E.1

Yeast with a diameter of 5.0 μm and density of 1.03 g/mL are in a 1.00 g/mL solution having a viscosity of 1.8 cP. What is the settling velocity of these particles?

A flocculent has been added which increases the mean particle diameter to 100 μm. What is the settling velocity of these particles?

E.2

A laboratory centrifuge is used to collect yeast cells after fermentation. During centrifugation the distance between the liquid surface and the axis of rotation is 3 cm. The distance from the top of the liquid surface to the bottom of the centrifuge tubes is 7 cm. The yeast cells are 5 μm in diameter and have a density of 1.03 g/mL. The fluid has viscosity of 1 cP and density of 1.00 g/mL.

a) If the centrifuge is operated at 1,000 rpm, how long is required to pelletize the yeast completely?
b) If the centrifuge is operated at 5,000 rpm, how long is required to pelletize the yeast completely?
c) If the tube is sitting upright on the benchtop, how long is required to pelletize the yeast completely?

E.3

Animal cells are cultivated on dextran bead microcarriers having a density of 1.02 g/mL and a diameter of 150 μm. A 50 liter operating volume tank having a diameter of 30 cm is used to cultivate cells grown on microcarriers to produce a vaccine. After growth, the stirring is stopped and the microcarriers are allowed to settle. The microcarrier-free fluid is then withdrawn to isolate the vaccine. The fluid has a density of 1.00 g/mL and a viscosity of 1.1 cP. Find:

a) The settling velocity of the microcarriers.
b) The Reynolds Number of the microcarriers.
c) The time needed for the microcarriers to settle completely.

E.4

Unfortunately, yeast cells and *Lactoccocus lactis* have densities that are very close (about 1.03 g/cm^3), and it is impractical to separate the two types of cells using equilibrium sedimentation. However, the cells are much different in size, with the particular yeast cell being 8 μm in diameter, and the bacterial cell being 1.0 μm in diameter. This difference in size has led you to consider a way to remove, at least partially, the bacterial cells from the yeast cells.

You start with a 20 mL tube that is 16 cm in height containing 10^8 yeast and 10^7 bacteria. The medium has a viscosity of 1.2 cP and a density of 1.00 g/cm^3.

Your idea is the centrifuge until all the yeast cells are below a certain height in the tube. At this point, some bacteria will remain in the upper portion of the tube. You remove the upper bacteria-containing portion carefully, then add fresh buffer to 20 mL and resuspend all the cells. You repeat this process. Then you repeat this process a third time. The fourth time you centrifuge the cells, you just discard the bacteria containing upper portion, leaving yeast cells with fewer bacterial cells.

a) How many bacterial cells remain if each time you centrifuge enough so that all the yeast are below the 8 cm line of the tube (half-way)?
b) How many bacterial cells remain if each time you centrifuge enough so that all the yeast are below the 4 cm line of the tube (three-quarters of the fluid is yeast-free)?
c) If you select the process described in b) above, what g-force will you need for each centrifugation step to take 20 minutes?