生物物理学 II　Handout No. 5

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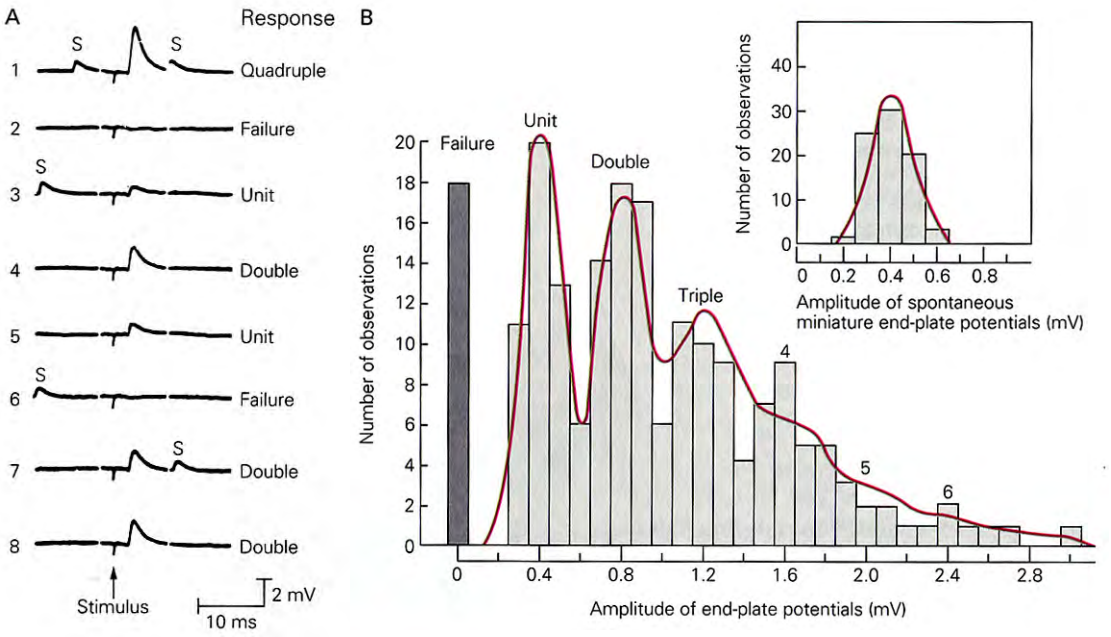

Figure 14-6 Neurotransmitter is released in fixed increments, or quanta. Each quantum of transmitter produces a unit postsynaptic potential of fixed amplitude. The amplitude of the postsynaptic potential evoked by nerve stimulation is equal to the unit amplitude multiplied by the number of quanta of transmitter released.

A. Intracellular recordings from a muscle fiber at the endplate show the postsynaptic change in potential when eight consecutive stimuli of the same size are applied to the motor nerve. To reduce transmitter output and to keep the end-plate potentials small, the tissue was bathed in a Ca^{2+}-deficient (and Mg^{2+}-rich) solution. The postsynaptic responses to the stimulus vary. Two presynaptic impulses elicit no postsynaptic response (failures); two produce unit potentials; and the others produce responses that are approximately two to four times the amplitude of the unit potential. Note that the spontaneous miniature end-plate potentials (S) are the same size as the unit potential. (Adapted from Liley 1956.)

B. After many end-plate potentials were recorded, the number of responses at each amplitude was counted and then plotted in the histogram shown here. The distribution of responses falls into a number of peaks. The first peak, at 0 mV, represents failures. The first peak of responses, at 0.4 mV, represents the unit potential, the smallest elicited response. This unit response is the same amplitude as the spontaneous miniature-end-plate potentials linsetl. The other peaks in the histogram occur at amplitudes that are integral multiples of the amplitude of the unit potential. The red line shows a theoretical distribution composed of the sum of several Gaussian functions fitted to the data of the histogram. In this distribution each peak is slightly spread out, reflecting the fact that the amount of transmitter in each quantum, and hence the amplitude of the postsynaptic response, varies randomly about the peak. The number of events under each peak divided by the total number of events in the histogram is the probability that the presynaptic terminal releases the corresponding number of quanta. This probability follows a Poisson distribution (see Box 14-1). The distribution of amplitudes of the spontaneous miniature potentials, shown in the inset, is also fit by a Gaussian curve. (Adapted from Boyd and Martin 1956.)

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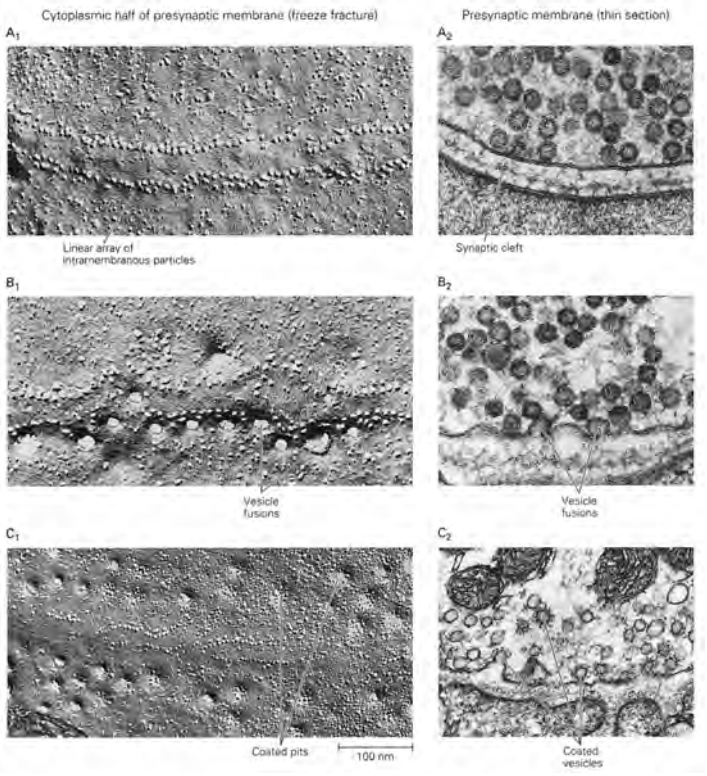

Figure 14-8 The events of exocytosis at the presynaptic terminal are revealed by electron microscopy. The images on the left are freeze-fracture electron micrographs of the cytoplasmic half (P face) of the presynaptic membrane (compare Figure 14-7). Thin-section electron micrographs of the presynaptic membrane are shown on the right. (Adapted from Alberts et al. 1989.)

A. Parallel rows of intramembranous particles arrayed on either side of an active zone may be the voltage-gated Ca^{2+} channels essential for transmitter release.

B. Synaptic vesicles begin fusing with the plasma membrane within 5 ms after the stimulus. Fusion is complete within another 2 ms. Each opening in the plasma membrane represents the fusion of one synaptic vesicle. In thin-section electron micrographs, vesicle fusion events are observed in cross section as -shaped structures.

C. Membrane retrieval becomes apparent as coated pits form within about 10 s after fusion of the vesicles with the presynaptic membrane. After another 10 s the coated pits begin to pinch off by endocytosis to form coated vesicles. These vesicles include the original membrane proteins of the synaptic vesicle and also contain molecules captured from the external medium. The vesicles are recycled at the terminals or are transported to the cell body, where the membrane constituents are degraded or recycled.

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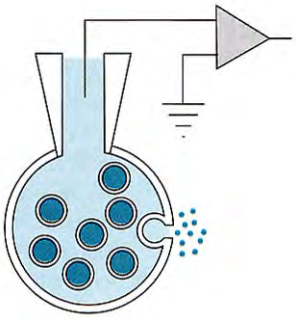

FIGURE 11.24 Release and Retrieval of Vesicle Membrane monitored by changes in membrane capacitance. Increases in cell capacitance measured with the whole-cell patch pipette recording technique occur in a stepwise fashion reflecting the fusion of individual vesicles with the plasma membrane. Corresponding decreases in capacitance are seen during vesicle retrieval. The recordings are from a rat mast cell, which has particularly large secretory vesicles (800 nm in diameter). (After Fernandez, Neher, and Gomperts, 1984.)