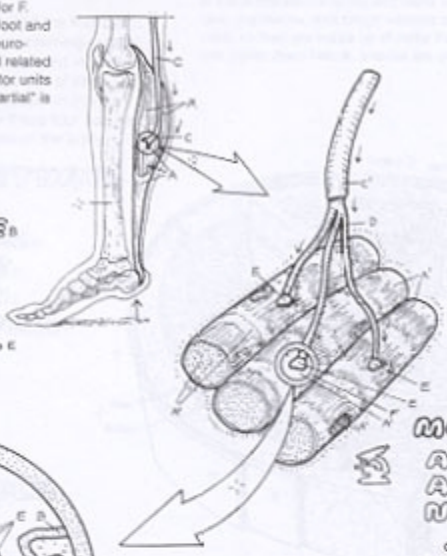
NEUROMUSCULAR INTEGRATION

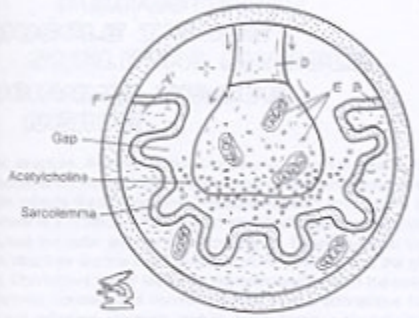
ON: Use very light colors for A and E, and a dark color for F. (1) Begin with the skeletal muscle lifting the heel of the foot and complete the motor unit and the enlarged view of the neuromuscular junction. (2) Color carefully the motor units and related ttles at the bottom of the plate: only the discharging motor units (in dark outline) are to be colored. Note that the word "partial" is not colored under the example of partial contraction.

SKELETAL MUSCLE A
MUSCLE FIBER A'
MOTOR END PLATE B
MOTOR NERVE C
AXON C
AXON BRANCH D
AXON TERMINAL E



MOTOR UNIT
AXON C
AXON BRANCH D
NEUROMUSCULAR JUNCTION F
MUSCLE FIBER A'

An axon of a single motor neuron, its axon branches, and the skeletal muscle fibers with which they form neuromuscular junctions constitute a *motor unit*. Within any given skeletal muscle, the number of muscle fibers innervated by a single motor neuron largely determines the specificity of contraction of that muscle; the fewer the number of muscle fibers in each motor unit, the more selective and refined the degree of contraction of that skeletal muscle.



NEUROMUSCULAR JUNCTION F
AXON TERMINAL E
MOTOR END PLATE B

Skeletal muscle consists of innumerable muscle fibers (cells). Skeletal muscle requires an intact nerve (innervation) to shorten (contract). Such a nerve, called a *motor nerve*, consists of numerous axons of motor neurons. A motor neuron (see Plate 15) is dedicated solely to stimulating muscle fibers to contract. Each single *muscle fiber* in a skeletal muscle is innervated by a *branch of an axon*. The microscopic site at which the axon branch attaches to the skeletal muscle fiber is called the *neuromuscular junction*. Each neuromuscular junction consists of an *axon terminal* closely applied to an area of convoluted muscle fiber sarcolemma called the *motor end plate*. There is a gap between the two surfaces. When a skeletal muscle fiber is about to be stimulated, a chemical neurotransmitter, called acetylcholine, is released by the axon terminal into the gap. The neurotransmitter induces a change in the permeability of the sarcolemma to sodium (Na^+), which initiates muscle fiber contraction. A muscle fiber can only contract maximally ("all or none" law).

GRADES OF CONTRACTION

Given the fact of "all or none" contraction by individual skeletal muscle fibers, grades of contraction of a skeletal muscle are made possible by activating a number of motor units and not activating others. A *resting* muscle activates no motor units. In a *partial contraction*, only some of the motor units are activated. In *maximal contraction* of a skeletal muscle, all motor units are activated. Gluteus maximus consists of skeletal muscle fibers having a nerve-to-muscle ratio of 1:1000 or more. There is no possibility of controlled, refined contractions from this muscle. The facial muscles, on the other hand, have a much lower nerve-to-muscle ratio, closer to 1:10. Here small numbers of muscle fibers can be contracted by implementing one or a few motor units, generating very fine control on the muscular effect (facial expression) desired.

AT REST
PARTIAL CONTRACTION A
MAXIMUM CONTRACTION A