Chapter 3

Withdrawal reflex: philosophy and physiology

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To the memory of Vito Valterra, the illustrious mathematician who, in 1932, published his “Mathematical Theory of the Struggle for Life”, a splendid mathematical analysis of survival strategies where the fundamental model is the withdrawal reflex.

“The chief function of the central nervous system is to send messages to the muscles which will make the body move effectivcly as a whole”. E.D. Adrian, Nobel Prize 1932.

The term “withdrawal reflex” is intended to mean any reflex whose end purpose is to protect the organism or one of its tissues from being damaged (Fig. 1). One example is the corneal reflex described as “irritation of the cornea causing the reflex closure of the lids” [1].

Fig. 1. Withdrawal reflex Child pricked with a rose thorn. The reflex withdrawal is controlled both by physical (analgesia endogenous system) and by mental (attention, anxious, depression) factors

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Reflex action in the leg or arm, provoked by a painful stimulus, is commonly used in pain studies. K.D. Craig writes: “With some exceptions, traumatic injury, such as lacerations or burns, provokes a vigorous withdrawal reflex, as well as protective movements and stereotyped patterns of verbal and nonverbal expressive behavior recognizable as pain onlookers” [2].

**Philosophical roots**

Aristotle did not consider muscular tissue as the organ of movement. In fact, in his *De Anima*, he expounds his concept whereby the instruments of animal movement are the bones which are moved by the nerves.

Galen (131-200 A.D.) was the first person to attribute movement to the muscles. In fact, in his book entitled *De Motu Musculorum*, he recognizes muscles as being the organs of movement. The nerves embedded in the muscles grow out of the brain and spinal cord. If a nerve is interrupted, no muscular movement is possible. A sectioned or compressed nerve deprives the muscle of feeling and movement. Therefore, in Galen’s conception, nerves are conductors that run from the brain “like streams” and provide the muscles with a force that allows them to function and contract.

To Galen’s credit, he introduced both the term and concept of muscular tone. In fact, in his *De Motu Musculorum*, he recognizes that muscles have four types of movement: contraction, extension, passive movement and tonic maintenance. Muscle tone is the “pneuma” effect, that is, the force which, according to historical philosophy, represents the cohesion between the macrocosm and the microcosm. This would explain why a muscle becomes flaccid when its nerves have been severed: that is, when its “pneuma” has been cut off. But, according to Galen, the pneuma that the brain provides for the nerves comes from the supreme source: the soul. The physiological notion regarding tone thus has a philosophical origin where it is conceived as being a permanent will of the soul.

Another concept introduced by Galen is “voluntary movement”. This is the type of movement a person can originate and control when wishing to do something or to stop doing something. With voluntary movement, the person can, therefore, initiate, accelerate, slow down, and stop a movement, and repeat the whole process. Galen considered that voluntary movement had a central origin and that it depended on the brain. However, since the brain was still under the control of the soul, movement had a transcendent origin. Galen had trouble explaining how the intelligent soul is able to move the body according to a specific end purpose. In other words, what remained an enigma for Galen was whether the soul acted directly on the body or by means of some instrument that acted as an intermediary between the soul and the movement.

Regarding the mechanism of muscular contraction, Galen could not provide an explanation. All we know is that he made a distinction between nerves and tendons. He divided the nerves in two categories: soft nerves (for sensitivity)