A) B)

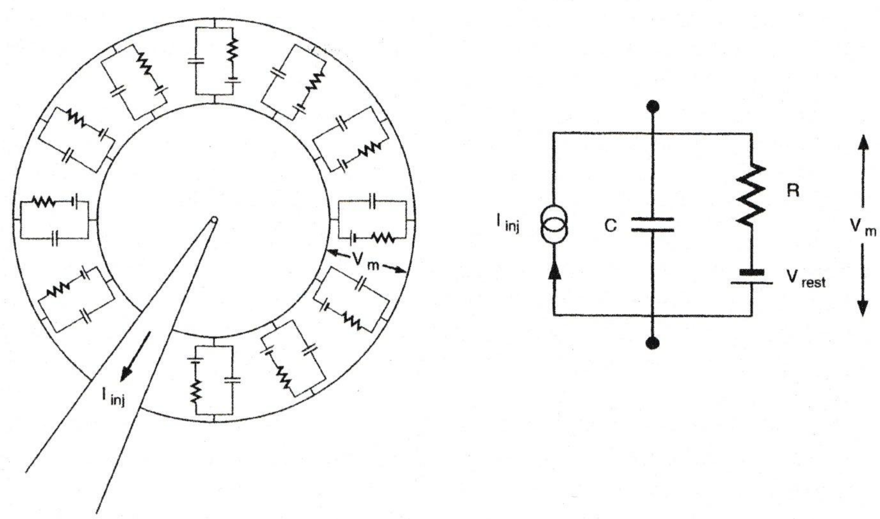

Fig. 1.2 Electrical Structure of a Small Passive Neuron **(A)** Equivalent electrical model of a spherical cell with passive membrane. An intracellular electrode delivers current to the cell. By convention, an outward current is positive; thus, the arrow. We assume that the dimensions of the cell are small enough so that spatial variations in the membrane potential can be neglected. **(B)** Under these conditions, the cell can be reduced to a single *RC* compartment in series with an ideal current source I_{inj}.

It is straightforward to describe the dynamics of this circuit by applying *Kirchhoff's current law*, which states that the sum of all currents flowing into or out of any electrical node must be zero (the current cannot disappear, it has to go somewhere). The current across the capacitance is given by expression 1.3. The current through the resistance is given by *Ohm's law*,

$$I_R = \frac{V_m - V_{rest}}{R} . \tag{1.4}$$

Note that the potential across the resistance is not equal to V_m, but to the difference between the membrane potential and the fictive battery V_{rest}, which accounts for the resting potential. Due to conservation of current, the capacitive and resistive currents must be equal to the external one, or

$$C\frac{dV_m(t)}{dt} + \frac{V_m(t) - V_{rest}}{R} = I_{inj}(t) . \tag{1.5}$$

With $\tau = RC$, with units of $\Omega \cdot F$ = sec, we can rewrite this as

$$\tau\frac{dV_m(t)}{dt} = -V_m(t) + V_{rest} + RI_{inj}(t) . \tag{1.6}$$

A minor, but important detail is the sign of the external current (after all, we could have replaced $+I_{inj}$ by $-I_{inj}$ in Eq. 1.6). By convention, an outward current, that is positive charge flowing from inside the neuron to the outside, is represented as a positive current. An outward going current that is delivered through an intracellular electrode will make the inside of the cell more positive; the physiologist says that the cell is *depolarized*. Conversely,