Effects on isolated neurons that may occur at no measurable elevation of tissue temperature or at constant system temperature have been investigated using land snails (*Helix aspersa*). Exposure of subesophageal ganglia of snails at ambient temperature (21°C) to 2450 MHz CW microwaves at 13 W/kg for 30-60 min caused changes in membrane input resistance and spontaneous firing activity either during irradiation or immediately afterward [Arbor and Lin, 1985; Ginsberg et al., 1992]. However, the direction of change was not consistent across neurons. The response of snail neurons to noise-modulated 2450 MHz microwaves (20% AM, 2 Hz-20 kHz) at 6.8 differed from the exposure to CW irradiation. Neither the membrane potential nor input resistance exhibited any change after 30 minutes of irradiation. A statistically significant increase in membrane input resistance was observed following 60-min of exposure [Lin and Arbor, 1983]. Similarly, exposure to pulse-modulated microwave (2450 MHz, 10^{-5} sec, 100 pps, ave SAR 81.5 W/kg) revealed a significant increase in the input resistance isolated snail neurons [Bernardi et al., 1991; Field et al, 1993]. It should be noted that the observed effects occurred at average SARs of 6.8 to 81.5 W/kg; the highest SAR was associated with pulse-modulated exposure. Since neural activity is governed by the behavior of membrane ion channels, there may be a direct relation between microwave exposure and ion channel function [Lin, 1995].

Blood-Brain Barrier Changes

The neural tissue layer commonly known as the blood-brain barrier (BBB) functions as a differential filter that permits the selective passage of material from blood to extracellular spaces. It maintains the physiochemical environment of the brain within certain narrow limits which are essential for life. Since the first report by Polyaschuk [1971], many investigators have reported studies on the effect of microwave radiation on the blood-brain barrier of experimental animals with varied results. Several authors using both high and low levels of microwave exposures have shown microwave-induced increase in BBB permeability [Oscar and Hawkins, 1977; Sutton and Carroll, 1979; Albert and Kerns, 1981; Lin and Lin, 1982; Goldman et al., 1984, Neilly and Lin, 1986; Neubauer et al., 1990; Salford et al., 1993, 1994]. However, other studies have not found microwave-induced disruption of BBB [Merritt et al., 1978; Preston et al., 1979; Lin and Lin, 1980; Gruenau et al., 1982; Williams et al., 1984; Ward and Ali, 1985]. Some of the apparent discrepancies undoubtedly stem from differences in microwave exposure conditions such as frequency, power level, and SAR distribution, and from differences in the use of a variety of assays and procedures to detect changes in BBB permeability.

Table 10 lists more recent studies of BBB and microwave exposures. It can be seen that the effect of microwave radiation on BBB permeability remains controversial. Disagreement in laboratory findings persist among even recent investigations, especially at lower SAR levels. Specifically, the most recent studies report microwave radiations alter BBB changes at SARs of 0.016-5 W/kg [Neubauer et al., 1990; Salford et al., 1993, 1994]. A particularly vexing question with the studies by Salford et al. is that barrier permeation appears to have been observed at all levels of RF exposure investigated including those at an extremely low level (0.016 W/kg). It suggests that the response may be independent of RF exposure.