

interstitial tissue is responsible for sex characters and behavior, it is the volume of tissue and not the number of cells that is important.

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Movements in Transplanted Limbs.

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In the course of the experimental work involving the use of the amphibian limb disc, many of the effects of this developing structure upon the nervous system have been discovered. Most of the transplantations have involved placing the limb disc posterior to its normal location. Such transplants show very weak function unless they are innervated by at least one of the nerves which under ordinary conditions would go into the normal limb. Detwiler and Carpenter¹ have studied coordinate movements in both the transplanted and normal limbs and have found that coordination is an expression of an innervation common to both the normal and the transplanted limb through some one of the bronchial plexus nerves. Such coordination is lost as soon as the communicating branches of such nerves are cut.

The work here reported deals with transplantations made in testing the growth of various isolated parts of the amphibian nervous system. The operation, in which the limb and associated tissues were used in order to block the growth of the nervous system, involves the removal of a part of the nervous system and the transplantation into the wound of a rectangular transplant of embryonic tissue which includes the rudiment of the limb and also of the pronephros. The establishment of a block within the nervous system has been reported previously.²

The transplants have been located either anterior or posterior to the normal limb level and their reactions noted. Their regional locations are (1) above the notocord in the region formerly occupied by the ninth, tenth and eleventh spinal cord segments; (2) in the region formerly occupied by the tenth cranial, the first and second spinal segments; (3) in the region of the mesencephalon and (4) in the orbit.

¹ Detwiler, S. R., and Carpenter, R. L., *J. Comp. Neur.*, 1929, **xlvi**, 427.

² Nicholas, J. S., *Proc. Soc. Exp. Biol. and Med.*, 1928, **xxv**, 662.

These transplantations because of the variety of the regions occupied by the developing limb afforded an opportunity for the study of the functions of limbs with innervations far different from the normal, both in their source and in the composition of their components.

The limbs transplanted into the region of the ninth, tenth and eleventh spinal segments are seldom functional although they are in direct relation with the cut end of the spinal cord from which fibers grow into the limb. The nerves which penetrate the limb are derived directly from the spinal cord or from the posterior branches of the spinal nerves and are found in normal pattern relationships within the limb. Quantitatively, the limbs are well innervated but the nerves do not possess the qualitative action necessary to produce physiologically complete muscular movements within the limb.

The limbs situated in the region of the tenth cranial, first and second spinal segments give some degree of function in 80% of the cases. Of these, 40% show movements which may be defined as normal, *i. e.*, the limb is capable of flexion, extension, abduction and adduction of either the whole limb or its parts. In the 20% non-functional limbs, the physiological deficiency was not due to failure of nerves to grow into the limb but to incoordinate action produced by aberrant nervous connections. These produce a simultaneous contraction of all the muscles in the limb resulting in a condition of dominant extension tonus or spasticity. The limbs which are termed functional are not coordinate with the normal limbs in their movements but are coordinate with muscle groups supplied by similar nerve groupings. The limbs transplanted to the medulla region showed movements which were coordinate with gill movements.

The innervation to such transplants may arise either through the seventh or ninth cranial nerves or through nerve cables which arise directly from the medulla and have no anatomical peripheral connections with cranial or spinal nerves. The reactions of the limb are physiologically similar whether the limb is innervated by a peripheral trunk such as the seventh or ninth cranial or by a direct connection with the medulla.

When limbs are transplanted in place of the mesencephalon, they may be innervated by the fifth or seventh cranial nerves. These transplants do not develop limbs in nearly so high a percentage of cases as in the preceding series due to failures in the vascular supply. When, however, they do develop they show the same conditions of function as those given above.

When the limb bud is transplanted into the orbit in place of the *globus oculi*, very few fully formed limbs develop. This location.

however, affords a chance to study the movements of the limb on the one side and to compare it with the normal movements of the eye upon the opposite side. So far in the course of experimentation only one limb has been secured which has shown perfect development in this location. This limb likewise showed movements of the whole limb which corresponded to the movements of the normal eye. The limb did not show movements of its component parts.

The experiments show that when the limb disc is transplanted to regions anterior to its normal location, functional connections can be effected through cranial nerves or through fiber outgrowths direct from the nervous system. Cranial nerve components which under ordinary conditions are associated with the somatic motor, special visceral (splanchnic) motor and sensory regions are capable of producing reactions within an extremity normally supplied by general motor and sensory elements. When such reactions are obtained they are coordinate with the reactions in groups supplied by the same innervation.

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Transplantations of Tissues in Fetal Rats.

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Transplantations have been used in order to determine the amount of differentiation which may take place in fetal mammalian structures and also to study the changes which may occur in such tissues following their transplantation to strange environments.

The method of procedure in operations upon the mammalian fetus has been described previously.¹ It is necessary to use fetuses of the earliest possible stage of development in order to secure the tissues in the least differentiated stages. This is difficult in the albino rat fetus because of the absence of anatomical landmarks which will assist the operator in localizing the tissue which it is desired to remove from the embryo. In order to secure an anatomical landmark a cross was made between albino and hooded stock. This cross gave both albino and hooded fetuses in the same litter, oft-times within the same uterine horn. Pigment develops in the eye of the hooded rat at about the tenth day of gestation age. Unless some

¹ Nicholas, J. S., *Anat. Rec.*, 1925, xxxi, 385.