Bones, Muscles, and Movement

1. What’s the difference between exoskeletons and endoskeletons? Which type of skeleton do humans have?
2. List three functions of the skeletal system
3. Is bone a living tissue? Explain why or why not.
4. Describe the structure and development of bone.
5. Identify the following bones of the skeletal system: Carpals, clavicle (collar bone), cranium, femur, fibula, humerus, mandible, maxillary bones, metacarpals, metatarsals, patella, pelvis, phalanges, radius, ribs, scapula (shoulder blade), coccyx (tail bone), sternum (breast bone), tarsals, tibia, ulna, and vertebrae.
6. What is a joint?
7. List the three types of joints found between bones.
8. Name and describe six types of freely movable joints. Be able to locate an example of each of these in your body.
9. Be creative and construct a model of one of the six freely movable joints.
10. What is another name for a broken bone? List 3 types of breaks that can occur in bones. Describe how bones heal and how doctors can help this process.
11. What is osteoporosis? Who can get it? List at least 5 health habits that deal with maintaining healthy bones and muscles.
12. What is the function of the muscular system?
13. Name and describe three types of muscle tissue. Give one example of each.
14. Be able to identify the following muscles on your body: Masseter, Trapezius, Deltoid, Pectoralis, Biceps, Abdominal, Quadriceps, Triceps, Latissimus dorsi, Gluteus maximus, Hamstrings, Gastrocnemius, and Soleus.
15. Describe the process that causes a muscle to contract.
16. Describe the difference between voluntary and involuntary muscles.
17. Using your model in # 9, show how muscles, bones, and joints work together to produce movement.
18. Find 3 texts in the Bible that mention bones and/or muscles. Tell about each one in your own words.
1. What's the difference between exoskeletons and endoskeletons? Which type of skeleton do humans have?

(exo-) G - “outside”  
(endo-) G - “within” or “inside”  
(skel-esthai, skellein) G - “to dry up”

Arthropods, like insects, arachnids, crabs and lobsters, are well known examples of organisms with exoskeletons. Many mollusks are considered to have exo-skeletons as well (shells). Some animals have endoskeletons, but also exhibit elements of an exoskeleton for protection. These include turtles, armadillos (the only mammal with a true bony exoskeleton armor), and pangolins, which have keratin scaly plates as an external armor. Humans, of course, have an endoskeleton.

2. List three functions of the skeletal system

- a. Support - The framework for the body
- b. Movement - Muscle connection
- c. Protection - Shields critical organs
- d. Mineral storage - Ca, P, for use in cellular functions
- e. Fat storage - Yellow bone marrow, reserve energy
- f. Production of blood cells - Red marrow in specific bones

3. Is bone a living tissue? Explain why or why not.

Bone is a living, connective tissue, made up of osteocytes (bone cells) arranged in a hardened mineral matrix. The living nature of bone allows for healing in case of fracture, for growth and development from birth to adulthood, and the formation of new blood cells.

4. Describe the structure and development of bone.

The two main forms of bone are compact bone and spongy bone. Compact bone is generally made up of collections of osteocytes (osseo - bone, cyte - cell), which sit in small pockets, called lacunae, in the rings of hardened mineral matrix called concentric lamellae. The concentric lamellae, with their small pockets (lacunae) containing osteocytes, are arranged in rings around a central canal (the Haversian canal), which contains blood vessels, and in some cases nerves. The cellular bundles, which resemble a tree trunk in cross section, are called osteons. Grouped together, the osteons form the compact bone. Filling spaces between osteons are interstitial lamellae (interstitial from Latin meaning “stand between”), while a band of circumferential lamellae wraps the osteons together around the periphery of the bone. Surrounding the bone is a sheath-like membrane, called the periosteum (peri - around, osteum - bone), which contains blood vessels and nerves for the bone. Near the shaft ends of long bones, and in many of the flat bones, the compact bone surrounds a web-like latticework of bone called spongy bone, which often also contains red marrow (where new blood cells are manufactured). The shaft of long bones in adults is frequently hollow, and filled with yellow marrow, which stores fat.

Bone formation begins when the person is still an embryo. Initially the skeleton is made up of cartilage, a semi-rigid flexible substance that gives shape to the nose and protects bone ends at joints. Bone forming cells called osteoblasts (osseo - bone, blast - bud) form a collar around the shaft of the cartilaginous model of the bone, providing a stronger framework. The interior of the shaft begins to hollow out, replaced by spongy bone. The bony area continues to expand toward the ends of the shaft. A secondary area of growth begins near the ends of the shaft, leaving a small plate of cartilage between the bony areas (the growth plate, where future lengthening takes place), while the ends of the bone at the joints retain a coating of cartilage.
5. Identify the following bones of the skeletal system: Carpals, clavicle (collar bone), cranium, femur, fibula, humerus, mandible, maxillary bones, metacarpals, metatarsals, patella, pelvis, phalanges, radius, ribs, scapula (shoulder blade), coccyx (tail bone), sternum (breast bone), tarsals, tibia, ulna, and vertebrae.

6. What is a joint?

A joint is the locations where bones meet. Some joints allow movement (like elbows), others do not (like where the skull bones are stitched together).

7. List the three types of joints found between bones.

a. **Fibrous** - Nearly immovable joints composed of fibrous connective tissue that suture bones together, for example the sutures between the bones in the skull.

b. **Cartilaginous** - Semi-rigid connections of cartilage between bones, allowing slight movement, for example the connection of ribs to the sternum, and the connection between vertebrae.

c. **Synovial** - Freely moving joints, characterized by friction-reducing hyaline cartilage on the bones where they slide over one another, a two-layer capsule over the joint that produces **synovial fluid** (syn - together, oon - egg) to lubricate the joint, and **ligaments** to hold the bones together around the joint.

8. Name and describe six types of freely movable joints. Be able to locate an example of each of these in your body.

a. **Ball and Socket** - Includes shoulder and hip joints. A ball-like end of one bone fits into a socket on the other bone, allowing rotation and movement in multiple directions.

b. **Hinge** - Includes the elbow and the knuckles. A hinge joint only allows limited movement - flexion and extension.

c. **Saddle** - Includes the lower joint of the thumb. Both bones have concave surfaces, like saddles, that can slide over one another. Allows movement in multiple directions, but with limited rotation.

d. **Ellipsoid** - Includes the wrist joint. Like a less developed ball and socket joint, it allows movement in multiple directions, but not rotation.

e. **Pivot** - Includes the joint where the skull meets the vertebrae. It only allows rotation.

f. **Gliding** - Includes some of the joints in the hand. Gliding joints are places where bones can only slide along each other.

9. Be creative and construct a model of one of the six freely movable joints.

10. What is another name for a broken bone? List 3 types of breaks that can occur in bones. Describe how bones heal and how doctors can help this process.

A bone break is also called a fracture. There are several ways to classify a fracture, depending upon the extent to which the bone is broken, the way it is broken, and whether or not the broken bone extrudes through the skin. A broken bone that also breaks out of the skin is called a **compound fracture**, whereas in a **simple fracture** the bone does not break the skin. **Compression fractures**, often seen in the vertebrae, are caused by squeezing pressure, and can crush the bone. **Stress fractures** are caused by repeated micro-trauma to a bone, often in the leg. The way in which the bone is broken is also used to determine fracture type. A partial break across a bone is called a **greenstick fracture**. A break across the bone is a **transverse fracture**, whereas when it is diagonally across the bone, it is called an **oblique fracture**. **Spiral fractures** twist up a bone. **Comminuted fractures** occur when the bone is broken into multiple pieces. One final type of fracture is a **pathological fracture**, caused by the breakdown of bone due to disease.
Bones can heal themselves when fractured because bone is a living tissue. At the site of the break, a blood clot forms first. Fibroblasts then begin moving into the area and building a cartilaginous callous. The osteoblasts then take over and begin building bone to reconnect the broken parts. Bone cells continue reshaping the repaired area to bring it back close to the original shape. Doctors assist this process by stabilizing bones in their correct position and immobilizing them to avoid repeated damage to the area as they heal.

11. What is osteoporosis? Who can get it? List at least 5 health habits that deal with maintaining healthy bones and muscles.

Bones are constantly undergoing a process of remodeling, being broken down and rebuilt. When the breaking down of the mineral component of bone exceeds the reformation of new mineral structure, bone density decreases. This is what occurs in osteoporosis. While all people are at risk of osteoporosis, older caucasian or asian women are more susceptible. The risks of getting osteoporosis, or of other bone or muscles disease, can be reduced by practicing positive health habits, including regular exercise, proper nutrition (including eating high calcium foods like broccoli, spinach and soy beans, and getting sufficient vitamin D), maintaining a healthy weight, and avoiding alcohol and tobacco.

12. What is the function of the muscular system?

The muscular system allows movement, both motor movement (walking, smiling, playing piano) and involuntary movements, like the beating of the heart and contractions in the digestive system.

13. Name and describe three types of muscle tissue. Give one example of each.

   a. **Skeletal Muscle** - Made up of long, striated, cylindrical cells with several nuclei. Skeletal muscles are primarily responsible for voluntary movement. Examples include the biceps and triceps.
   
   b. **Cardiac Muscle** - Branching striated cells with a single nucleus, found in the walls of the heart, and responsible for the involuntary pumping of the heart.
   
   c. **Smooth Muscle** - Tapered cells with a single nucleus, found in the walls of organs like the intestines. Responsible primarily for involuntary movements, like the movement of food through the digestive tract, or to constrain the size of tubes in the body.

14. Be able to identify the following muscles on your body: Masseter, Trapezius, Deltoid, Pectoralis, Biceps, Abdominal, Quadriceps, Triceps, Latissimus dorsi, Gluteus maximus, Hamstrings, Gastrocnemius, and Soleus.

15. Describe the process that causes a muscle to contract.

Skeletal muscles are striated, appearing to have alternating light and dark bands under the microscope. These bands are made up of myofibrils, bundles of myofilaments called myosin and actin. The myofibrils can be divided into units of contraction called sarcomeres. Within the sarcomeres, the myosin and actin are arranged such that the actin is arranged as almost a sheath around strings of myosin. A chemical input of energy causes these filaments to move, sliding the myosin out or into the actin sheath, and thus extending or contracting the sarcomeres, and thereby the muscles.

16. Describe the difference between voluntary and involuntary muscles.

Voluntary muscles, like the skeletal muscles, can be actively and intentionally controlled, whereas involuntary muscles, for the most part, are not directly controlled, but work without active thinking. This is a good thing, as breathing and blood circulation would cease during sleep if they were both run solely by voluntary muscles.
17. Using your model in # 9, show how muscles, bones, and joints work together to produce movement.

18. Find 3 texts in the Bible that mention bones and/or muscles. Tell about each one in your own words.

Genesis 2: 21-24 (NIV) - So the LORD God caused the man to fall into a deep sleep; and while he was sleeping, he took one of the man's ribs and closed up the place with flesh. Then the LORD God made a woman from the rib he had taken out of the man, and he brought her to the man. The man said, "This is now bone of my bones and flesh of my flesh; she shall be called 'woman,' for she was taken out of man." For this reason a man will leave his father and mother and be united to his wife, and they will become one flesh.

Job 10: 8-12 (NIV) - "Your hands shaped me and made me. Will you now turn and destroy me? Remember that you molded me like clay. Will you now turn me to dust again? Did you not pour me out like milk and curdle me like cheese, clothe me with skin and flesh and knit me together with bones and sinews? You gave me life and showed me kindness, and in your providence watched over my spirit.

Luke 24: 36-43 (NIV) - While they were still talking about this, Jesus himself stood among them and said to them, "Peace be with you." They were startled and frightened, thinking they saw a ghost. He said to them, "Why are you troubled, and why do doubts rise in your minds? Look at my hands and my feet. It is I myself! Touch me and see; a ghost does not have flesh and bones, as you see I have." When he had said this, he showed them his hands and feet. And while they still did not believe it because of joy and amazement, he asked them, "Do you have anything here to eat?" They gave him a piece of broiled fish, and he took it and ate it in their presence.

Ezekiel 37: 4-10 (NIV) - Then he said to me, "Prophesy to these bones and say to them, 'Dry bones, hear the word of the LORD! This is what the Sovereign LORD says to these bones: I will make breath enter you, and you will come to life. I will attach tendons to you and make flesh come upon you and cover you with skin; I will put breath in you, and you will come to life. Then you will know that I am the LORD.' So I prophesied as I was commanded. And as I was prophesying, there was a noise, a rattling sound, and the bones came together, bone to bone. I looked, and tendons and flesh appeared on them and skin covered them, but there was no breath in them. Then he said to me, "Prophesy to the breath; prophesy, son of man, and say to it, 'This is what the Sovereign LORD says: Come from the four winds, O breath, and breathe into these slain, that they may live.'" So I prophesied as he commanded me, and breath entered them; they came to life and stood up on their feet—a vast army.
DRY BONES HEAR THE WORD OF THE LORD
Skeletal and Muscle images courtesy of the National Library of Medicine.
Modified to include new numbering by R. Baker.
### Skeleton (Front)

<table>
<thead>
<tr>
<th>A1 - cranium</th>
<th>A8 - maxillary bones</th>
<th>A15 - phalanges</th>
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<tbody>
<tr>
<td>A2 - clavicle</td>
<td>A9 - mandible</td>
<td>A16 - tibia</td>
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<tr>
<td>A3 - humerus</td>
<td>A10 - sternum</td>
<td>A17 - fibula</td>
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<tr>
<td>A4 - radius</td>
<td>A11 - ribs</td>
<td>A18 - tarsals</td>
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<tr>
<td>A5 - ulna</td>
<td>A12 - vertebrae</td>
<td>A19 - metatarsals</td>
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<tr>
<td>A6 - pelvis</td>
<td>A13 - carpals</td>
<td>A20 - phalanges</td>
</tr>
<tr>
<td>A7 - femur</td>
<td>A14 - metacarpals</td>
<td>A21 - patella</td>
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### Skeleton (Rear)

<table>
<thead>
<tr>
<th>B1 - scapula</th>
<th>B2 - coccyx</th>
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### Muscles (Front)

<table>
<thead>
<tr>
<th>A1 - pectoralis</th>
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<tbody>
<tr>
<td>A2 - biceps</td>
<td>A4 - abdominal</td>
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### Muscles (Rear)

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<tr>
<td>B2 - trapezius</td>
<td>B5 - latissimus dorsi</td>
<td>B8 - gastrocnemius</td>
</tr>
<tr>
<td>B3 - deltoid</td>
<td>B6 - gluteus maximus</td>
<td>B9 - soleus</td>
</tr>
</tbody>
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### Types of Fractures:

[Diagram of fractures]
A. ________________________________
B. ________________________________
C. ________________________________
D. ________________________________
E. ________________________________
NOTES: