Medical Neuroscience | Tutorial Notes

Lower Motor Neuronal Control—Central Pattern Generators

MAP TO NEUROSCIENCE CORE CONCEPTS[1]

NCC1. The brain is the body's most complex organ.

NCC3. Genetically determined circuits are the foundation of the nervous system.

LEARNING OBJECTIVES

After study of the assigned learning materials, the student will:

1. Describe central pattern generators and their significance for locomotion and other rhythmic behavior.

TUTORIAL OUTLINE

I. Overall organization of the neural centers that control movement

- A. spinal cord circuits: "final common pathway" or "basic motor system" (see **Figure 16.1**[2])
  - 1. **segmental reflexes** involving alpha (and gamma) motor neurons (i.e., **"lower motor neurons"**), local circuit interneurons, and afferent somatic sensory input (e.g., myotatic or "knee-jerk" reflex)
  - 2. **intersegmental reflexes** mediated by interneurons that coordinate the activities of segmental circuits at multiple levels of the spinal cord (and brainstem) (e.g., central pattern generators for locomotion)

II. Central pattern generation

- A. spinal cord circuits are capable of coordinating rhythmical activities of the extremities to produce locomotory behaviors, such as walking, running, and even swimming or flying (in some species)
- B. comparable circuits are also present in the brainstem for the coordination of rhythmical activities, such as respiration, chewing, swallowing and a variety of coordinated somatic and visceral motor activities
- C. general properties of central pattern generators:
  - 1. some neurons in circuit function as "pacemakers", by generating burst of spikes, prolonged depolarizations or oscillatory activity
  - 2. the expression of such pacemaker activity is usually initiated by descending central command inputs or peripheral sensory inputs

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[1] Visit **BrainFacts.org** for *Neuroscience Core Concepts* (©2012 Society for Neuroscience) that offer fundamental principles about the brain and nervous system, the most complex living structure known in the universe.

[2] Figure references to Purves et al., *Neuroscience, 5th Ed.*, Sinauer Assoc., Inc., 2012. [click here]

3. the same circuit may produce different rhythms

D. in animal experiments, transection of the spinal cord of a cat above the lumbar enlargement will not abolish coordinated walking movements of the hindlimbs if the cat is placed on a moving treadmill (see **Figure 16.15C**)

1. not explained by simple reflexive response to passive stretch of muscle spindles (behavior survives additional section of dorsal roots)

2. basic pattern of coordinated activity is "wired" into the segmental circuits of the spinal cord; i.e., **central pattern generator**

E. normally, intersegmental connections coordinate the activities of central pattern generators in cervical and lumbar enlargements to produce locomotory behavior

F. as in all other considerations of spinal cord circuitry, central pattern generators are subject to descending control and modulation

G. difficulty in eliciting walking behavior in human spinal cord patients suggests that descending controls play a larger role in coordinating or facilitating central pattern generation in the human spinal cord

STUDY QUESTION

Which of the following behaviors do you think is mediated by central pattern generators?

A. walking
B. running
C. swimming
D. scratching
E. laughing
F. chewing
G. breathing
H. all of the above