RECENT TRENDS IN NEUROPHYSIOLOGY OF THE VISCERAL NERVOUS SYSTEM.

By

B. K. ANAND

All India Institute of Medical Sciences, New Delhi

Friends, I have been asked to say something about some of the recent trends in the development of our knowledge about neurophysiology specially the neurophysiology of those nervous regions which regulate and control the visceral activities of the body. As most of you are aware, when neurophysiological studies were taken up in the beginning it consisted mostly of anatomical studies of tracts, paths, some of the functional areas and so on and that was the entire knowledge about neurophysiology at that time. Later on when more gadgets and more devises were made available to us, the study of some of the fundamental processes mainly occuring in the peripheral nervous system were undertaken. That was the time when neurophysiology of the peripheral end organs, the peripheral nerves, the processes by which nerve impulse travels, inwards, how this is brought about by ionic exchanges and so on held the field for a long time. Such studies on neurophysiology mostly started in England, and in fact even now one finds that those are the types of studies which are still holding sway in most of the physiological laboratories in England. But what has happened recently is that a shift has taken place from the study of the fundamental processes which could be studied at the peripheral nervous system, to the study of "functional neurophysiology" which naturally revolves round the study of the functional processes of the brain, of the brain-stem, of the spinal cord, and so on. Some of the aspects have already been high lighted by my predecessor Dr. Baldev Singh. Now even in the study of the functional processes, it was found that it was much easier to study those functions which one could easily interpret in the animal. That is why for a long time the neocortical mechanisms by which the sensations reach consciousness, the mechanisms for the execution of the voluntary movements, and the mechanisms of some of the association functions depending upon the activity of the huge mass of internuncial neurons connecting sensory areas of neocortex with the motor areas have been studied. Recently with the development of other techniques by which we could even study those functions, which do not depend upon just seeing the responses in the animals, it has been realised that in addition to the neocortical mechanisms, there are other very large & important areas in the brain, mostly present as a sort of a cap on top of the upper brain-stem which have got very important functions. It has now been realised that what was anatomically described by Broca (1878) as the "*limbic*

lobe" of the brain is a functional unit which has now been given the name of *"limbic system"* denoting that this anatomicol lobe has got a sort of unity of function, as the functions regulated from here are common to most of the structures in this area. It has been shown that that is the region which regulates and controls the internal activities-the visceral activities-in contrast to the regulation of the somatic activities from the neocortex. In other words we have the neocortex which regulates our responses in terms of the various activities which take place inside our body. Now what is the aim of all these internal activities ? The aim ultimately is the maintenance of *"milieu interieur"*. If that is the aim, then naturally one would realise that the study of the functions of the limbic system ultimately is projected towards the study of the regulation of the constancy of *"milieu interieur"*. We know that the constancy of *"milieu interieur"* depends on three main factors. There is the autonomic outflow which regulates the internal activities by sending a dual nerve supply to the various internal organs. Then we have got the endocrinal system which also helps to maintain this *milieu interieur.* And finally the affective behaviour of the individual plays an important role in this regulation. We find that all these three factors are regulated from the limbic system. We have got the regulation of the autonomic activities from the limbic system. We have also got the regulation of the endocrinal functions from the limbic system through its regulation of the secretory activity of the trophic hormones of the anterior pituitary which ultimately lead to the regulation of the secretion of the other endocrines. And finally this is also the region from where the affective behaviour of the individual is regulated, integrated and controlled. If one studies the organisation of the pattern of activity of this system, again one finds that there are large similarities between how the neocortical system works and how the limbic system functions. On the neocortical side which regulates somatic activity, we find that we have got the sensory inputs coming from mostly the peripheral structures in the body. These go up and first relay in the brain stem areas, where Dr. Baldev Singh has told you are some of the lower centres which regulate the postural activity and other special type of activities produced in relation to the external environment. Then these sensations are projected to the sensory areas of the brain where the sensations reach consciousness. The execution of movements in relation to these sensations are initiated from the motor areas. In between the two we have got the whole mass of association areas which have the function of integrating the sensory input into sensory areas with the motor execution from the motor side.

Coming to the higher nervous regions regulating visceral activities, one finds similar arrangements. We have got the sensation coming from the various internal organs, which ultimately have been shown to project to the hypothalamic region. But before projecting into hypothalamus these are also

giving collaterals into the brain-stem regions, just like the somatic afferents. For the somatic regulation, we have got most important postural regulation centres in the reticular formation. One would, therefore, expect in these brain-stem regions centres for visceral regulation also. Already one is familiar with the presence of the cardiac centre, respiratory centre, vasomotor centre, adrenaline centre and so on in this region. But now one realises that most of the functions which are ultimately projected towards the regulation of the *milieu interieur* would have some sort of regulation from this region.

Finally these internal sensations reach the hypothalamus. Hypothalamus also is the execution area (motor area) for regulation of *milieu interieur.* Hypothalamus produces its effects by on one side regulating the autonomic activity and on the other side regulating the secretions of anterior pituitary. Thus between the sensory input into the hypothalamus, and the motor output again from the hypothalamus, we have got this huge mass of neurons which constitute the *limbic systems.* We find that all these areas of the limbic system have got to and from projections connecting them ultimately with the hypothalamic region.

On the somatic side (neocortex) one knows that if you have experimental procedures involving sensory areas or motor areas, one can always predict specific effects of those destructions or stimulations. But when we come to the huge mass of association areas one can only predict that some changes in somatic activity will be produced, of a sensory as well as of motor nature, but there will be always an amount of unspecificity attached to these—it is a sort of a general removal of some of the functions rather than a specific change. Similarly one finds that experimental procedures involving some of limbic areas produce comparable effects. Because the hypothalamus is equivalent to the sensory and the motor area s of the neocortex, one can always predict definite, specific responses in autonomic activity, in endocrinal activity, and in affective behaviour after stimulations or destructions of the hypothalamus. But when one comes to the limbic areas, one finds that in function, in terms of regulation of internal activities, these regions have got the same type of arrangement as the neocortical association areas. Therefore, experimental studies on the limbic system have produced same conflicting results because you cannot get any specific changes from specific areas of the limbic system. You can expect unspecific changes in the autonomic activity, in the endocrinal activity, and in the affective behaviour, depending on whether the limbic areas are removed, or stimulated, the effects produced will also depend upon extent of destruction. This brings about how the limbic system regulates the internal activities in a similar manner as neocortex regulates external activity.

We also find that all these regions are intimately related to the awareness, or the conscious functions. These phenomena have already been referred to

by Dr. Baldev Singh. If we study phylogenetically, or evolutionally, we find that the spinal cord and the brain stem were the first ones to evolve. On top of these first developed the limbic areas, and on top of these ultimately developed the neocortex. With the evolution of the spinal cord and brain stem, came the general awareness, and, therefore, we say that the conscious area is not in the neocortex, but in the upper brain-stem in the reticular formation. That is the "Activating System" of Magoun. With the development of limbic system on top of that, the "feeling" part of this awareness arose and that is the affective behaviour of the individual. With the development of neo-cortex on top of that the "knowledge" about this awareness, i. e. concious awareness of all these things originated. So the consciousness is located at all these different higher nervous levels. This is the general awareness, then there is the feeling of that awareness, and finally the knowledge about that awareness.

Side by side with these regions the cerebellum also developes. As the limbic system arose on one side of brain-stem, the paleo-cerebellum developed on the other side of brain-stem. As the neo-cerebrum (neocortex) developed on the one side the neo-cerebellum developed on the other side. That is why one finds that, although previously it was known that only the neo-cerebellum is connected with the neo-cerebrum, it has now been shown that the paleo-cerebellum is connected to the limbic system. Therefore, not only the cerebellum regulates the voluntary activity of the cerebrum, but the cerebellum can also influence the autonomic activities and the visceral activities through the limbic system.