Explanation of question 8, part c from the Problem Set:

You are recording from a neuron. Please describe the effect (increase / decrease / no change) on \( R_m \) (total membrane resistance), \( C_m \) (total membrane capacitance), and excitability (probability of firing an action potential based on a standard depolarization stimulus given in distal dendrites) of the following:

a. The total dendritic length is increased (but average conductance per unit area of membrane is unchanged).

\[ R_m = \text{total membrane resistance is decreased because adding more membrane increases the total conductance of the neuronal membrane.} \]

\[ C_m = \text{total capacitance is directly proportional to total neuronal membrane surface area, which is increased by addition of dendritic length, therefore } C_m \text{ is increased.} \]

Excitability – how easy it is to fire action potentials at the cell body with a standard depolarization in distal dendrites. This is decreased by addition of more membrane with increase in volume for current to spread from the point source. The neuron is less electrotonically compact.

b. The average radius of the dendrites conducting the signal from distal tips to soma is increased.

\[ R_m = \text{decreased because increased radius necessarily adds more membrane with more leak conductance.} \]

\[ C_m = \text{increased because increased radius necessarily adds more membrane (see a above).} \]

Excitability – is increased mainly because of the more favorable length constant, which is directly proportional to (square root of) the radius; specific resistance \( R_M \) and specific capacitance \( C_M \) (the other components of the length constant equation) would be expected to remain constant as long as the membrane added has the same characteristics (i.e., density of leak channels) as the original – this should have been stated in the question.

c. The leak conductance of the dendritic membrane is increased.

\[ R_m = \text{decreased because it is inversely proportional to total membrane conductance.} \]

\[ C_m = \text{unchanged because there is no change in surface area, membrane thickness or dielectric constant (this would not change substantially with addition of leak channels, which are at an average density of one per 20um}^2 \text{ – see lecture notes – not enough to impact the dielectric of the lipid bilayer)} \]

Excitability is decreased because of the effect of reduced specific resistance on the length constant (decreased) and time constant (shorter).