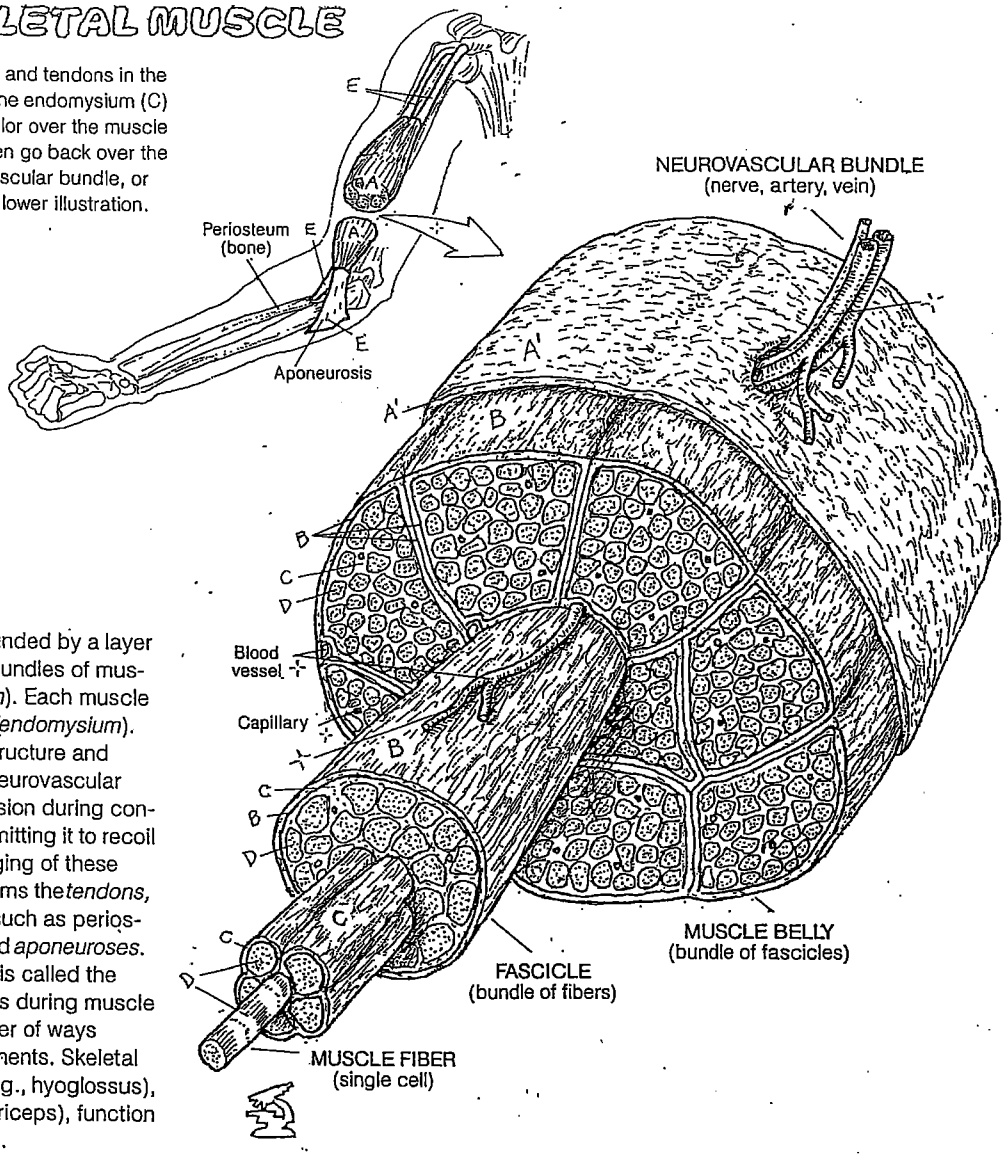
NAME:

INTRODUCTION TO SKELETAL MUSCLE

Color light colors for A–E. (1) Begin with the muscle belly and tendons in the illustration. (2) When coloring the narrow borders of the endomysium (C) in the enlarged section, it is recommended that you also color over the muscle fiber ends (D) with the very light endomysium color, and then go back over the fiber ends with a darker color (D). Do not color the neurovascular bundle, or the cut ends of blood vessels and capillaries. (3) Color the lower illustration.

- SKELETAL MUSCLE
  - BELLY (A)
    - FASCIA:
      - EPIMYSIUM (A')
      - PERIMYSIUM (B)
      - ENDOMYSIUM (C)
    - MUSCLE FIBER (CELL) (D)
  - TENDON (E)

A named skeletal muscle (e.g., biceps brachii), surrounded by a layer of deep fascia (*epimysium*), consists of fascicles or bundles of muscle fibers enveloped in thin fibrous tissue (*perimysium*). Each muscle fiber is surrounded by a thin sheath of fibrous tissue (*endomysium*). Each of these fibrous layers is important to muscle structure and function, providing support for nerves and vessels (neurovascular bundles), ensuring uniform distribution of muscle tension during contraction, and maintaining the elasticity of muscle, permitting it to recoil to its resting length following stretching. It is the merging of these fibrous layers at the ends of the muscle fibers that forms the *tendons*, which integrate the muscle to its attachment site(s), such as periosteum or another tendon. Broad, flat tendons are called *aponeuroses*. The mass of the fasciae-enveloped contractile fibers is called the *belly* of the muscle. It is the muscle belly that shortens during muscle contraction. The belly may be shaped one of a number of ways depending on its tendinous arrangement and attachments. Skeletal muscles are named in relation to their attachments (e.g., hyoglossus), shape (e.g., trapezius), number of heads (e.g., quadriceps), function (e.g., adductor magnus), or position (e.g., brachialis).



OVER

NAME:

See 13

TISSUES: SKELETAL MUSCLE MICROSTRUCTURE

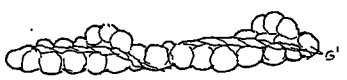
CN: Use the same colors used on Plate 13 for sarcolemma (A) and mitochondrion (D). Use the same color used on the skeletal muscle cell for the myofilbril (E) here. Use light colors for G and J, a dark color for H, and very dark colors for F and K. The cell nucleus is not shown here. (1) Begin with the drawing of the arm. (2) Color the parts of the muscle cell in the central illustration; note the presence of mitochondria (D) between the myofibrils. (3) Color the parts of the exposed (lowest) myofibril and the color-related letters, bands, lines, zone. Note that the cut end of this myofibril receives the color E, for identification purposes, and is part of the A band of the sarcomere adjacent to the one to be colored. (4) Color the relaxed and contracted sarcomere, the filaments, and the mechanism for contraction, noting the color relationship with the myofibril and its parts.

A part of a skeletal muscle cell is shown with the *sarcolemma* opened to reveal some cellular contents. The most visible of the contents are the *myofibrils*, the contractile units of the cell. They are enveloped by a flat tubular *sarcoplasmic reticulum* (SR) that, in part, regulates the distribution of calcium ions (Ca++) into the myofibrils. Inward tubular extensions of the sarcolemma, called the *transverse tubule system* (TTS), run transversely across the SR, at the level of the Z lines of the myofibrils. The TTS, containing stores of sodium ions (Na+) and calcium ions (Ca++), conducts electrochemical excitation to the myofibrils from the sarcolemma. *Mitochondria* provide energy for the cell work.

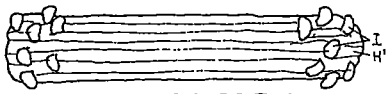
The myofibrils consist of myofilaments: *thick filaments* (largely myosin) with heads that project outward as *cross bridges*, and *thin filaments* (largely actin) composed of two interwoven strands. These two filament types are arranged into contractile units, each of which is called a *sarcomere*. Each myofibril consists of several radially arranged sarcomeres. At the end of each sarcomere, the thin filaments are permanently attached to the *Z line*, which separates one sarcomere from the next. The relative arrangement of the thick and thin filaments in the sarcomere creates *light* (*I, H*) and *dark* (*A*) *bands/zone* and the *M line*, all of which contribute to the appearance of cross-striations in skeletal (and cardiac) muscles.

Shortening of a myofibril occurs when the thin filaments slide toward the center (H zone), bringing the Z lines closer together in each sarcomere. The filaments do not shorten; the myosin filaments do not move. The close relationship of the TTS to the Z lines suggests that this site is the "trigger area" for induction of the sliding mechanism. This sliding motion is induced by *cross bridges* (heads of the immovable thick filaments) that are connected to the thin filaments. Activated by high-energy bonds from ATP, the paddle-like cross bridges swing in concert toward the H zone, drawing the thin filaments with them. The sarcomere shortens as the opposing thin filaments meet or even overlap at the M line.

Occurring simultaneously in all or most of the myofibrils of a muscle cell, shortening of sarcomeres translates to a variable shortening of the resting length of the muscle cell. Repeated in hundreds of thousands of conditioned muscle cells of a professional athlete, the resultant contractile force can pull a baseball bat through an arc sufficient to send a hardball a hundred meters or more through the air.



THIN FILAMENT$_{G'}$



THICK FILAMENT$_{H'}$

SKELETAL MUSCLE CELL

- SARCOLEMMA$_A$
- SARCOPLASMIC RETICULUM$_B$
- TRANSVERSE TUBULE SYS$_C$
- MITOCHONDRION$_D$
- MYOFIBRIL$_E$
  - SARCOMERE$_F$
    - I BAND$_G$
      - THIN FILAMENT (ACTIN)$_{G'}$
    - Z LINE$_{F'}$
    - A BAND$_H$
      - THICK FILAMENT (MYOSIN)$_{H'}$
        - CROSS BRIDGE$_I$
        - H ZONE$_J$
          - M LINE$_K$