

(for example, lactate and ammonium) or effectively remove such metabolites from the microenvironment of the cells.

## SUGGESTIONS FOR FURTHER READING

- CHALMERS, J. J., "Animal cell culture. Effects of agitation and aeration on cell adaption," in *Encyclopedia of Cell Technology*, R. Spier, J. B. Griffiths, and A. H. Seragg, eds., Wiley, New York, 2000. (See also other related articles in this book.)
- FRESHNEY, R. I., *Culture of Animal Cells: A Manual of Basic Technique*, 2d ed., Alan R. Liss, Inc., New York, 1987.
- HO, C. S., AND D. I. C. WANG. *Animal Cell Bioreactors*, Butterworth-Heinemann Press, Stoneham, MA, 1991.
- HU, W-S., AND PESHA, M. V., Mammalian Cells for Pharmaceutical Manufacturing, *ASM News*, 59(2):65–68, 1993.
- MARINO, M., C. ANGELO, A. IPPOLITO, G. CASSANI, AND G. FASSINA, Effect of bench-scale culture conditions on murine IgG heterogeneity, *Biotechnol. Bioeng.* 54: 7–25, 1997.
- SHULER, M. L., H. A. WOOD, R. R. GRANADOS, AND D. A. HAMMER, *Baculovirus Expression Systems and Biopesticides*, Wiley-Liss, New York, 1995.

The series *Advances in Cell Culture* published by Academic Press, New York, is a good source of review articles.

## PROBLEMS

- 12.1. Cite the major differences between animal, plant (see Chapter 13), and bacterial cells in terms of cell structure and physiology.
- 12.2. Describe the role of glutamine in animal cell metabolism.
- 12.3. Compare serum-containing and serum-free media in terms of their advantages and disadvantages.
- 12.4. What are the roles of CO<sub>2</sub> provided in air to animal cell cultures?
- 12.5. What are the common features of animal cell bioreactors?
- 12.6. Compare the following immobilization methods used for animal cells in terms of their relative advantages and disadvantages: microcarrier (surface) culture, porous beads, encapsulation, and gel entrapment.
- 12.7. What do you think is the most suitable reactor type, mode of operation (batch, continuous perfusion), and cultivation method (suspended, immobilized) for animal cell cultures, in general? Compare your choice with the other alternatives in detail.
- 12.8. Compare various methods for the aeration of animal cell cultures. Comment on the advantages and disadvantages of each method.
- 12.9. Describe the process for formation of hybridomas.
- 12.10. What value of  $k_L a$  must be achieved to sustain a population of  $1 \times 10^7$  cells/ml when the oxygen consumption is  $0.1 \times 10^{-12}$  mol O<sub>2</sub>/h-cell?