2.4 Specialized Information Processing Areas: Laminar Structures in the Cortex

While all brain areas have expanded in the course of evolution, the greatest change in the evolution of primates, including humans, is the massive increase from the small structure, known as the *pallium*, found in early vertebrates to the large cortex (including not just the neocortex but also the hippocampus) that dominates our brains. Cortical areas exhibit a different mode of organization than the ganglia/nuclei in the rest of the brain, a laminar structure in which neurons are organized into layers. The neocortex, in particular, is organized into six layers. At the beginning of the 20th century, Brodmann (1909/1994) described these layers in slices of cortex prepared with the same stains used to identify neurons. Different stains resulted in different appearances but each of them revealed six layers (Figure 6A). Brodmann showed that different layers consist of types of neurons that are distinguished in terms of size, patterns of axons and dendrites, etc. As is suggested in the figure, many of the projections from individual neurons project to neurons in the layers above or below them, creating what are known as cortical columns.

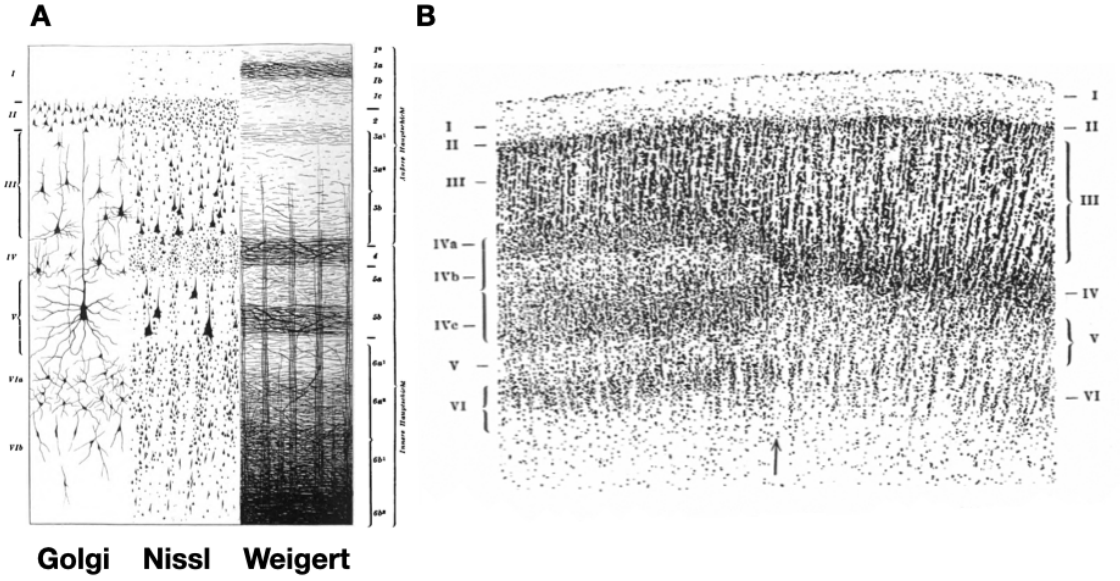

Figure 6. A. Examples of the appearance of a typical section of neocortex with three different stains, revealing the existence of six different layers. B. Broadmann's identification of locations (marked by an arrow) where thickness of layers changes, marking a boundary between different regions. Figures reprinted from Brodmann (1910).

One feature that stood out to Brodmann was that the layers in different parts of the neocortex are of different thickness and often exhibit sharp boundaries where the thickness of layers changes (Figure 6B). He viewed these as demarcating distinct areas of the neocortex. He numbered these in the order in which he investigated them, producing the map in Figure 7. Subsequent neuroanatomists used other measures, such as patterns of connectivity between

neurons, leading to somewhat different maps. Brodmann's numbering scheme, though, remains widely used.

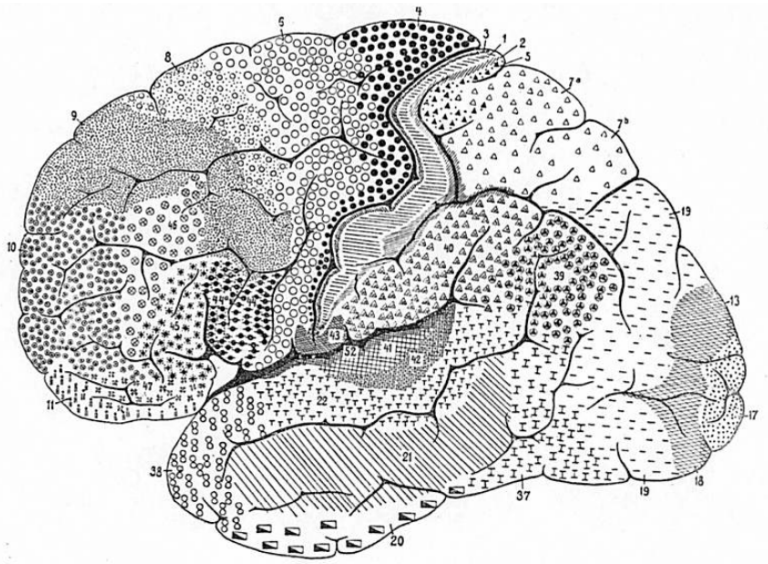

Figure 7. Brodmann's map of different areas (now referred to as *Brodmann Areas*) in the human brain. Figure reprinted from (Brodmann, 1910).

In section 9 we will examine the type of processing facilitated by the arrangement of neurons in the neocortex. For now, though, we will emphasize a feature of neocortex that is often overlooked. It is common to treat the neocortex as an autonomous information processing structure. Sensory information first arrives at primary sensory areas, e.g., BA (Brodmann Area) 17 for vision, BAs 3, 2, 1 for somatosensory information. It is then processed through a variety of intermediate areas, sometimes referred to as *association areas*. Finally, motor commands are developed in premotor cortex (BA 6), and further articulated in motor cortex (BA 4). However, as we discuss further in section 9, each of these areas is as densely interconnected with subcortical nuclei, especially those in the thalamus and the basal ganglia, as they are with other cortical areas, rendering the neocortex a component in a functionally-integrated neural system.

2.5 Summary

In this section we have introduced the basic components of the nervous system—neurons, nerve nets, ganglia/nuclei, and cortical sheets. Each of these will figure in our discussions below. We turn first to the question of how neuroscientists acquire knowledge about these entities.