


UNIVERSITY OF BUEA



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DEPARTMENT OF PLANT AND ANIMAL SCIENCES

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# MECHANISMS OF NEOROMUSCULAR PHYSIOLOGY

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## Introduction

- Animal movements, such as locomotion, eating, copulation, and nearly all forms of non chemical communications are expressions of neural commands which are translated into coordinated activity.
- Three fundamental mechanisms generate movement in animals which are: **ciliary, Amoeboid movements, flagella bending and muscle contraction.**
- The contraction of muscles are the most apparent and dramatic signs of animal life and have therefore excited the imagination since the times of the ancients.

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- The neurophysiological mechanisms of complex behavior such as learning and memory are very poorly understood, but it is agreed that the physical substratum for complex behavior is a vast array of neural circuitry that lies between the relatively simple efferent sensory pathways and efferent motor pathway.
- The point of contact between a motor neuron and a muscles cell is called the **neuromuscular junction**. The motor neurons connects the central nervous system (CNS) to the skeletal muscles cells (effectors). Impulses (action potential) are responsible for starting the contraction of these muscles.

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- All behavioural acts are ultimately generated by the motor output of the nervous system, which controls the contraction of muscles.
- The motor output, in turn, is strongly influenced by the sensory output.
- The behavior (i.e. sum total of movements) of the organism is constantly modified by stimuli from the environment.
- The simplest neural network is the reflex arc. The premodial **reflex arc** may have consisted of a receptor cell directly innervating an effector.

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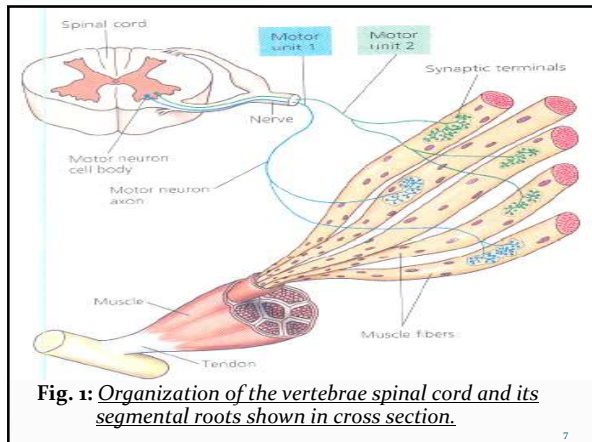
## Vertebrate nervous system

- In spite of its awesome structural complexity, the vertebrate nervous system offers certain advantages for experimental neurophysiology. One of these expressions is so called **Bell-Magendie rule**, enunciated over a century.
- Here, the **afferent** (sensory) nerve fibres (i.e., the axons) enter the central nervous system (CNS) via the dorsal root of the cranial and spinal nerves, whereas the **efferent** (motor) nerve fibre leaves the CNS via the ventral roots.
- The motor fibres arise from the nerve cell bodies in the ventral horn of the spinal cord. The afferent fibres arise from the monopolar cell bodies in the dorsal root or spinal ganglia.

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- The segregation of sensory and motor axons into dorsal and ventral roots makes it possible selectively to stimulate or to eliminate by transaction the sensory input to or motor output from the CNS.
- The CNS “filters” sensory input – namely, it enhances certain features of the incoming stimuli and suppresses others.

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## Cross-bridge function and the production of force in muscles

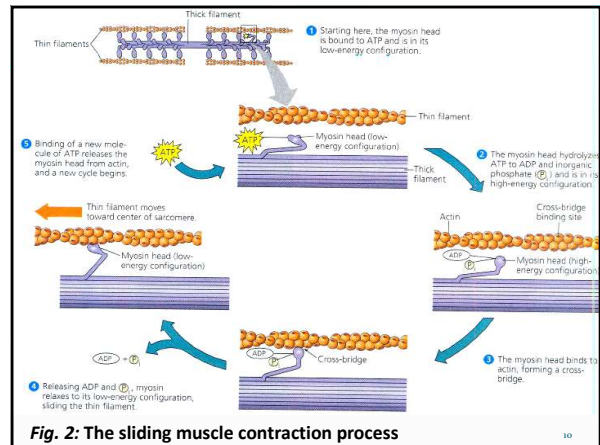
- The force of muscles contraction arises from the sequential binding of several sites on the myosin head to sites of the actin filament. The head of the cross bridge then separates from the actin filament, freeing it to another cycle of sequential binding farther along the actin filaments.
- Thus supporting the ideas that the sliding movement between the actin and myosin filaments results from forces produced by the cross bridges acting on the actin filaments.
- The cross bridges must alternately attach to the actin filament, exert forces, detach, and re-attach at another locus.

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## How do the cross bridge produce sliding force between thick and thin filaments?

- There have been a number of suggestions. The most widely accepted view is that a *rotation* of the myosin head produce forces, and that that this force is transmitted to the thick filament through the neck of the of the myosin molecules.
- The neck forming the *cross bridge link* between the head of the myosin molecule and the thick filament.
- In this hypothesis, the link acts as a connection between the myosin head and the thick filaments transmitting the force produced by rotation of the head of the actin filaments.

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## Acetylcholine, calcium ions and muscle contraction

- When the skeletal muscle is at rest, there is a protein called **tropomyosin** blocking the receptor site on the actin filament so that myosin and actin cannot bond.
- The calcium ions regulate the troponin complex and this troponin complex controls the position of tropomyosin. Thus a **concentration of calcium** is needed so that the tropomyosin-troponin complex is rearranged to allow for myosin and actin to bind in order for the sliding-filament theory to take place.

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- **Acetylcholine** hits the muscle membrane and opens up **large gates** that allows calcium ions to flow through and that allows the troponin-tropomyosin complexes to reform and the calcium will come in and it contracts at that point.

- Acetylcholine diffuses into the membrane of the myocyte (from the dendrite of the effector neuron) at the neuromuscular junctions, and this causes the integral proteins to restructure and allow calcium ions to flow into the cell along new pathways / gradients ("gates" are opened by the acetylcholine).

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- An enzyme called **acetylcholinesterase** breaks down acetylcholine.
- The enzyme acetylcholinesterase which is produced at the neuromuscular junction, then destroys acetylcholine and this permits the re-absorption of calcium ions into the muscle cell and terminates the contraction.
- Upon retraction the calcium has to be absorbed by the myosin molecules and is moved along in another way, that way the movement is done back to its original state, so calcium ions are also required to terminate contraction.

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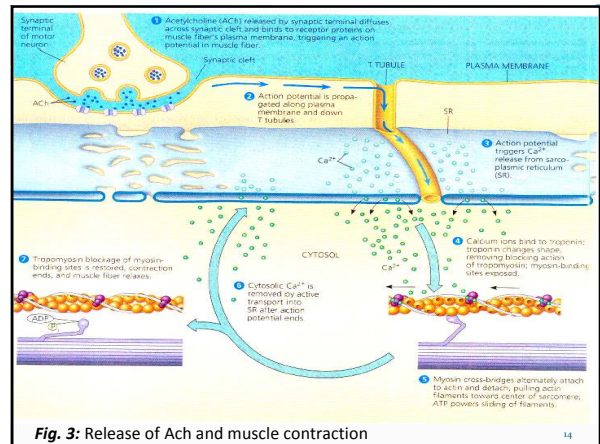
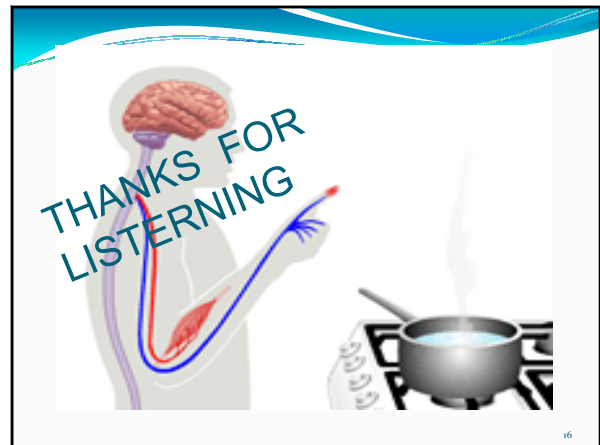


Fig. 3: Release of Ach and muscle contraction

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- ## Muscle sense
- The brain's ability to know where our muscles are and what they are doing is known as **muscle sense**. This permits us to perform everyday activities without having to concentrate on muscle position.
  - It's kind of like being in a position while you relax, and forgetting about the position, but as soon as you get up to do something else, your brain understands where you were.
  - You don't have to go to a set position to start from any sort of position, you can be laying on your side and still be able to write and so on, because you can get to different muscle states through sometimes novel pathways and so on.

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