NERVE AND MUSCLE ACTION

INTRODUCTION

When a nerve cell (**NEURON**) is stimulated, a remarkable series of reactions takes place. The stimulus travels to terminal knobs at the end of the nerve cell where another nerve cell or a muscle may be stimulated in turn. The entire process is completed in milliseconds (1 millisecond = .001 seconds).

In this set, you will study how a stimulus travels to a muscle cell. You will then learn how a muscle cell contracts under this stimulus through a group of integrated electro-chemical and physical reactions.

Some of the slides you will study were photographed using an electron microscope (E.M.). The magnification given, for example, Slide 1 - (100x) means that the microscope was set at that power when the photograph was taken.

1 SINGLE CELL (100x)

This slide shows the cell body of a neuron. It is called a **CYTON** (CI-ton) (C). It contains the nucleus and the cytoplasm. **DENDRITES** (DEN-drites) (D) are branches, leading to the neuron, that receive messages from sense organs or other neurons. The **AXON** (A) carries messages from the neuron to other cells and stimulates them to perform their special functions. *Can you see that the axon has many fine **TERMINAL BRANCHES** (T)?*

2 SYNAPSE (left side - 200x) (right side - E.M. 300,000x)

The axons of neurons end in terminal branches that contact and stimulate other cells. The left side of this slide shows these terminal branches (B) touching the cyton (C) of the neuron it stimulates. The right side of the slide is a greatly magnified view showing the **TERMINAL KNOBS** (K) found at the end of terminal branches. In this case, the knobs are situated so that they can stimulate the cyton (C) directly without passing the stimulus through the dendrites. In other cases, they stimulate dendrites first.

The terminal knobs secrete **NEUROTRANSMITTERS** (NEW-row-trans-MITTers). These are chemicals that cause waves of stimulation in the neurons. The stimulus then passes down the axons to the terminal branches. You will study the effect of the stimuli in the axons in the next slide. The effect of the stimuli on muscle cells will be discussed in Slide 5.

By Herbert A. Nestler

8 SARCOMERES (left side-relaxed - E.M. 45,000x) (right side-contracted - E.M. 31,000x)

The contracting strands in muscle cells are called **MYOFIBRILS** (MY-oh-FYE-brils). There are many myofibrils in a single muscle cell (or fiber). Each myofibril is divided into **SARCOMERES** (SAR-koh-meers) by "Z" lines (Z). Attached to the Z lines are many fine **ACTIN FILAMENTS** (F) that extend to a clear, light H-band (H). Among the actin filaments are dark **MYOSIN** (MY-oh-sin) filaments (M). These produce two dark A-bands (A) on each side of the H-band, where they overlay the actin filaments. This is the relaxed condition of the muscle.

Refer to the microslide as you study the process of contraction. In Slide 7 you learned that the cell membrane is stimulated by acetylcholine. Excitation passes through tiny tubes found throughout the muscle cell. Within a millisecond, Ca^{++} ions rush out of cell reservoirs and remove chemical inhibitors from the actin fibers. Now, myosin fibers, energized by ATP, "pull" on actin fibers, let go, and pull again. This pulls the Z-lines closer together until the opposing actin fibers meet at (H). This is shown by the contracted sarcomeres on the right side of the slide. Notice the wide H-bands in the relaxed sarcomeres. Compare them with the narrowed H-bands of the contracted sarcomeres. When millions of sarcomeres in many cells shorten in this way, the whole muscle contracts.

As a muscle cell contracts, an enzyme breaks the acetylcholine down, and the products are reabsorbed into the synaptic knob. The Ca^{++} ions are pumped back into their reservoirs and the muscle relaxes with the aid of ATP. If the muscles must stay contracted, the nerve keeps firing impulses and the concentration of the neurotransmitters is kept up at the muscle cell membrane.

Malathion, a powerful insecticide, prevents enzymes from breaking down neurotransmitters. Overstimulated muscles go into convulsions and cause death. Curare, used on poisoned arrows, causes muscle paralysis because it prevents acetylcholine from stimulating muscle cells or nerve cells. Very small quantities of curare are also used in certain surgical procedures to cause muscle relaxation.

Photomicrographs 1, 2L, 3, 4, 5, 7 by Dr. J. Metzner; 2R, 8R by Photo Researchers, Inc.