8 Biophysical nanotechnology

8.1 Force measurements in single protein molecules

Atomic force microscope (AFM)-related techniques can induce and monitor the unfolding of single protein molecules. Experiments on the protein titin, which is a main component of skeletal muscles (Figs. 8.1–8.3), revealed that the force for unfolding of its individual domains with cross sections of less than 5 nm^2 is of the order of 100–300 pN and dependent on the pulling speed (Rief et al., 1997; Gaub and Fernandez, 1998; Carrion-Vasquez et al., 1999). A similar investigation on bacteriorhodopsin showed that its helices are anchored to the bacterial membrane with 100–200 pN (Fig. 8.4; Oesterhelt et al., 2000). Similarly, single-molecule force spectroscopy on spider dragline silk protein molecules revealed that the molecule unfolds through a number of rupture events, indicating a modular structure within single silk protein molecules (Oroudjev et al., 2002). The minimal unfolding module size of 14 nm indicates that the modules are composed of 38 amino acid residues (Oroudjev et al., 2002). Adhesion between two adjacent cell surfaces of the eukaryote *Dictyostelium discoideum* involves discrete interactions characterized by an unbinding force of about 23 pN. This force probably originates from interactions of individual "contact site A" (csA) glycoprotein molecules (Fig. 8.5; Benoit et al., 2000).

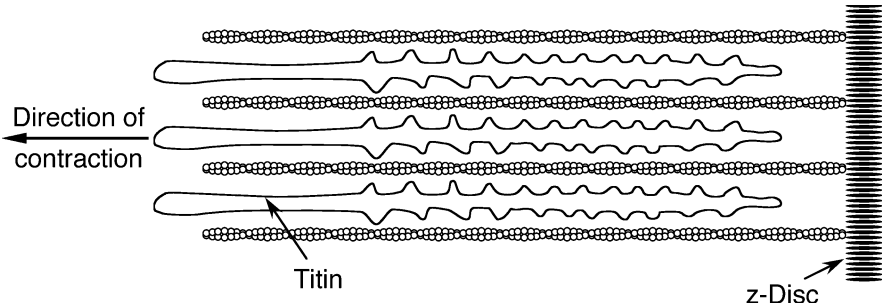

Fig. 8.1 Molecular architecture of skeletal muscle fibers. AFM-related techniques contributed to the understanding of the role of individual titin molecules in such fibers: some skeletal muscle proteins can withstand drags of 600 kp cm^{-2} (see Figs. 8.2 and 8.3; Rief et al., 1997; Gaub and Fernandez, 1998; Carrion-Vasquez et al., 1999)

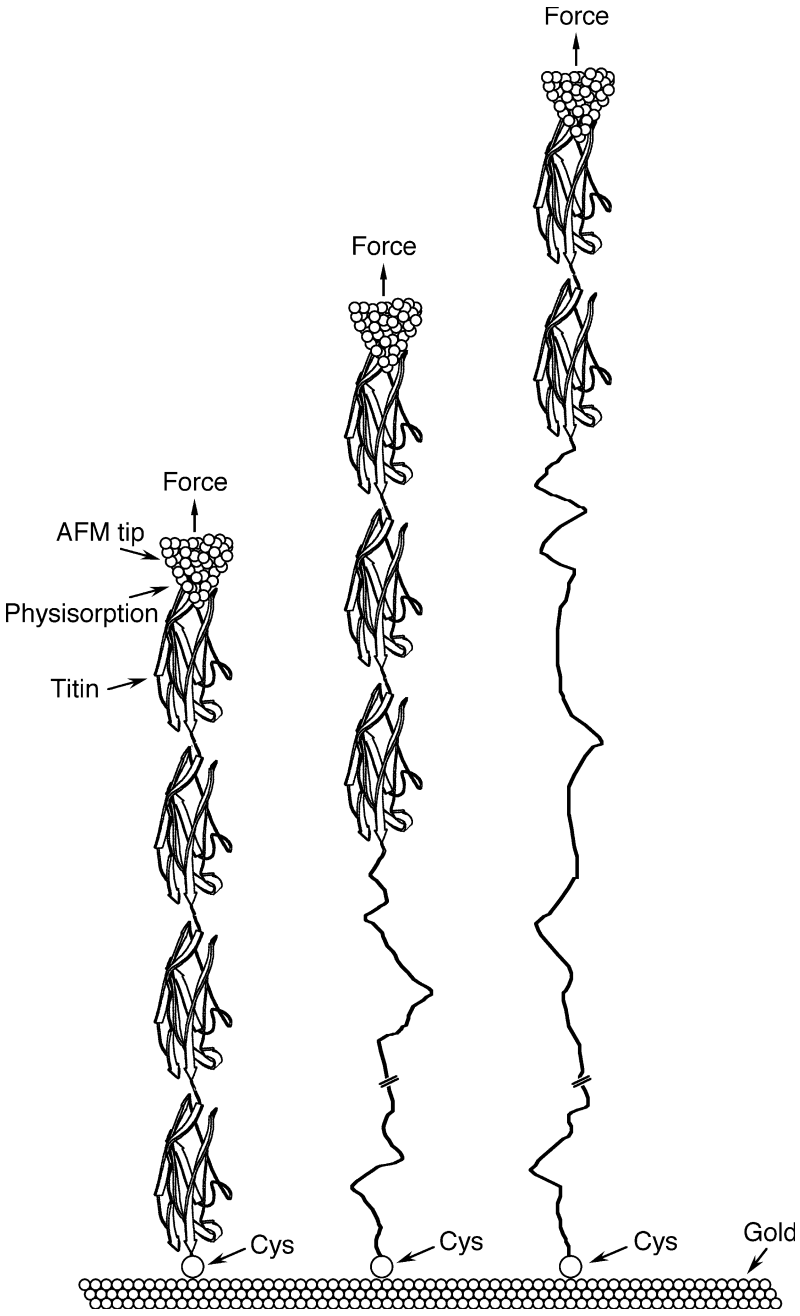

Fig. 8.2 Unfolding of a titin fragment with the help of an AFM (Gaub and Fernandez, 1998; Carrion-Vasquez et al., 1999). The unfolding force for the protein, anchored with a cysteine (Cys) to a gold surface, ranged from about 100 to 300 pN (see Fig. 8.3)