# Brain

The obvious risks which this localization entails are apparently compensated by the advantage of direct short connections with the sense organs localized in or on top of the head (olfaction, taste, vision, audition, vestibular sense), which together with the brain could be seen as something like the cockpit of the animal, or the pilot if one prefers.

The intimate relation of the brain to the sense organs points to the brain’s essential role as an information handling device.

More commonly it is a combination of information from different sensory modalities that gives away the aggressor, or the prey, or the sexual partner, or the dangerous cliff etc.

Equally important, the monitoring of motor behavior, both in its planning and in its execution, provides crucial information necessary for the correct interpretation of any situation signaled by the senses.

concentration of CO2, concentration of sugar, various hormones in the blood), and is in turn capable of emitting chemical messages addressed to other parts of the body, by far the greatest part of the information traffic in which the brain is involved uses nerve fibers as carriers of signals.

The bulk of the brain itself is also made up of masses of fibers: axons, dendrites, glia.

From the volume of the brain and the average thickness of the fibers (not including the glia), we get an estimate of the sum total of the length of all fibers contained in a single (human) brain as reaching from the earth to the moon and back.

Since what happens within the brain is essentially based on the exchange of signals among neurons, and since such exchange can only happen where neurons come in close contact with each other, it is advantageous to provide for each neuron contacts with as many other neurons as possible.

In reality, the synaptic neighbours of a single neuron, both on the giving and on the receiving side, thanks to the long neural cell processes number several thousands on an average, ranging from a minimum of very few (exceptionally perhaps only one) to several hundreds of thousands (synapses between parallel fibers and a single Purkinje cell in the cerebellum).

The length of the individual fibers in the brain varies a great deal, from less than one tenth of a millimeter to over hundred millimeters, corresponding to the diameter of the whole (human) brain.

the neurons with which it enters into direct synaptic contact, can be distributed widely in disparate parts of the brain, including the immediate neighbourhood as well as far away regions.

There is a distinction of two kinds of brain “substance”, or better, of two distinct compartments of the brain (Figure 3), which coincides roughly with a distinction of regions containing long, mostly insulated (“myelinated") fibers on the one hand, and regions containing a multitude of short fibers and neural cell bodies on the other.

In the so-called white substance (or white matter), the one predominantly made up of long fibers, there are no synapses, whereas synapses abound in the grey substance (or grey matter).

Although the equipment of elementary components in the grey substance (dendrites, axons, excitatory and inhibitory synapses, glia) is remarkably similar in different places (and in different animal species), there are striking local differences in the architecture in which these components are arranged.

In some places, neighbouring dendritic trees are intimately interwoven so that they largely share the same territory and hence also the same set of axons to establish synapses with.

of Purkinje cells in the cerebellum) stand neatly separated with no overlap, each defining its individual choice of synaptic contacts.

There are places in the brain where the fibers which carry the input are connected directly to the neurons which relay the output to distant places, whereas in other regions complicated networks of so-called interneurons are interposed between input and output, sometimes vastly outnumbering the output and input elements (as in the case of the cerebral cortex).

There are also differences in the number of inhibitory neurons with respect to that of the excitatory ones, differences in the “plasticity”, i.e.

Other, quantitatively imposing parts of the grey substance (cerebral cortex, cerebellar cortex, visual ganglia of many invertebrates) are arranged in layered structures where the fibers within one layer, confined to a two-dimensional space, are neatly distinct from those connecting different layers to each other.

Thus there is a “visual cortex”, an “auditory cortex”, a “somatosensory cortex”, and similar subdivisions of the brain stem defined by the kind of sensory inputs they receive.

The origin of the motor output also provides the name for various regions: there is a “motor cortex”, there are “oculomotor nuclei”, “motor speech centers”, etc.

The same acoustic input from the cochlea at one time (and in one place) may be used to determine the localization of the source, at another time (and in another place in the brain) it may elicit a startle reaction, or (in humans) it may be understood as a linguistic utterance.

To a certain extent, the different roles of cortical areas, as well as of various subcortical organs, can be inferred from the position they occupy in the global organization of the brain between sensory input, associational regions and motor output.

The macroscopical layout of compartments in the brain is also reflected in the structure of the white substance which contains the long fibers, mostly bundled to form several distinct “fascicles”, responsible for the functional relations of the various compartments with each other.

In the vertebrate brain the two cortices, cerebral and cerebellar, leap to the eye, as well as the optic tectum (in “lower” vertebrates) and the brain stem.

The cerebral cortex in the human brain is the largest piece of grey substance and is in itself composed of separate lobes (frontal, temporal, parietal, occipital) well demarcated by particular deep furrows, although parts of a continuous sheet of grey substance.

The weight of the brain varies a great deal in different animals, ranging from a few milligrams in insects to 1.3 kilograms in humans, and further to the brains of elephants and whales with brain weights about 5 times that of a human brain.

Between different orders, differences in brain weight (relative to the weight of the body) are said to indicate different degrees of “encephalisation”, by which term is meant a hypothetical tendency of evolution to produce, in the long run, ever bigger and better brains in successive generations of animals.

The number of neurons in animals of different sizes grows with the size of the brain but stays behind the volume of the brains.

This is due to the proportion of volume occupied by the neuronal cell processes, which in larger brains tend to be longer for obvious geometrical reasons.

Also, the relative sizes of various subdivisions of the brain in different animal species (and even in individual human beings) are sometimes taken as indicating different attitudes or different proficiencies in various performances.

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