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Unmodifiability of Locomotor Coordination in Amphibia, Demonstrated by the Reverse Functioning of Mutually Exchanged Right and Left Limbs.

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According to the so-called resonance principle,¹ a spinal limb center produces motor impulses specific for each individual muscle, to which the motor nerves, specified appropriately by their muscles, respond selectively. A reflex pattern is an orderly timed (coordinated) sequence of such specific impulses. Left and right half of a spinal center act separately.² Corresponding left and right muscles are of identical specificity.³

A supernumerary muscle, through its specified nerve, picks up the messages emitted for the normal muscle of the same name in the district; therefore, a supernumerary limb grafted into the district of a normal limb acts always simultaneously and identically with the latter. If the supernumerary and the nearby normal limb are of opposite laterality (*e. g.*, a right leg grafted near a left leg), their movements are mirror images of each other, and if the supernumerary limb can reach the ground, its movements necessarily counteract the effects of the normal limb.⁴ The animals never "learn" to remedy this impediment, at least not in the cases where the normal limb remains functional.

There the question arose as to whether, if the normal limbs were removed and limbs of opposite laterality were grafted in their places, the function of the latter would still be reversed as it is in the presence of the normal limbs, or whether some adjustment in the emission pattern of the reflex might not make the grafts serviceable to the body.

In a number of salamanders (*Amblystoma punctatum* larv.), fully developed right and left fore limbs, including the shoulder girdles, were exchanged by dorso-dorsal transplantation, *i. e.*, palms downward and fore arms pointing caudad. After reinnervation had taken place, the grafts moved in perfect coordination, but *always in exactly the reverse sense from what the animal obviously intended.*

¹ Summary in P. Weiss, *J. Comp. Neur.*, 1935, **61**, 135.

² Weiss, P., *Ergebn. d. Biol.*, 1928, **3**, 1.

³ Weiss, P., *Pflüger's Arch. f. d. ges. Physiol.*, 1931, **226**, 600.

⁴ Unpublished results.

When the animal, to judge from the movements of the normal hind limbs, intended to walk forward, its exchanged fore limbs moved so as to make it walk backward, and upon amputation of the normally progressing hind limbs the backward movement went actually into effect.

This demonstrates that the reflex pattern for the fore limbs, in spite of the awkward consequences it entailed for these animals, had remained unchanged and unadjustable; the left spinal fore limb center continued to discharge a reflex sequence as if for a normal left limb, though such was now missing, and regardless of the fact that the central intention was turned into exactly the opposite effect by being picked up by the grafted right limb with its inverted anatomy. The same holds for the right spinal center in its dealing with a left limb substituted for the right limb.

Although the observations were extended over a period of several months and beyond metamorphosis, the reversed walking and swimming remained unchanged. This fact proves an utter lack of modifiability in the innate patterns of spinal reflex organization in amphibia. An anatomical disarrangement or inversion of the periphery results in functional activities which, in regard to the body, are correspondingly disarranged or reversed. The function remains under all circumstances "organ-correct", whereas it is "body-correct" only as long as the organ retains its normal anatomical relation to the body.

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Studies in Water Balance. 1: The Excessive Oxygen Usage Response of Dehydrated Animals to Water and Electrolytes.

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In certain forms of oedema, particularly those accompanying lipoid nephrosis and certain nutritional states, there is present a marked lowering of the basal metabolic rate. For this reason, it seemed to be desirable to investigate the possible relationship of the total metabolism to water output and to the production of oedema. It has been suggested recently¹ that such a relationship does exist.

¹ Davis, H. A., *Science*, 1935, **81**, 493.