feed is $S_0 = 10$ g glucose/l. The kinetic constants of the organisms are $\mu_m = 0.2\ h^{-1}$, $K_s = 1$ g glucose/l. The value of C is 1.5, and the recycle ratio is $\alpha = 0.7$. The system is at steady state.

a. Find the substrate concentration in the recycle stream (S).
b. Find the specific growth rate (μ_{net})of the organisms.
c. Find the cell (biomass) concentration in the recycle stream.
d. Find the cell concentration in the centrifuge effluent (X_2).

Solution Using eq. 9.9, we determine μ_{net}.

$$\mu_{net} = [1 + \alpha(1 - C)]D = [1 + (1 - 1.5)0.7](0.1) = \mu_g$$
$$= 0.065\ h^{-1}$$

Then

$$S = \frac{K_{s\,net}}{\mu_m - \mu_{net}} = \frac{(1)(0.065)}{0.2 - 0.065} = 0.48\ g/l$$

$$X_1 = \frac{D(S_0 - S)Y^M_{X/S}}{\mu_g} = \frac{(0.1)(10 - 0.48)0.5}{0.065}$$
$$= 7.3\ g/l$$

A biomass balance around the concentrator yields

$$(1 + \alpha)X_1 = \alpha C X_1 + X_2$$
$$X_2 = (1 + \alpha)X_1 - \alpha C X_1$$
$$= (1.7)(7.3) - (0.7)(1.5)(7.3)$$
$$= 4.8\ g/l$$

9.3.2. Multistage Chemostat Systems

In some fermentations, particularly for secondary metabolite production, the growth and product-formation steps need to be separated, since optimal conditions for each step are different. Conditions such as temperature, pH, and limiting nutrients may be varied in each stage, resulting in different cell physiology and cellular products in multistage systems.

An example of a multistage system that may be beneficial is in the culture of genetically engineered cells. To improve genetic stability, a plasmid-carrying recombinant DNA usually uses an inducible promoter to control production of the target protein (see Chapter 8). In the uninduced state, the plasmid-containing cell grows at nearly the same rate as the cell that loses the plasmid (a revertant), so the plasmid-free cell holds little growth advantage over the plasmid-containing cell. However, if the inducer is added, the plasmid-containing cells will make large quantities of the desired protein product but will have greatly reduced growth rates. Thus, a single-stage chemostat would not be suitable for the production of the target protein because of resulting problems in genetic stability. A multistage system can circumvent this problem. In the first stage, no inducer is added and the plasmid-containing cell can be maintained easily (usually an antibiotic is added to kill plasmid-free cells; see Chapter 14 for a more complete discussion). In the second