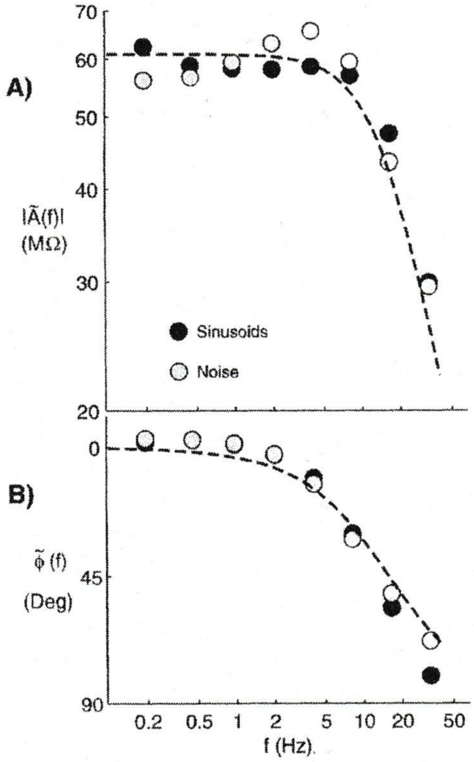

Fig. 1.4 Cortical Cells Behave Like an *RC* Circuit When either noise or sinusoidal currents are injected into the cell body of regularly firing cells in guinea pig visual cortex, the membrane potential can be adequately modeled as resulting from convolving the current input by a low-pass filter of the sort described in Eqs. 1.14 and 1.15 (dashed lines; here with $R = 58.3$ MΩ and $\tau = 9.3$ msec; $V_{rest} = -70.7$ mV; Carandini et al., 1996). **(A)** The amplitude of the filter and **(B)** its phase. The noise current curve reveals a shallow peak at around 8 Hz. We conclude that from the point of view of somatic input-output, these cells can be reasonably well described by a single *RC* compartment. The responses were obtained by computing the first harmonic of the membrane potential response and dividing by the current. The power of the first harmonic was between 9 and 141 times the power of the higher harmonics. Reprinted by permission from Carandini et al., (1996).

of such cells. This simplest model of a spiking neuron, known as a *leaky integrate-and-fire* unit, is so important that it deserves its own detailed treatment in Chap. 14.

We can recover the Green's function $h(t)$ of the *RC* compartment by applying the inverse Fourier transform to Eq. 1.13, which results in

$$h(t) = \frac{1}{C} e^{-t/\tau} \tag{1.17}$$

for $t \geq 0$ and 0 for negative times (the units of the Green's function are ohms per second (Ω/sec)). Conceptually, the extent of this filter, that is, the temporal duration over which this filter is significantly different from zero, indicates to what extent the distant past influences the present behavior of the system. For a decaying exponential as in an *RC* circuit, an event that happened three time constants ago (at $t = -3\tau$) will have roughly 1/20 the effect of something that just occurred (Fig. 1.3B). This is expected in a circuit that implements a low-pass operation. Input is integrated in time, with long ago events having exponentially less impact than more recent ones.

1.4 Synaptic Input

So far, we have not considered how the output of one neuron provides input to the next one. Fast communication among two neurons occurs at specialized contact zones, termed *synapses*. Synapses are the elementary structural and functional units for the construction of