A REFLEX ARC IS THE SIMPLEST FORM OF N EURAL CONTROL IN VERTEBRATES

A ***reflex arc*** is a simple neural circuit linking a sensory receptor to an effector. The reflexes they produce, which are responses to specific stimuli, are usually rapid and automatic. Reflex arcs control behavioral responses that must occur quickly, such as emergency reactions and the automatic maintenance of some kind of equilibrium. A good example of a familiar emergency reaction is the withdrawal reflex. When we touch something hot or press down on something sharp, our hand jerks back automatically. How is this response mediated? The sensory neurons involved in this response run from the hand to the spinal cord. The sensory neurons enter the <u>dorsal</u> part of the spinal cord cell via the dorsal root of the spinal nerve. The cell bodies of these sensory neurons are located in a ***dorsal-root ganglion*** that lies just outside the spinal cord near its dorsal side (see Figure below). The axons of the sensory neurons then enter the spinal cord and synapse with interneurons within the gray matter of the spinal cord. The interneurons in turn synapse with motor neurons, the axons of which exit the cord ventrally via the ventral root, and conduct information to the muscles. In this reflex, a strong signal from the appropriate sensory cells both fires the flexor muscles and inhibits the motor neurons to the extensor muscles, and the hand is pulled back.. This crucial motor response is well under way before the signals responsible for the conscious sensation of pain (which exit the reflex pathway in the spinal cord) ever reach the brain.

The kind of circuit that automatically maintains equilibrium is exemplified by the well-known knee-jerk reflex, a part of the postural control system. Stretch receptors within the muscle measure the degree to which the muscle is stretched. As the force against which the muscle must act—the amount of weight on one leg for instance—increases, the muscle is stretched, and the receptors signal this fact through sensory neurons to the spinal cord. As in the previous example, the information is sent both to motor neurons for immediate action and to the brain for analysis. The arrival of signals from the receptor increases the firing rate of the motor neurons, and the muscles tighten to accommodate the added load they perceive. Without the organism's being aware, the knee-jerk reflex automatically tunes posture. Physicians regularly test for this response by tapping a patient's knee with a special rubber hammer (see Figure). The response ascertains whether certain nerves and a portion of the spinal cord are functioning normally. When the physician taps the knee, a stretch receptor is stimulated and impulses travel up a sensory neuron to the spinal cord and back down a motor neuron to the leg, where they stimulate muscle fibers to contract, causing the leg to jerk. A minimum of three cells are involved in this reflex arc: a receptor-sensory neuron, a motor neuron, and an effector cell (muscle).

Using these simple reflexes as a model, we can make several generalizations about the reflex arcs of the somatic system:

1. For a particular reflex arc there is never more than one sensory neuron in the pathway, however long it must be, to carry the sensory information from the receptor to the spinal cord (there may be many such neurons running side by side serving the same function).

2. The cell body of the sensory neuron is always located in a dorsal-root ganglion lying outside the spinal cord.

3. The axons of sensory neurons always enter the spinal cord <u>dorsally</u> whereas the axons of motor neurons always leave the spinal cord <u>ventrally</u>.

4. There is a single motor neuron in the pathway carrying information from the spinal cord to the effector.

Very few reflex pathways involve only two neurons, one sensory and one motor, in series, as in initiating the knee jerk reflex. Such a reflex is termed a **monosynaptic reflex.** Transmission across a chemical synapse always involves a synaptic delay, but with only one synapse, the delay between the stimulus and the response is minimized. Almost all spinal reflexes have at least one interneuron between the sensory neuron and the motor neuron, as does the hand withdrawal reflex. At least one interneuron is usually interposed between the sensory neuron and the motor neuron, and it is common for many interneurons to be involved even in relatively simple reflex arcs. These **polysynaptic reflexes** have a longer delay between stimulus and response; the length of the delay is proportional to the number of synapses involved.. Polysynaptic reflexes can produce far more complicated responses than monosynaptic reflexes can, because the interneurons can control several different muscle groups. It is important to keep in mind that a reflex arc, whether it includes few cells or many, almost always sends information to the brain, where instructions to counteract or augment the behavioral reaction can be issued. If you know that the doctor is going to strike your knee, for instance, allowing sufficient time to issue neural commands to modify the reaction, you can consciously either inhibit or exaggerate the response.

Reflex circuitry is able to control and coordinate a variety of simple responses and automatically fine-tune behavior such as walking, whose details must constantly be adjusted as body weight rhythmically shifts.