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Relationships between dendrite and spine neck diameters in freeze-fractured rat hippocampal formation. KRISTEN M. HARRIS.

Theoretical mathematical models have described how dendritic spine necks might provide synaptic input attenuation and isolation, as well as impedence matching to the dendrite. These models require that as the dendrite narrows, so do spine necks. Granule cells from the dentate gyrus of rat hippocampal formation were chosen to study this relationship empirically because their spiny dendrites taper with distance from the cell body.

In Golgi-impregnated granule cells it is possible to see dendritic taper, count many spines, and observe thin spine necks; but difficult to resolve spine neck diameters. Conversely, examination of serial thin sections through spines yields accurate estimates of their neck diameters, but it is difficult to obtain many observations. The freeze-fracture complimentary-replica technique seemed promising because replicas can be viewed at high magnifications with good resolution of many spine neck diameters.

The diameters of cross-fractured spine necks were measured in six adjacent 50 μm regions from the granule cell bodies to the hippocampal fissure. Cross fractures were measured because they appeared more frequently and were similar to profile diameters seen in the same field. The distribution of spine neck diameters was skewed in each of the six regions, with smaller diameters always occurring more frequently. The dendritic diameter was measured at the location of each spine neck. Although this measure is subject to variability in the freeze fracture plane, we have no reason to believe that narrow and wide dendrites will be selectively fractured at different relative depths.

Measurements from 162 spines showed that spine necks narrow as dendrites taper so that the ratio of spine neck diameter to dendrite diameter does not change significantly. Thus, our preliminary results demonstrate a way to analyze many spine necks, and provide an empirical anatomical basis for models relating spine necks to impedance matching.

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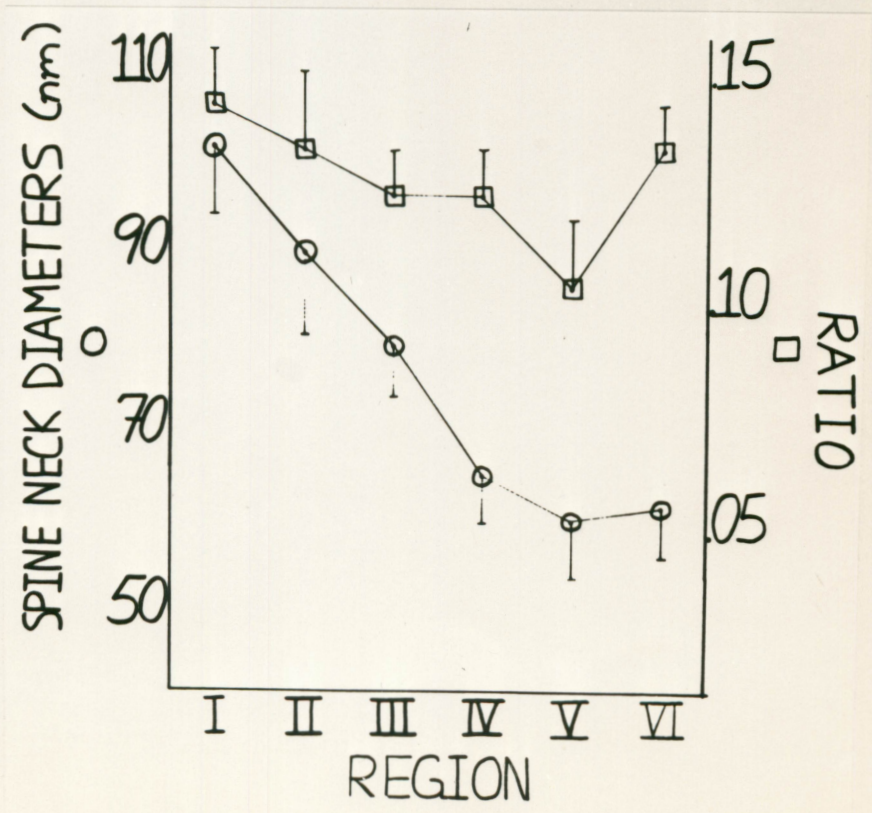

Figure 1: a) A segment of dentate granule cell dendrite from an adult rat is revealed in freeze-fracture. The small arrows indicate cross fractures of spine necks, while the large arrow is at the base of a spine revealed in profile. b) This graph is from measures of 162 spine neck(O) and dendrite diameters. Regions I-VI are 50 micrometer regions extending across the molecular layer. Note that the ratio (□) of spine neck diameter to dendrite diameter does not differ significantly across regions. (Calibration bar = 0.25 micrometers; points on graph are mean+ sem.)