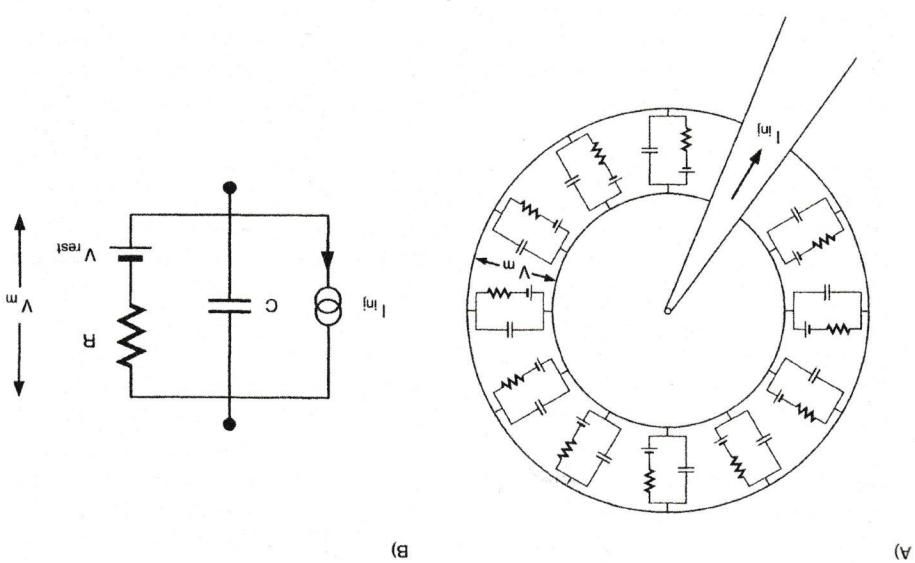


...the all-important proteins embedded in the membrane, allowing ions to pass, making up anywhere from 20 to 80% of the range of specific cellular functions. They act as doors or gates in the membrane. A variety of such "gates" exists, with some substances can be transferred from one side of the membrane to the other through these channels by a simple or the resting potential of the cell, the membrane includes three elements,  $C$ ,  $R$ , and  $I_{inj}$ , in contrast to quasi-active membranes, it is also sometimes known as a few cells can be mimicked by such reasons.

...terms of the specific membrane resistance area (in units of  $\Omega \cdot \text{cm}^2$ ).  $R$  is being considered. The inverse of  $R_m$  of dendritic membrane or, for short, as measured in units of siemens per square

...al experiment. Assume that we have and have managed to insert a small electrode directly into the cell. This (in contrast to an ideal voltage source,



**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, the arrow, 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

$$I_R = \frac{V_m - V_{rest}}{R} \quad (1.4)$$

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

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

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

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

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,