2010 ANATOMY–TRAINING HANDOUT

■ BASIC ANATOMY (STRUCTURE AND FUNCTION)

- Skeletal system
- Muscular system
- Major diseases
- Treatment and prevention of diseases

■ PROCESS SKILLS - observations, inferences, predictions, calculations, data analysis, and conclusions.

■ BE SURE TO CHECK THE 2010 EVENT RULES FOR EVENT PARAMETERS AND TOPICS FOR EACH COMPETITION LEVEL

INTERACTION OF SKELETAL AND MUSCULAR SYSTEMS:

- Skeletal and Muscular systems works together to allow movement
- Bone attaches to bone via ligaments
- Muscle attaches to bone via tendons
- Skeletal muscles produce movement by bending the skeleton at movable joints.
- Skeleton provides structure of body and muscles allow skeleton mobility

SKELETAL SYSTEM:

Functions
- Support & shape to body
- Protection of internal organs
- Movement in union with muscles
- Storage of minerals (calcium, phosphorus) & lipids
- Blood cell production

Skeleton
- 206 Bones
- Axial skeleton: (80 bones) in skull, vertebrae, ribs, sternum, hyoid bone
- Appendicular Skeleton: (126 bones) - upper & lower extremities plus two girdles
- Half of bones in hands & feet
Types of Bone

- **Long bones**: longer than they are wide; shaft & 2 ends (e.g.: bones of arms & legs, except wrist, ankle & patella)

- **Short bones**: roughly cube-shaped (e.g.: ankle & wrist bones)

- **Sesamoid bones**: short bones within tendons (e.g.: patella)

- **Flat bones**: thin, flat & often curved (e.g.: sternum, scapulae, ribs & most skull bones)

- **Irregular bones**: odd shapes; don't fit into other classes (e.g.: hip bones & vertebrae)

Types of Vertebrae:

- **Cervical (7)** - transverse foramina, bifid spinous processes, vertebral prominens.
  - Atlas - 1st; supports head
  - Axis - 2nd; pivots to turn head
- **Thoracic (12)** - long spinous processes, rib facets
- **Lumbar (5)** - large bodies thick, short spinous processes

Types of Synovial Joints

- **Ball & Socket** - allows for complete range of motion. Example: shoulder, hip
- **Pivot** – one bone pivots in the arch of another. Example: Axis/Atlas, and proximal radioulnar joint
- **Saddle** – two directional movement between thumb and trapezium carpel
- **Hinge** – like door hinge – bending & extending. Example: elbow, knee, finger joints
- **Ellipsoid (Condyloid)** – side to side and back & forth. Example – radius end into carpal bones
- **Plane or Gliding** – least moveable – side to side only. Examples: intercarpal & intertarsal joints, between vertebrae
**Cellular Structure of Long Bone**

**Compact bone**

The hard outer layer of bones is composed of compact bone tissue, so-called due to its minimal gaps and spaces. This tissue gives bones their smooth, white, and solid appearance, and accounts for 80% of the total bone mass of an adult skeleton. Compact bone may also be referred to as dense bone or cortical bone.

**Spongy bone**

Filling the interior of the organ is the spongy bone tissue which is composed of a network of rod- and plate-like elements that make the overall organ lighter and allowing room for blood vessels and marrow. Spongy bone accounts for the remaining 20% of total bone mass, but has nearly ten times the surface area of compact bone.
Types of cells constituting the bone

- **Osteoblasts** – bone forming cells synthesize and secrete unmineralized ground substance and are found in areas of high metabolism within the bone

- **Osteocytes** – mature bone cells made from osteoblasts that have made bone tissue around themselves. These cells maintain healthy bone tissue by secreting enzymes and controlling the bone mineral content; they also control the calcium release from the bone tissue to the blood.

- **Bone lining cells** - made from osteoblasts along the surface of most bones in an adult. Bone-lining cells are thought to regulate the movement of calcium and phosphate into and out of the bone

- **Osteogenic cells** - respond to traumas, such as fractures, by giving rise to bone-forming cells and bone-destroying cells

- **Osteoclasts** – bone absorbing cell – large cells that break down bone tissue – important to growth, healing, remodeling

Red and Yellow Bone Marrow

The formation of blood cells, termed **hematopoiesis**, takes place mainly in the red marrow of the bones.

In infants, red marrow is found in the bone cavities. With age, it is largely replaced by yellow marrow for fat storage.

In adults, red marrow is limited to the spongy bone in the skull, ribs, sternum, clavicles, vertebrae and pelvis. Red marrow functions in the formation of red blood cells, white blood cells and blood platelets.

Cartilage – Characteristics and Types

- Mostly water; no blood vessels or nerves
- Tough, resilient
- New cartilage forms from chondroblasts
- Heal poorly

- **Hyaline Cartilages**: fine collagen fiber matrix- most abundant type- found in articular (movable joint) cartilages, costal cartilages (connect ribs to sternum), respiratory cartilages (in larynx & upper respiratory passageways) & nasal cartilages

- **Elastic Cartilages**: similar to hyaline cartilage, more elastic fibers (very flexible) – found in external ear & epiglottis (larynx covering)

- **Fibrocartilage**: rows of chondrocytes with thick collagen fibers; highly compressible with great tensile strength- found in menisci of knee, intervertebral discs & pubic symphysis
Typical Bone Fractures

Bone Repair Process
- Injury – broken blood vessels, hematoma
- Invasion of blood vessels & generalized cells (2-3 days)
- Fibroblasts develop (1 week)
- Chondroblasts develop
- Callus forms (4 weeks)
- Remodeling with osteoclasts (8 weeks)

Skeletal Disorders
- Spinal Stenosis-narrowing of the spinal column
- Achondroplasia-Defect in the formation of cartilage at the epiphysis of long bones (dwarfining)
- Juvenile Rheumatoid Arthritis-chronic inflammatory diseases involving the joints or other organs in children under 16
- Ankylosing spondylitis-immobility of a joint in the spine
- Osteosarcoma-malignant sarcoma of bone
- Osteoarthritis-A type of arthritis marked by progressive cartilage deterioration in synovial joints and vertebrae
- Osteoporosis-Loss of bone mass that occurs throughout the skeleton. Predisposes people to fractures
- Disc Herniation-Rupture of the soft tissue that separates two vertebral bones into the spinal canal
- Scoliosis-A lateral curvature of the spine

MUSCULAR SYSTEM
**Muscle Function:**
- Stabilizing joints
- Maintaining posture
- Producing movement
- Moving substances within the body
- Stabilizing body position and regulating organ volume
- Producing heat—muscle contraction generates 85% of the body’s heat

**Characteristics of Muscle Tissue**
- Excitability- receive and respond to stimuli
- Contractility- ability to shorten and thicken
- Extensibility- ability to stretch
- Elasticity- ability to return to its original shape after contraction or extension

<table>
<thead>
<tr>
<th></th>
<th>Skeletal Muscle</th>
<th>Smooth Muscle</th>
<th>Cardiac Muscle</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Attached to bone</td>
<td>On hollow organs, glands and blood vessels</td>
<td>Heart</td>
</tr>
<tr>
<td><strong>Function</strong></td>
<td>Heart contraction to propel blood</td>
<td>Compression of tubes &amp; ducts</td>
<td>Move the whole body</td>
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<tr>
<td><strong>Nucleus</strong></td>
<td>Multiple, peripheral</td>
<td>Single, central</td>
<td>Central &amp; single</td>
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<td><strong>Control</strong></td>
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<tr>
<td><strong>Striations</strong></td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td><strong>Cell Shape</strong></td>
<td>Cylindrical</td>
<td>Spindle-shaped</td>
<td>Branched</td>
</tr>
</tbody>
</table>
Skeletal Muscles

There are nearly 650 muscles attached to the skeleton. See muscle list for competitions.

They work in pairs: one muscle moves the bone in one direction and the other moves it back again.

Most muscles extend from one bone across a joint to another bone with one bone being more stationary than another in a given movement. Muscle movement bends the skeleton at moveable joints.

Muscles are anchored firmly to bone by tendons made of dense fibrous connective tissue shaped like heavy cords. Though very strong and secure to muscle, tendons may be injured.

Attachment to the more stationary bone by tendon closest to the body or muscle head or proximal is the origin and attachment to the more moveable bone by tendon at the distal end is the insertion.

During movement, the origin remains stationary and the insertion moves.

The force producing the bending is always a pull of contraction. Reversing the direction is produced by the contraction of a different set of muscles. As one group of muscles contracts, the other group stretches and then they reverse actions.

Muscle contractions can be short, single contractions or longer ones.
Skeletal Muscle Anatomy

Each muscle has thousands of muscle fibers in a bundle running from origin to insertion bound together by connective tissue through which run blood vessels and nerves.

Each muscle fiber contains many nuclei, an extensive endoplasmic reticulum or sarcoplasmic reticulum, many thick and thin myofibrils running lengthwise the entire length of the fiber, and many mitochondria for energy.

The basic functional unit of the muscle fiber is the **sacromere** which consists of thick filaments with myosin (protein) molecules and thin filaments with actin (protein) molecules plus smaller amounts of troponin and tropomysin.

When viewed under the microscope, they appear as striations of **dark A bands** and **light I bands**. The A bands are bisected by the H zone with the M line or band running through the center of this H zone. The I bands are bisected by the Z disk or line.

A **sacromere** consists of the array of thick and thin filaments between two Z disks.

**Sliding-Filament Model**

In the thick filaments, myosin molecules contain a globular subunit, the **myosin head**, which has binding sites for the actin molecules of the thin filaments and ATP.

Activating the muscle fiber causes the myosin heads to bind to actin molecules pulling the short filament a short distance past the thick filaments.

The linkages break and reform (using ATP energy) further along the thick filaments. Thus the thin filaments are pulled past the thick filaments in a ratchet-like action. No shortening, thickening or folding of individual filaments occurs.

As the **muscle contracts**, the width of the I bands and H zones decrease causing the Z disks to come closer together, but there is no change in the width of the A band because the thick filaments do not move. As the **muscle relaxes or stretches**, the width of the I bands separate as the thin filaments move apart but the thick filaments still do not move.
Muscle and Tendon Injuries

**Strains** – injuries from overexertion or trauma which involve stretching or tearing of muscle fibers. They often are accompanied by pain and inflammation of the muscle and tendon. If the injury is near a joint and involves a ligament, it is called a sprain.

**Cranps** – painful muscle spasms or involuntary twitches.

**Stress-induced muscle tension** – may cause back pain and headaches.

Muscular Disorders:

**Poliomyelitis** – viral infection of the nerves that control skeletal muscle movement.

**Muscular Dystrophies** – most common caused by mutation of gene for the protein **dystrophin** which helps in attaching and organizing the filaments in the sacromere. Duchenne Muscular Dystrophy and Becker muscular dystrophy are the two most common types. The gene for dystrophin is on the X chromosome so the disorder is sex-linked. Muscle function is impaired.

**Myasthenia gravis** – autoimmune disease affecting the neuromuscular junction. Patients have smaller end plate potentials due to the antibodies being directed against the receptors, affecting the ability of the impulse to cause the muscle contraction. Administering an inhibitor of acetylcholinesterase can temporarily restore contractibility.

Effects of Exercise on Skeletal and Muscular System

**Skeletal System**

- Exercise slows decline in minerals and maintains joint mobility
- Stress of exercise helps the bone tissues to become stronger
- Hyaline cartilage at the ends of the bones becomes thicker and can absorb shock better
- Ligaments will stretch slightly to enable greater joint flexibility

**Muscular System**

- Exercise helps muscles become more effective and efficient.
- Tendons will become thicker and able to withstand greater force
- High intensity exercise for short duration produces strength, size and power gains in muscles
- Low intensity exercise for long durations will give endurance benefits
- Trained muscles have better tone or state of readiness to respond
- Exercise promotes good posture enabling muscles to work effectively and helps prevent injury