Chapter 12

Cutaneous Receptors

Ainsley Iggo

Department of Veterinary Physiology
University of Edinburgh
Edinburgh, Scotland

1. INTRODUCTION

The skin is richly innervated with axons of afferent nerve fibers, estimates of the numbers ranging around 1 million. The density of innervation is, however, quite variable; most of the afferent fibers terminate in the face or the extremities, with relatively few supplying the dorsal surface of the trunk. The structure of the skin of the face and extremities, as well as the degree of specialization of the receptors, is also more complex. Glabrous or hairless skin occurs at these places, and complex hair follicles (sinus hairs) are present in the face of many mammals. Structural features of glabrous skin, in addition to the thickening of the epidermis, are a regular epidermal ridge formation, associated with uniformly organized nerve supply, and the presence of complex encapsulated sensory receptors in regular arrays and with sweat glands. Hairy skin, in contrast, has as its dominant feature hair follicles of several kinds often arrayed in regular patterns. In hairy skin, the majority of the sensory receptors are integral parts of the hair follicles or other organized, but less numerous, receptors, and most afferent nerve fibers end either in the hair follicles or close to the basal layer of the epidermis. Some nerves penetrate the basement membrane of the epithelium to end closer to the skin surface, but these are found in highly specialized skin, such as Eimer's organs in the snout of the mole. Nerves ending within the basement membrane of the epidermis include the distinctive Merkel disc, which is associated with
Merkel's cell. Nonmyelinated fibers and specialized small myelinated axons also end on the epidermal side of the basement membrane, or close to it (Cauna, 1969). As a general feature, sensory receptors do not penetrate deeply into the epidermis, and when they are present the epidermis itself may be thickened and specialized. Many receptors lie just beneath the basement membrane or within 100–200 µm of it, although isolated larger receptor structures such as the Pacinian corpuscle and Ruffini ending, may be more deeply located in the corium.

In the older literature, two plexuses of nerves were described in the skin, a superficial and a deep. The plexuses were nerves containing many axons. The deep one can now be identified as a branching nerve network carrying fibers to be distributed to the superficial plexus; the latter, lying close to the epidermis, contains axons being distributed to the nerve terminals. Neither of these plexuses is a receptor. Some of the older histological methods (silver staining, osmication), in skilled and experienced hands capable of yielding exact information about the axons, often failed to reveal the nerve endings, as is now clear from electron microscopic studies. For these technical reasons, the older work could not establish the actual relation of the superficial plexus to the receptors, although the structure of encapsulated receptors was sometimes described with great accuracy (Ruffini, 1894). It can now be stated that the superficial plexus is distributing axons to subepidermal and basal-epidermal receptors of several kinds and that it does not form a syncitium.

The deep plexus is in its turn derived from still deeper nerves that arise from cutaneous branches of mixed or cutaneous nerves. These larger nerves usually run for some distance as distinct nerve fascicles in the subcutaneous tissue and contain both afferent (dorsal root) and efferent (sympathetic) nerve fibers. The cutaneous nerves may also include fascicles that supply articular joints. For example, the saphenous nerve when it leaves the femoral nerve includes axons which leave it in a separate fascicle to supply the posterior aspect of the knee joint. All the cutaneous nerves, except the trigeminal, eventually join major mixed nerves (i.e., nerves supplying both muscle and skin and containing motor and sensory fibers) derived from cranial or spinal nerves, and these latter eventually form the dorsal (afferent) and ventral (efferent) spinal roots. From an experimental viewpoint, therefore, it is possible to work on nerves containing exclusively cutaneous fibers only in the periphery, and even at such places the nerves may contain joint afferents and will always include sympathetic axons. The dorsal roots are always mixed with cutaneous, muscular, and visceral components, as also are the dorsal root (and cranial nerve) ganglia.

In the account that follows, the morphological characteristics of the skin nerve supply will be treated systematically, working from the center