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Function of De-afferented Amphibian Limbs.

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In analyzing the so-called resonance phenomena of nervous control, discovered by the author,[1] the necessity arose to reinvestigate the problem of the significance of afferent excitations for the establishment and persistence of motor functions in Amphibia. In a number of toads and axolotls, limbs were de-afferented by removing all the spinal ganglia and attached dorsal roots of the limb segments (fore limb, hind limb or both), either on both sides or on one side only. In contrast to most of the earlier experiments, the operation was performed without opening the vertebral canal so that injury or degenerative damage to the motor roots could be strictly avoided. In one series the sympathetic system has been preserved, in another series it was removed within the de-afferented area, including ganglia and rami communicantes.

A. *Experiments with toads.* Twenty-eight animals were operated (in ether anesthesia) and examined as to their motor functions from immediately after the operation to 22 days later.

I. *Motility.* After bilateral de-afferentation of the hind legs (17 cases) no essential change from normal could be noticed in the performance of locomotor functions: jumping and walking on rough ground are well-aimed, well-coordinated and vigorous. The reflexes of righting, turning and wiping are performed in the normal way. The resting posture is normal, except for a certain lack of contact between the plantar surface of the foot and the ground. It is evident, therefore, that after de-afferentation the motor functions of the affected limbs persist without significant alterations. This is strikingly borne out by unilateral de-afferentation, no asymmetry in jumping, righting, etc., appearing in such animals.

No difference could be found in the motor functions between animals possessing (14 cases) or deprived of (11 cases) the sympathetic chain.

De-afferentation of the fore limbs alone was effected in one case only. The locomotion of the animal was not markedly impaired; wiping reflexes of the arms could be obtained but the hind limbs were used preferentially. A certain hypertonicity of the flexors and pronators was characteristic of the resting posture.

[1] Compare the recent review by DeSilva, H. R., and Ellis, W. D., *J. Gen. Psychol.*, 1934, **11**, 145.

Serious disturbances resulted from the combined de-afferentation of both the fore and the hind limbs (2 cases). Such animals were extremely apathetic and hardly ever moved "spontaneously". If, however, they could be induced to move, their jumping, walking, righting and turning were coordinated.

II. *Tonus.* Neither the view that the maintenance of the tonic posture requires proprioceptive control nor the assumption that it is due to sympathetic innervation could be substantiated by these experiments on the toad. In order to test the tonic (postural) phenomena, the animals with de-afferentated hind limbs were suspended vertically, head upward. Hanging freely, they kept their hind legs completely adducted and flexed. This posture could be maintained for several minutes (longest observed time, 9 minutes), in some specimens without any dropping of the legs at all, in some others with a gradual drop to a half-relaxed position; great individual differences were observed between more "motile" and more "tonic" individuals. The fact that the de-afferentation does not visibly impair the ability to assume and maintain tonic postures against gravity is most strikingly demonstrated after unilateral de-afferentation. In the suspension tests of such animals no marked asymmetry of posture can be discerned between the de-afferented limb and the normal limb of the opposite side; when the limbs drop, they do so simultaneously, to the same extent. Asymmetry due to a loss of tonus in the de-afferented limb is, however, observed whenever the motor supply has been damaged in addition to the de-afferentation. If motor damage has been avoided, the asymmetry described for the first time by Brondgeest[2] for the frog could never be obtained on the toad with intact brain. We must conclude, therefore, that proprioceptive control is at least not indispensable in the production and maintenance of muscular tonus in Amphibia.

The tonus of de-afferented limbs is "plastic" in one direction: when the limb with tonic flexion is passively extended, it remains in the new extended position without tending to return to the old posture; on the other hand, one invariably fails in an attempt to make the limb resume its flexed position by passively flexing it.

The sympathetic nervous system proved to be entirely unessential for the maintenance of tonus. Animals bilaterally de-afferented and unilaterally sympathectomized assumed perfectly symmetrical postures in the suspension tests. Possibly the sympathectomized leg showed fatigue slightly earlier in some cases, but certainly not as a rule.

[2] Brondgeest, P. J., *Arch. f. Anat., Physiol. and wiss. Med.*, 1860, 703.

B. *Axolotl.* In axolotls of about 5 to 7 cm. in length the spinal ganglia and dorsal roots were removed in the arm segments (2nd, 3rd, 4th, and 5th) on one side. Owing to motor injury, 2 out of the 10 operated animals showed partial motor paralysis. In the remaining 8 cases, however, observed from the operation up to 4 weeks afterwards, the locomotor functions of the de-afferented limbs were found to be perfectly normal and undisturbed. In walking the limbs were used in normal coordination. In a few cases there seemed to be a slight hypertonicity of the extensor and adductor muscles in the resting position, which did not, however, even in the most extreme cases, impede the normal motor activity of the limb.

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Effect of Irradiated Ergosterol and Calcium Lactate on Calcification of Trichina Cysts.*

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Workers in the field of experimental parasitology have repeatedly shown that in the normal course of infection with *Trichinella spiralis,* cysts begin to form around the coiled larvae in the muscle fibers in 4 to 6 weeks following infection. These cysts, at first extremely delicate, gradually become more conspicuous and after about 7 or 8 months there begins a deposit of calcareous material, resulting finally in calcification of the entire cyst. Complete calcification of the cyst and the contained larvae seldom occurs normally in less than one year and in many instances the calcification process is much slower.

It seems quite probable that the more general symptoms of trichiniasis, muscular pains, fever, eosinophilia, etc., are, in part at least, due to toxic products formed by the breaking down of large amounts of muscle tissue together with waste products of the larvae. Thus a continuous inoculation of the infected host with toxic proteins occurs. When cyst formation, the protective mechanism of the body for walling off the parasite, has progressed sufficiently, production of poisonous products and the effects of mechanical irritation by the larvae tend to be inhibited.

* This series of experiments was performed at Northwestern University, Department of Zoology, under the direction of Dr. Franklin D. Barker.