PART I: REFLEXES
BACKGROUND
A reflex is a sequence of events initiated by a sensory input and executed by a muscle or gland. Reflexes are the simplest functional responses of the nervous system. Reflex actions often appear purposeful. For example, the withdrawal of an appendage from a painful stimulus and the movements that allow balance to be maintained are actions that are obviously advantageous. The adaptive nature of reflex activity will be illustrated by many of the reflexes examined in this exercise.

Reflexes contribute to the maintenance of homeostasis. In **negative feedback mechanisms** a controlled variable is regulated at an appropriate value. Receptors or sensors that pass information on to an integrator monitor the controlled variable. Deviations of the variable from its ideal level, or **setpoint**, result in activation of effectors that oppose the departure from the setpoint.

A **reflex arc** is a negative feedback circuit in which a detection system is linked to a response system. Reflex action usually requires the following components (Fig. 5–1):

- An **afferent, or sensory, component**. This component includes **sensory receptors** (these maybe modified epithelial cells or afferent neurons) and **afferent neurons** to transmit impulses to the central nervous system where they synapse with other neurons.
- An **integrator**, often called an **integrating center,** or a collection of **association neurons** when it exists within the central nervous system, that determines that magnitude of the response that is appropriate.
- An **efferent or motor component** consisting of **neurons** that transmit impulses peripherally and an **effector** that responds to the nerve impulses. The effector often consists of muscle fibers, but it may be a gland.

Spinal reflexes require a functional spinal cord but can occur without brain activity. Although the brain is not required for spinal reflexes to occur, cerebral activity frequently alters spinal reflex action in humans, by either facilitating or inhibiting a reflex. Some of the reflexes to be examined in this exercise require the presence of functional brain tissue if they are to occur. The changes in the size of the pupils of the eyes in response to light are in this category.

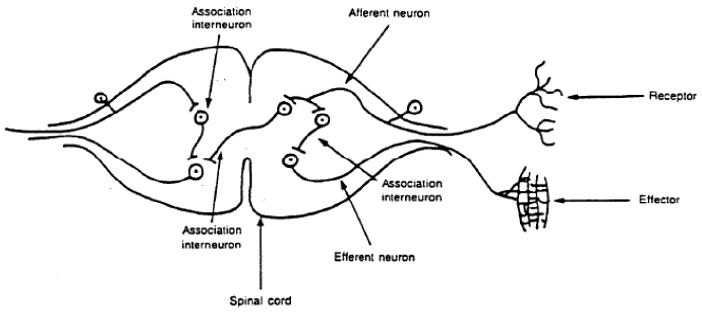


Figure 5-1. The components of a spinal reflex arc.

In this exercise several reflex responses will be studied. Some of these do not require brain activity; others could not occur without impulses from the brain. The reflexes to be examined will also illustrate the advantages of reflex activity and will demonstrate that several types of tissue can serve as the effector tissue in a reflex response.

In the first part of this exercise, you will demonstrate **stretch reflexes** (or **tendon** reflexes). The receptors for stretch reflexes are called **muscle stretch receptors**. They are embedded among the muscle fibers of almost every skeletal muscle (Fig. 5–2). Stretching a muscle stretches its stretch receptors, resulting in reflexive contraction of the stretched muscle. Stretch reflexes are **monosynaptic**, that is, the afferent neuron synapses directly on the efferent neuron, without an intermediate association neuron (Fig. 5–2).
The **patellar reflex** is an example of a stretch reflex. The patellar reflex can be initiated by tapping the tendon below the patella, or kneecap. The stretching of the extensor muscles **(quadriceps femoris)**, to which the tendon is attached, results in their reflex contraction and an extension of the lower leg. The stimulus we will use to elicit the patellar reflex, a tap on the knee, is an artificial means of stimulating a reflex response. The normal function of stretch reflexes is to oppose involuntary stretching of muscles, making it possible for the body to be held in an erect position and to resist unexpected changes of position. The patella is attached to a large muscle of the upper leg, the **quadriceps femoris**. Contraction of this muscle extends the leg. When we stand up, the quadriceps femoris is contracted and must generate enough tension to support the weight of the upper body. Stretching of stretch receptors in this muscle occurs if the knee buckles slightly. The resulting stretch reflex opposes this buckling.

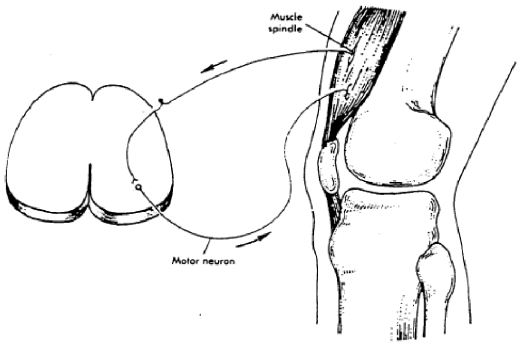


Figure 3-2. A stretch reflex arc runs from stretch receptors in the stretched muscle to motor neurons that excite the muscle.

The force of a reflex response can be altered if other muscular activity occurs simultaneously. The additional muscular activity reduces the resistance of synapses in reflex arcs in other parts of the body. Mental activity can also influence the expression of reflex activity, in part by increasing muscle tone. On the other hand, fatigue decreases muscle tone. You will observe the effects of mental activity, muscular activity, and fatigue on stretch reflexes in Part I-A

Not all individuals have reflex responses that are equally forceful. It is important, however, that in an individual the reflexes on the two sides of the body be of essentially the same magnitude. A difference in response on the two sides can indicate an abnormality in the nervous system.

In Part I-B of this exercise you will demonstrate reflexes of the eye. In the **pupillary reflex** the effectors are the smooth muscle of the iris, which is innervated by both the sympathetic and parasympathetic branches of the autonomic motor system. The size of the pupil changes in response to changes in input from either branch. Parasympathetic input constricts the pupil, while sympathetic input dilates it. The pupillary reflex opposes changes in the intensity of light reaching the retina; in bright light the pupils constrict, and in dim light they dilate.

A reflex such as the patellar reflex, in which response is seen on the same side of the body to which the stimulus was applied, is said to be **ipsilateral**. A reflex action seen on the side of the body opposite to the side stimulated is called a **contralateral** reflex. Stimulation of one eye by light normally results in both ipsilateral and contralateral reflexes. The constriction of the contralateral pupil is called the **consensual** reflex. This reflex is lost in some conditions in which information transfer from one side of the brain to the other is impaired.

The **ciliospinal reflex** is another reflex in which a change in the size of the pupil is seen. Stimulating the skin on the back of the neck can evoke it. Stimulating the back of the neck increases the number of sympathetic nerve impulses to muscles that dilate the iris.

PROCEDURE, PART I-A. TENDON OR STRETCH REFLEXES

Work with a partner and take turns being the subject and experimenter.

A. Patellar reflex

1. Subject: sit on a stool or a table with both legs hanging freely.
2. Experimenter: using a Taylor hammer, tap the tendon just below the subject's knee. Describe the subject's responses in Table 3-1A.
3. Experimenter: test the other leg in the same way and enter the results in Table 3-1A.
4. Experimenter: write down an addition problem consisting of ten numbers of at least three digits each. Have the subject sit down in a position that allows the patellar reflex to be checked. Check the subject's normal reflex action once or twice, then give the subject the prepared problem and instruct him or her to do it in the shortest time possible without the use of a pencil, pen, or calculator. While the subject is concentrating on the problem, check his or her patellar reflexes. Describe them in Table 3-1A.
5. Subject: once again assume a position in which the patellar reflexes can be checked.
6. Experimenter: test the patellar reflex. Then instruct the subject to clasp his or her hands together and hold them tightly clasped while contracting the muscles of the arms as if to pull the hands apart. While the subject is engaged in this muscular activity, check the patellar reflexes. Enter the results in Table 3-1A.
7. Subject: walk up and down a flight of stairs until you feel quite tired. Then sit down as before.
8. Experimenter: check the subject's patellar reflexes immediately after he or she sits down and compare them to the patellar reflexes observed earlier. Use Table 3-1A to describe the results and compare the strength of the responses observed

TABLE 3-1. RESULTS, PART I-A. TENDON OR STRETCH REFLEXES

	Magnitude of response (weak, moderate, or strong)	
Conditions under which patellar reflex was tested and leg tested	Subject 1	Subject 2
3-1A. *Patellar reflex*		
Normal		
Left leg		
Right leg		
During concentration		
Left leg		
Right leg		
During muscular activity		
Left leg		
Right leg		
After strenuous activity		
Left leg		
Right leg		

PROCEDURE, PART I-B. EYE REFLEXES

A. Pupillary reflex

1. Subject: stand in a place where the lighting is relatively dim, away from a window or lamp.
2. Experimenter: note the size of the pupil of each eye and enter this value in Table 3-2A.
3. Experimenter: shine a light into the subject's right eye. Record the diameter of each pupil in Table 3-2A.
4.

TABLE 3-2. RESULTS, PART I-B. EYE REFLEXES

	Pupillary responses			
	Diameter (mm)		Change in size (± mm)	
Experimental conditions	Subject 1	Subject 2	Subject 1	Subject 2
3-2A. *Pupillary reflex*				
Left eye				
Dim light				
Bright light				
Right eye				
Dim light				
Bright light				

B. Consensual reflex

1. Subject: again stand in a place where light is not shining directly into your eyes.
2. Experimenter: note the size of the subject's pupils. Instruct him or her to hold a hand vertically between the two eyes (touching nose and forehead). Shine a light into the subject's left eye. The hand should prevent the light from striking the right eye directly. Record the results in Table 3-2B.

	Pupillary responses			
	Diameter (mm)		Change in size (± mm)	
Experimental conditions	Subject 1	Subject 2	Subject 1	Subject 2
3-2B. *Consensual reflex*				
Left eye				
Dim light				
Bright light in left eye only				
Right eye				
Dim light				
Bright light in left eye only				

C. Ciliospinal reflex

1. Experimenter: while observing the subject's pupils, lightly pinch or scratch the back of his or her neck. Describe the response in Table 3-2C.