

out doubt, retain their sense of sight, and guide their movements accordingly, notwithstanding the complete removal of their cerebral hemispheres.

*Mammals.*—While the removal of the cerebral hemispheres (including *corpora striata*) in the lower vertebrates is compatible with survival for a considerable length of time, the case is different with mammals. In these the operation causes fatal shock, or is followed by secondary effects which result in speedy death. For this reason it is not found possible to determine, as in the lower vertebrates, what functions, after considerable lapse of time, might still be exhibited by the lower centres in the entire absence of the higher. The hemispheres have been removed from rabbits and guinea-pigs—all spontaneity seems to be abolished; but it is usual for the animals, after the period of quiescence has passed, to make apparently spontaneous running movements, which, however, are found to depend upon irritation, caused by the secondary changes set up in the wound.

Whether, after the removal of the cerebral hemispheres, rabbits and other rodents can see, is a question which has been the subject of lively controversy. The question is one which cannot be said to be definitely settled, though the facts mentioned in regard to fishes, frogs, and birds, would incline one to believe that the conclusion arrived at by Christiani, in his experiments, is correct. He is of opinion that, although they do not see like normal rabbits, they are still able to guide their movements in accordance with retinal impressions. Goltz, by repeated operations, destroyed a large extent of both hemispheres of two dogs; he thus describes their condition: "Both animals were essentially only wandering; eating, and drinking; reflex machines. Both were utterly indifferent to man and beast. Both had obtuseness of all their senses. Each had sensation in every part of the skin, and effected movements with all its muscles. Neither exhibited any expression of pleasure; on the other hand, both were easily roused to wrath. Both were profoundly demented."

Dr. Ferrier remarks that the impairment of all the sensory and motor faculties in these and other dogs operated upon by Goltz—in which it is certain that not one of the specific centres was entirely destroyed—would, without doubt,

have been more profound than in rabbits and guinea-pigs, had it been possible to extirpate the hemispheres entirely; and when we come to consider the effects of partial cerebral lesion in man, we shall see reason for believing that if in him the whole of the hemispheres were removed, providing this were compatible with life, there would be such complete and enduring paralysis of motion and annihilation of all the forms of sense, that scarce a trace would remain to those responsive and adaptive reactions which survive the removal of the cerebral hemispheres in animals lower in the scale.

It thus appears that, notwithstanding the complete extirpation of the cerebral hemispheres, animals, in proportion to their lowness in the scale, besides duly retaining and regulating all their organic functions, remain possessed of varied powers which may be classed, generally, under the heads of equilibration, co-ordination of locomotion, emotional expression, and adaptive reactions, in accordance with impressions made upon their organs of sense. These are organized in the mesencephalic and spinal centres in the highest degree in fishes, frogs, and pigeons, to a less degree in the lower mammals, and least of all in monkeys and in man.

The question as to whether the actions of the lower centres are indicative or not of intelligence, was briefly discussed. We are entitled to say that the activity of the lower centres does not affect the consciousness of the individual; for when, by lesion of the internal capsule, the sensory tracts are cut off from their cortical connections, the individual has absolutely no consciousness of impressions made upon his organs of sense, so that we may conclude that, in man at least, states of consciousness are indissolubly connected with the activity of the cerebral hemispheres. There seems to be nothing which can, *a priori*, be urged against the notion that the various factors of intelligence have their substrata in definite regions, specially related to certain motor and sensory functions.

Dax (1836) established the special relation of aphasia to right hemiplegia and lesions of the left hemisphere; but the connection between aphemia, or aphasia and lesion, more particularly of a definite region of the left hemisphere, namely, the base of the third frontal convolution, was pointed out by Broca (1861). The