FUNCTIONS
1. The lower limbs support the trunk of the body while standing and the rib cage supports the thoracic wall.
2. The bones move because of muscles attached to them by tendons. The muscles contract and pull the bones like levers. Bone and body movement is determined by arrangement of bones and design of joints.
3. Bones store fat and minerals, most importantly calcium and phosphate (among others). This is important because the bone stores these until another organ needs the minerals or fat and then the bone releases them.
4. Hematopoeisis. This occurs within cavities and hollow spaces of spongy bone (found in flat bones and ends of long bones) and the marrow cavity of long bones in children.

CLASSIFICATION
5. Long—with diaphysis and epiphyses.
   Short—cube-like
   Flat—thin and curved
   Irregular—does not fit into other categories

BONE STRUCTURE
6. Bones are made up of more than one type of tissue. They have nervous tissue (nerves and neurons), connective tissue (along cavities, cartilage), epithelial tissue and muscle tissue (in blood vessels).
7. Compact—external layer, dense, looks smooth, made of osteons arranged longitudinally.
   Spongy—made up of trabeculae and open spaces that are filled with yellow or red bone marrow.
8. (Clockwise from top left): Articular surface/cartilage, Epiphysial Plate, Spongy Bone, Medullary Cavity, Endosteum (“within bone”), Periosteum (“around bone”), distal epiphysis, epiphysis, diaphysis, epiphysis.
9. Epiphysis b. hyaline cartilage c. reduces friction between bones in a joint
10. Both types of canals are found in bone and contain blood vessels and nerves. Haversian canals run longitudinally (longways) and Volkman’s canals run transversely (side to side, or across).
Volkman’s canals connect the Haversian canals and therefore connect osteons to one another.

11. Osteocytes get nutrients and blood from the canaliculi that are connected to the Haversian canals. The canaliculi form small channels from the canal to the lacunae where the osteocytes live.

12. Bone marrow is found in the medullary cavity and in spaces in spongy bone tissue. Yellow bone marrow is fat. It is present in the medullary cavity of adult long bones. Red bone marrow is hematopoietic tissue. It produces red blood cells. In children, the medullary cavity is filled with red bone marrow.

13. Osteoblast builds bone; osteoclast breaks down bone (crushers) and osteocytes are old osteoblasts that are caught in the hard matrix of bone. A. Osteocytes live in the lacunae. B. caniculae connect lacunae to lacunae. C. osteoid- collagen fibers that calcium sticks to.

14. The periosteum (“around bone”) is the external layer, or covering, around the diaphysis and part of the epiphyses of the long bone. It is made of dense irregular connective tissue and also has osteoclasts and osteoblasts, as well as nerve fibers, blood vessels, and lymphatic vessels.

BONE REMODELING

15. To regulate the amount of calcium found in the blood
16. Resorption is breaking down bone to add calcium to the blood; Depositing is creating bone to remove calcium from the blood.
17. Hormonal control by the thyroid/parathyroid or mechanical control from weight bearing exercises
18. Negative Feedback
19. Parathyroid Gland; Parathyroid Hormone
   a. PTH stimulates osteoclasts to break down some bone and release the calcium from it into the blood stream.
   b. Calcium Blood Levels rise back to normal.
   c. The signal is shut off and the parathyroid gland stops producing PTH.
20. Thyroid Gland; Calcitonin
   a. Calcitonin increases bone deposit, so more calcium is taken from the blood and used to calcify more bone tissue.
   b. Calcium Blood Levels drop back to normal.
   c. The signal is shut off and the thyroid gland stops producing calcitonin.
OSSIFICATION
21. Long bones grow by the process of endochondral ossification.
22. The process of bone formation is called ossification or osteogenesis. There are two types:
   a. Intramembranous ossification, which forms the bones of the skull and the clavicles (collarbones)
   b. Endochondral Ossification, which happens when cartilage is replaced by bone. This forms long bones.
23. A. Mesenchyme- embryonic connective tissue that changes/differentiates into osteoblasts at the start of bone formation
   B. ossification center- the cluster of osteoblasts formed from mesenchyme.
   C. osteoid- the collagen fibers laid down by osteoblasts that attract calcium and make the hard matrix of bone.
   D. woven bone- bone matrix laid down around (woven around) blood vessels in the connective tissue, forms spongy bone/trabeculae.
   E. bone collar- the hardened outer edge of the bone that becomes dense and eventually forms compact bone.
24. 5,4,7,6,2,3,1,8
25. A- perichondrium- mesenchyme that surrounds cartilage in early bones that eventually becomes periosteum b- mesenchyme-embryonic connective tissue that forms osteoblasts during bone formation C- osteoid- collagen fibers laid down by osteoblasts that attract calcium, making the bone matrix. D- bone collar- a coating of bone matrix that surrounds the diaphysis.
   E- diaphysis chondrocytes-cartilage cells that eventually die and form the cavity inside the diaphysis.
   F- periosteal bud- blood vessels that infiltrate the cavity in the diaphysis.
   G- osteoclasts- bone crushers that create the medullary cavity in long bones.
   H- osteoblasts- build compact and spongy bone
26. 7,2,4,5,3,6,1
27. Cartilage in the epiphyseal plate ossifies near the diaphysis while cartilage cells continue to grow near the epiphysis. At the end of adolescence, the cartilage cells stop growing and eventually the epiphyseal plate becomes completely ossified, forming the epiphyseal line.

FRACTURES
28. Comminuted fractures are when the bone is broken into three or more pieces. It’s common in people with brittle bones, like with osteoporosis. Compression fractures are when the bone is crushed. This is common in the vertebrae in back or spinal injuries.
29. A pathological fracture is a fracture caused by a disease. An example would be when a bone is broken due to osteoporosis—the disease causes the break which then causes the person to fall. A traumatic fracture is caused by injury, such as a car accident or fall.

30. A greenstick fracture occurs commonly in children because children have a higher amount of cartilage because their bones are still developing. In adults most of this cartilage has calcified.

31. Simple fractures are also called closed fractures. In these fractures, the bone is broken but stays in place. A compound fracture, or open fracture, is when the bone is broken and is exposed to the open surface due to something entering through the skin or the bone breaking through the skin.

32. An impacted fracture happens when the broken ends of bones are forced together. This is common in falls.

33. In a spiral fracture, the bone breaks unevenly due to a twisting motion, like the bone was twisted apart. This is common in sports due to the twisting movement of the body.

**BONE REPAIR**

34. A- hematoma, or blood clot forms from the broken blood vessels at the site of injury B- cartilage callus- created by Fibroblasts, forms a splint to hold the broken ends together. C- capillaries deliver blood clotting proteins, nutrients to wound for bone repair, causes inflammation. D- woven bone- The cartilage callus is converted to woven, or spongy, bone and is now called a bony callus. E- phagocytes- cells of the immune system that break down debris at the wound and fight any bacterial infection.

35. 4,1,5,3,2

**DISEASES**

36. **A- Paget’s Disease:** Cause is unknown, possibly caused by a virus. With this disease, there is excessive deposit and resorption. Bones have high ratio of spongy bone compared to compact bone. Later, osteoblasts continue to work while osteoclasts slow down so bones grow irregularly or cavities are filled with this specialized bone. Treated by drug therapies. It is rare before age 40, but affects about 3% of North Americans.

**b- Osteoporosis:** Caused by decreased amounts of sex hormones (common in older women because sex hormone production slows after menopause), insufficient exercise, smoking, low calcium and...
phosphate, and abnormal vitamin D receptors. It causes more bone to be broken down than built up. Bones become porous and density is reduced. Because bones are weaker, it causes higher chance of fractures, stooped posture, and weakness. It can be treated with higher vitamin D intake, hormone replacement therapy, exercise, and drug therapies.

c- Osteomyelitis: Caused by a pus-forming bacteria that enters the body through a wound (like a compound bone fracture) or from an infection near the bone. The bone and bone tissue get inflamed and it causes a fever and pain, as well as joint stiffness, bone destruction, and possibly shortening of a limb. It can be treated with antibiotics, draining the pus, or removing dead bone fragments.

d- Osteomalacia (includes Rickets): Bones are not mineralized like normal, due to lack of Vitamin D or calcium in the diet. The osteoid is secreted but not calcified, so bones stay soft and weak. Rickets is the disease in children, but it is much more severe since they are still growing rapidly. In adults, it mostly leads to pain. With children suffering from rickets, they may develop bowed legs and deformed pelvis, skull and rib cage. Since the epiphyseal plates do not calcify when they should (or ever) they continue to get wider and the ends of long bones continue to widen and grow longer. This is usually treated or prevented by drinking Vitamin D milk or exposing the skin to sunlight.