



**Figure 12.5.** Example of scale-up of animal cell cultivation using BHK (baby hamster kidney) 21 cells. Numbers in parentheses denote total amount of cells produced at the indicated stage. (With permission, from H. W. D. Katinger and W. Scheirer, *Acta Biotechnologica* 2:3, 1982.)

matrix systems, weighted porous beads) are used for anchorage-dependent cells. However, some modified stirred reactors and airlift or bubble-column reactors are used for suspension cultures. Membrane bioreactors and microencapsulation methods have been developed for simultaneous cell cultivation, product concentration, and toxic product removal. Many of these systems behave as perfusion reactors (see Chapter 9). In essence, a perfusion system exists when cells are retained in the reactor, medium is added continuously or semicontinuously, and spent medium is removed. The removal of spent medium removes toxic metabolites.

The classic method for animal cell culture has been roller bottles, and they have been important components in the scale-up of processes using anchorage-dependent cells (Fig. 12.5). With roller bottles the liquid covers about 25% of the surface area. Bottles are