15.5. SUMMARY

The principles from bioprocess engineering are NOT restricted to use for biomanufacture of chemicals, medicinals, or other biological compounds. These same principles have many applications in medicine. Indeed, as biomedical engineering has become more oriented to molecular and cellular systems and bioprocess engineering more toward animal cells, the boundary between these two activities has become very porous.

Important concepts in this chapter include ideas of how to produce tissue constructs on a commercial scale. Also the efficient production of virus for use in gene therapy is an unresolved bioprocess problem. The basic understanding of the dynamics of viral infection of cells is important both in design of biomanufacturing processes and for gene therapy. Quantitative approaches to describing such processes can lead to rational design both for the biomanufacturing process and for therapeutic strategies. Bioreactor design is also an important component of design of artificial organs and reactors to generate functional tissue from stem cells.

The list of examples of the intersection of bioprocessing and medicine is a growing one that will present many readers of this text with exciting career possibilities.

SUGGESTIONS FOR FURTHER READING

A good source for most topics in biomedical engineering is

BRONZINO, J. D., Editor-in-Chief, *The Biomedical Engineering Handbook* (2d ed., 2 vols.), CRC Press LLC, Boca Raton, FL, 2000.

Chapters 97, 106, 109, 116, 120, 124, and 133 were used in preparation of this chapter.

Other useful sources include

DEE, K. U., D. A. HAMMER, AND M. L. SHULER, A Model of the Binding, Entry, Uncoating, and RNA Synthesis of Semliki Forest Virus in Baby Hamster Kidney (BHK-21) Cells, *Biotechnol. Bioeng. 46*:485–496, 1995.

LE DOUX, J. M., H. E. DAVIS, J. R. MORGAN, AND M. L. YARMUSH, Kinetics of Retrovirus Production and Decay, *Biotechnol. Bioeng. 63*:654–662, 1999.

NAUGHTON, G. K., Skin: The First Tissue-Engineered Products, The Advanced Tissue Sciences Story, *Sci. Am. 280* (4):84–85, 1999.

TUBO, R., Restoring Wounded Knees, *Sci. & Med. 6*(2):6–7, 1999.

PROBLEMS

15.1. Many experiments for virus trafficking are done with prebound virus. Virus attaches at low temperature to suppress endocytosis, and unbound virus is washed away. Cells are then warmed to 37°C to initiate endocytosis. Derive equations in this case for the time-dependent concentration of internalized virus and virus that enters the cytosol and uncoats.