101
MUSCULOSKELETAL SYSTEM

This plate illustrates how skeletal muscles work at the organ system level. Since the overwhelming majority of them act on the bones of the skeleton, many biologists have suggested that we should speak of a single musculoskeletal system rather than two separate systems.

Color titles A through E and the related structures in the illustrations at the right and the upper left. A light color for A is recommended.

Most action of *skeletal muscle* occurs at joints, where the muscle itself must cross the joint or be attached to a tendon that crosses the joint. Biologists always describe this action in terms of the movement of the joint, not the bone being moved. Thus the action depicted here is the flexing of the elbow joint against the resistance offered by the dumbbell.

Muscles normally work in functional groups rather than as isolated muscle units. This can make analysis of function for a specific muscle difficult. Generally, muscles function in one of four modes for any given movement of a joint. The mover muscles are the protagonists of a joint movement. In flexing the elbow joint, as in curling a dumbbell to exercise the muscles of the arm, the *prime mover* is the brachialis muscle. Its assistant, or *synergist*, is biceps brachii. (The brachialis is the principal mover because it has a better mechanical advantage than the biceps due to its lower origin on the humerus and its attachment to the more rigid ulna rather than the radius, which rotates.) To make flexion of the elbow joint possible, the *antagonist* to the elbow flexors, triceps brachii, must be inhibited from contracting. Further, in flexing the elbow with the palm of the hand over the top of the dumbbell instead of under it (elbow joint pronated instead of supinated), the supinators of the elbow must be prevented from acting. Therefore, the elbow pronators (pronator teres shown here) act as *neutralizers* to resist the contractions of the supinators. Finally, the shoulder (pectoral) girdle must be prevented from drooping as the weight is lifted, so there are *fixator* muscles, principally the trapezius in this case, that literally hold the shoulder up. In most movements of the body, all four of these modes of action take place.

Color the heading Musculoskeletal Integration, titles F through G^3, and the related structures in the illustration at the lower left. Use a light color for G.

Skeletal muscle is intimately associated with fibrous sheets of connective tissue. It is because of this relationship that muscles can withstand considerable bruising without rupture of muscle tissue, damage to nerve supply, or development of hemorrhage. Just under the skin is the fatty *superficial fascia* (also called subcutaneous tissue). When a person "puts on weight" above that desired, it is generally due to the addition of fat to the superficial fascia. The pattern of distribution of this fat is influenced by sex hormones. This variably thick fascial layer offers insulation and a source of fuel in the face of reduced food input.

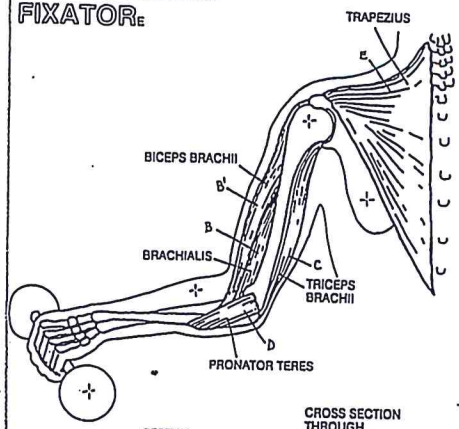
Examining the musculoskeletal arrangement of the forearm, you will note that the forearm is divided into muscle compartments by extensions of sheets of fibrous tissue called *deep fascia*. Thinner sheets of this fibrous tissue further divide the muscle into smaller bundles known as fascicles. Within a fascicle, each *muscle cell* has its own fibrous *sheath*. In this way, nerve filaments and capillaries are conducted to the fascicles and individual muscle cells. Larger *arteries, veins,* and *nerves* are located in the larger sheets (septa) of deep fascia.

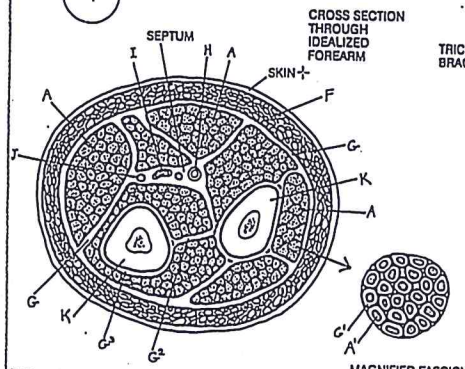
The integration and coordination of muscular and skeletal tissue is further enhanced by the insertion of fasciae and tendons into the *ligaments* and the *periosteum* (the connective tissue covering of bone). Note how the ligament itself integrates with the periosteum. In fact, some of the ligamentous fibers integrate with the collagen fibers in the bone, providing a superbly strong attachment. Each blood vessel is surrounded by fibrous tissue that becomes part of the fascial framework. Each nerve is bound in layers of fibrous tissue very similar to those of muscle. Thus the musculoskeletal body wall is largely secure from the bumps and bruises experienced in life.

Following severe muscle injury, postinflammatory healing often involves proliferation of fibrous tissue, which produces scarring, meaning fascial or tendon or ligament shortening. This can result in a permanent limitation of movement since the muscle is literally tied down by connective tissue. Nerve supply is essential to the health of muscle. If the nerve supplying a muscle should be severed, the muscle will atrophy (wither away), and in a year or two it will die and be replaced with fibrous tissue.

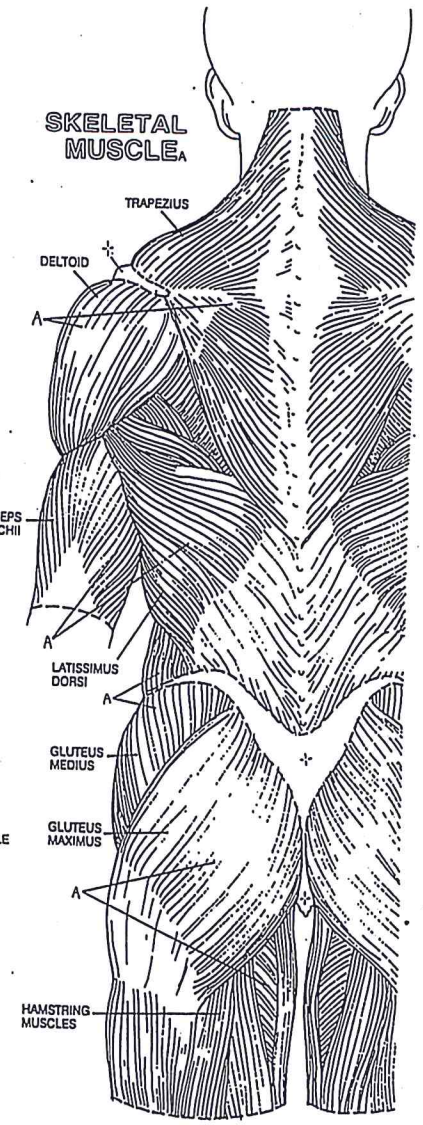
MUSCULOSKELETAL SYSTEM.

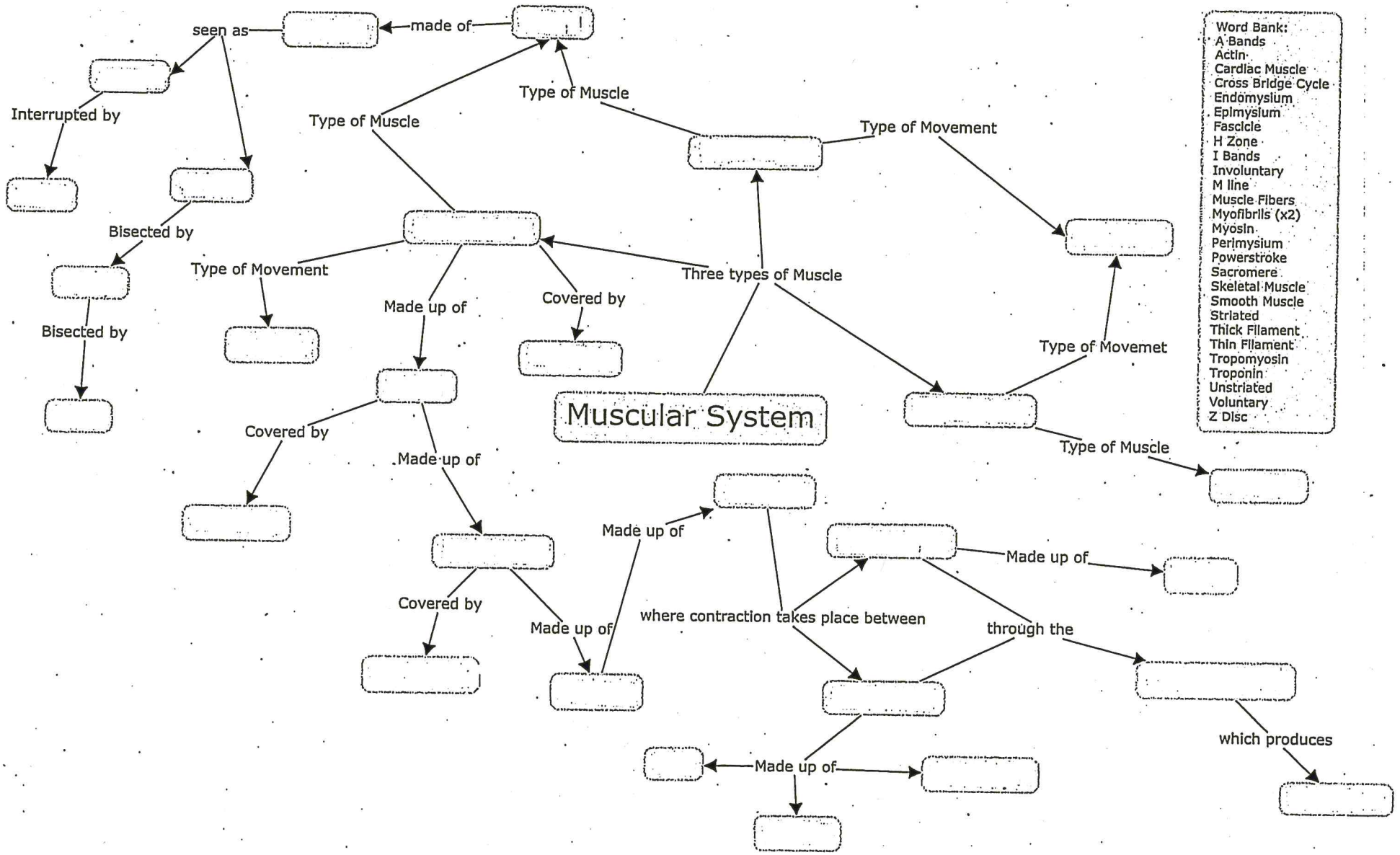
PRIME MOVER$_B$/SYNERGIST$_{B'}$
ANTAGONIST$_C$
NEUTRALIZER$_D$
FIXATOR$_E$





MUSCULOSKELETAL INTEGRATION.*
SUPERFICIAL FASCIA$_F$
DEEP FASCIA$_G$
ARTERY$_H$/VEIN/NERVE$_J$
SKELETAL MUSCLE CELL$_{A'}$/FIBROUS SHEATH$_{G'}$
LIGAMENT$_{G^2}$
BONE$_K$/PERIOSTEUM$_{G^3}$




Word Bank:
A Bands
Actin
Cardiac Muscle
Cross Bridge Cycle
Endomysium
Epimysium
Fascicle
H Zone
I Bands
Involuntary
M line
Muscle Fibers
Myofibrils (x2)
Myosin
Perimysium
Powerstroke
Sacromere
Skeletal Muscle
Smooth Muscle
Striated
Thick Filament
Thin Filament
Tropomyosin
Troponin
Unstriated
Voluntary
Z Disc
Muscular System
seen as
made of
Interrupted by
Bisected by
Bisected by
Type of Muscle
Type of Muscle
Type of Movement
Type of Movement
Three types of Muscle
Made up of
Covered by
Covered by
Made up of
Made up of
Covered by
Made up of
Type of Movemet
Type of Muscle
Made up of
Made up of
where contraction takes place between
through the
which produces
Made up of