g product/g cells, what would be the effect on volumetric productivity upon scale-up?

10.6. A continuous culture system is being constructed. The fermentation tank is to be 50,000 l in size and the residence time is to be 2 h. A continuous sterilizer is to be used. The unsterilized medium contains 10^4 spores/l. The value of k_d has been determined to be 1 min^{-1} at 121°C and 61 min^{-1} at 140°C. For each temperature (121°C and 140°C), determine the required residence time in the holding section so as to ensure that 99% of the time four weeks of continuous operation can be obtained without contamination (due to contaminants in the liquid medium).

10.7. Discuss the effects on sterilization of mixing in a batch fermenter.

10.8. A medium containing a vitamin is to be sterilized. Assume that the number of spores initially present is 10^5/l. The values of the pre-Arrhenius constant and E_{0d} for the spores are

$$E_{0d} = 65 \text{ kcal/g-mol}$$
$$\alpha = 1 \cdot 10^{36} \text{ min}^{-1}$$

For the inactivation of the vitamin, the values of E_{0d} and α are

$$E_{0d} = 10 \text{ kcal/g-mol}$$
$$\alpha = 1 \cdot 10^{4} \text{ min}^{-1}$$

The initial concentration of the vitamin is 30 mg/l. Compare the amount of active vitamin in the sterilized medium for 10-l and 10,000-l fermenters when both are sterilized at 121°C when we require in both cases that the probability of an unsuccessful fermentation be 0.001. Ignore the effects of the heat-up and cool-down periods.

10.9. Consider the data given in the table on the temperature changes in a 10,000-l fermenter, which includes the heat-up and cool-down periods. Use the values for the Arrhenius parameters given in Problem 10.8 and assume an initial spore concentration of 10^5/l and a vitamin concentration of 30 mg/l.

Time (min)	Temperature (°C)
0	30
10	40
20	54
30	70
40	95
50	121
55	121
60	121
65	106
70	98
90	75
100	64
120	46
140	32