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Early Evidence for Chemotaxis

The growth of axons from a ganglion to a target tissue may be directed by soluble molecules emanating from the target. The axon's growth cone would be expected to migrate up the concentration gradient of these molecules (chemotaxis). Such a view was put forward by Santiago Ramón y Cajal at the turn of the past century (see fileserver entry on his work), but more convincing evidence for such a view came from placing ganglia close to, but not touching, various potential target tissues. Lumsden and Davies (1983, 1986) have dissected the trigeminal ganglia of sensory neurons out of embryonic mice before the neurons contacted their normal target tissue, the whisker pad. When these explanted ganglia are placed in culture medium near a variety of potential target tissues from the embryonic mouse, the trigeminal neural axons extend only toward the whisker pad tissue. In fact, when cultured between whisker pad epithelial tissue and whisker pad mesenchymal tissue, they only migrate toward the epithelial tissue (Figure 1). This observation can best be explained by postulating the secretion of some chemotactic substance by the whisker pad epithelium. The chemotaxis of the trigeminal axons to the whisker pad is not only target-restricted but also neuron-restricted and temporally restricted. The whisker pad tissue does not attract the axons from other sensory ganglia, and it will attract the trigeminal neurons only during a specified time.

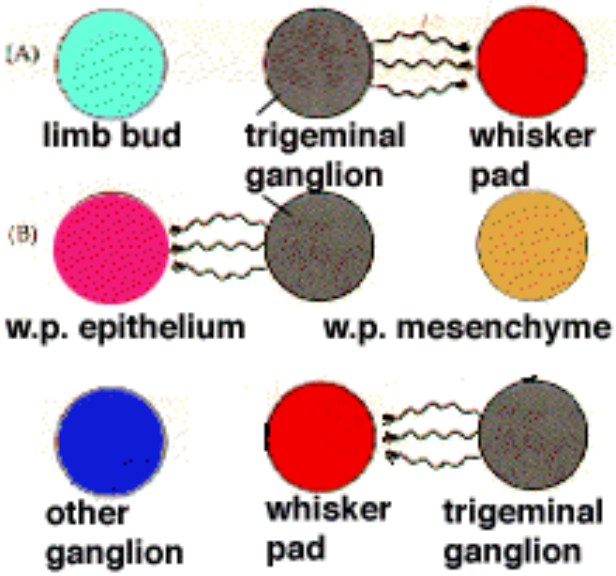

Figure 1 Summary of the experiments of Lumsden and Davies showing chemotaxis between neural tissue (trigeminal ganglion) and its target (whisker pad). The chemoattraction is specific for (A) the target and (B) the epithelial cells of the target. Moreover, the chemotactic ability of the whisker pad is specific for the trigeminal neurons.

Such diffusible substances could be shown to be temporally regulated. Pollack and Muhlach (1981) showed that the migration of tadpole motor axons from the spinal cord to the limb mesoderm could be mimicked in culture. Early (stage 5) spinal cord explants would send axons into early (stage 5) limb buds, but the stage 5 spinal cords were not induced to send their axons into older (stage 15) limb bud.

Also in the 1980s, there was also evidence for factors that could repel growth cones and retard axonal growth. In the snail *Helisoma*, neurotransmitters released by one nerve's growth cone can inhibit or accelerate the elongation of other growth cones. The pattern of neuronal connections is influenced by such interactions. Neuron 5 secretes serotonin, which completely inhibits the axonal growth of neuron 19 by causing the retraction of that growth cone's filopodia (Haydon et al., 1985; Kater, 1985). In this way, neuron 5 prevents neuron 19 from synapsing with it. In these snails, nerves can also alter the growth cones of other neurons by electrical activity. Once electrical potentials are established (as at neuromuscular junctions), the action potential can cause the cessation of axonal outgrowth for other neurons (Cohan and Kater, 1986)

Literature Cited

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