

SKELTAL SYSTEM

OBJECTIVES/RATIONALE

To pursue a career in health care, proficiency in anatomy and physiology is vital. The student will describe biological and chemical processes that maintain homeostasis; analyze forces and the effects of movement, torque, tension, and elasticity on the human body; associate the disease process with changes in homeostasis; identify changes in structure and function due to trauma and disease; and identify normal and abnormal anatomy and physiology.

TEKS: 121.3 (c)(1)(F)(H),
121.4 (c)(1)(G)(H)(I),
121.5 (c)(1)(E)(F)(G)

TAKS: ELA 1, 3
Mathematics 6, 7, 8
Science 1, 2, 3, 4, 5

KEY POINTS

Power Point

- I. Introduction
 - A. Bony framework of body
 - B. 206 bones in adult
 - C. Functions
 - 1. Support: body structure and shape
 - 2. Protection: vital organs surrounded
 - 3. Movement and Anchorage of muscles (levers for muscular action)
 - a. Tendons: attach muscle to bone
 - b. Ligaments: attach bone to bone
 - 4. Mineral storage: calcium and phosphorus
 - 5. Blood cell formation - hematopoiesis
- II. Bone Composition
 - A. Collagen: chief organic constituent (protein)
 - B. Inorganic calcium salts (Vitamin D essential for absorption of minerals i.e. calcium)
 - 1. Deposition favored by
 - a. Estrogen, testosterone
 - b. Alkaline phosphatase
 - c. Thyrocalcitonin
 - d. Mechanical stress i.e. traction
 - 2. Withdrawal favored by
 - a. Alkaline phosphatase
 - b. Parathormone
 - c. Inactivity
 - C. Cells

1. Osteoblasts: bone building, bone repairing cells in the periosteum
 2. Osteocytes: mature bone cells within the bone matrix
 3. Osteoclast: causes reabsorption of bone
- D. Periosteum
1. Dense, fibrous membrane covering bone
 2. Contains blood vessels
 3. Essential for bone cell survival and bone formation
- III. Types of Bones Based on Composition
- A. Compact bone
1. Very dense, stress bearing
 2. Haversian systems
 - a. Lamellae: concentric cylinder shaped calcified structure
 - b. Lacunae: small spaces containing tissue fluid
 - c. Osteocytes: facilitate exchange of calcium between blood and bone
 - d. Canaliculi: canals connecting the lacunae together and to the haversian canal which carries nutrients and wastes to and from the osteocytes
- B. Cancellous bone
1. Light, spongy
 2. Low stress areas where weight of bone would be a problem
 3. Found at ends of long bones, ribs, sternum, hips, vertebrae, cranium
 4. **No** haversian systems
 5. Web-like arrangement
- IV. Classification of Bones According to Shape
- A. Long bones (extremities): levers
1. Epiphysis: at the ends, covered with hyaline cartilage for articulating bones; cancellous bone
 2. Diaphysis: shaft, covered with periosteum; medullary canal with yellow and red marrow (lined with endosteum); covered with periosteum for bone growth, repair, and nutrition; compact bone
 3. Femur, tibia, fibula, humerus, ulna, radius, clavicle
- B. Short: cube shaped, allows flexible movement
1. Cancellous bone covered by compact bone
 2. Carpals, tarsals, metacarpals, metatarsals, phalanges
- C. Flat: flat plates; protect vital organs and provide broad surface area for muscle attachment
1. Cranial bones, facial bones, scapula, sternum
- D. Irregular: peculiarly shaped to provide support and protection, yet allow flexibility
1. Vertebrae, ribs, ear, hip, hyoid
- E. Sesamoid bones
1. Extra bones found in certain tendons i.e. patella

- V. Bone Formation
 - A. Initially collagen fibers secreted by fibroblasts
 - B. Cartilage deposited between fibers
 - C. Skeleton fully formed by 2nd month of fetal development (all cartilage)
 - D. After 8th week of fetal development ossification (mineral matter deposited and replaces cartilage) begins
 - E. Childhood and adolescence: ossification exceeds bone loss
 - F. Early adulthood thru middle age: ossification equals bone loss
 - G. After age 35: bone loss exceed ossification
 - H. Skull
 - 1. Begins as fibrous membrane
 - 2. Ossification center in the middle of the membrane: begins in the middle and radiates out
 - 3. Ossification not complete at birth: fontanel (soft spots) on infant's head allow molding of skull during birth and with the open joints allows for growth of the brain
 - I. Other bones
 - 1. Begin as hyaline cartilage
 - 2. Short bones: one ossification center in middle and proceeds toward the periphery
 - 3. Long bones: three ossification centers (one at each end and one in the center of the shaft)→ ossification from center toward each end and from each end toward the center
- VI. Bone Growth
 - A. Grow in length at the epiphyseal line
 - B. Grow in width by the addition of bone to the surface
 - C. Controlled by the anterior pituitary (growth hormone)
 - 1. Dwarfism: hypofunction
 - 2. Giantism: hyperfunction
 - 3. Acromegaly: hyperfunction after puberty; enlarges bones of hands, feet, face
- VII. Bone Markings
 - A. Purpose
 - 1. Join one bone to another
 - 2. Provide a surface for attachment of muscles
 - 3. Create an opening for passage of blood vessels and nerves
 - 4. Used as landmarks
 - B. Examples
 - 1. Process: bony prominence or projection
 - 2. Condyle: a rounded knuckle-like prominence usually at a point of articulation
 - 3. Epicondyle: small projection
 - 4. Head: a rounded articulating process at the end of a bone
 - 5. Spine: a sharp, slender projection
 - 6. Tubercle: a small rounded process
 - 7. Tuberosity: a large rounded process

8. Trochanter: a large process for muscle attachment
9. Fossa: a depression or hollow
10. Foramen: a hole
11. Crest: sharp ridge
12. Line: a less prominent ridge of a bone than a crest
13. Meatus: a tube-like passage
14. Sinus/antrum: a cavity within a bone
15. Depression: hollow region or opening
16. Fissure: narrow, slit-like opening
17. Sulcus: a groove
18. Facet: a small area on a bone

VIII. Bone Marrow

A. Yellow marrow

1. Medullary cavity of long bones
2. Fat storage

B. Red marrow: hematopoietic tissue

1. In all cancellous bone in children
2. In adults: cancellous bone of vertebrae, hips, sternum, ribs, cranial bones, proximal ends of femur and humerus
3. Forms RBCs, platelets, some WBCs, and destroys old RBCs and some foreign materials

IX. Axial Skeleton

A. Skull: 22 bones

B. Cranium: houses and protects the brain with 8 bones

1. Frontal: forms forehead and orbits of eyes; supraorbital margins (ridge to protect eyes)
2. Ethmoid: forms roof of nasal cavity, very light bone has horizontal plate, perpendicular plate, and two lateral masses
3. Parietal, Right and Left: form sides and roof of skull, internal surface rough to accommodate the brain
4. Temporal, Right and Left: forms temple, cheek, ear openings
 - a. Squamous portion: forms temple
 - b. Zygomatic process: forms cheek
 - c. Petrous portion: forms auditory canal
 - d. Mastoid portion: behind the ear
 - e. Tympanic portion: walls of acoustic meatus
5. Occipital: back of skull, inferior portion has foramen magnum where spinal cord passes through; sides of foramen have two projections (condyles) that articulate with the first cervical vertebra (atlas)
6. Sphenoid: fills space between orbital plates, contains sphenoidal sinuses, upper surface has a depression called the sella turcica, where the pituitary gland rests
7. Wormian Bones: extra bones formed by irregular connections of cranial sutures

8. Cranial Sutures: unite the bones of the cranium; as child grows, irregular bands of connective tissue ossifies and turns into hard bone
 - a. Coronal suture: between frontal and parietal bones
 - b. Sagittal suture: between right and left parietal bones
 - c. Lambdoidal suture: between parietal and occipital bones
 - d. Squamous suture: between temporal and parietal bones
 - e. Abnormalities
 - (1) Microcephalus: premature fusion
 - (2) Hydrocephalus: delayed fusion (increases intracranial pressure)
9. Fontanelles: fusion of the cranial bones is not complete at birth, so a space between the bones remains
 - a. Anterior (Bregmatic): “soft spot”, closes at 18 months
 - b. Posterior (Occipital): triangular, closes at 2-3 months
 - c. Anteriolateral (Sphenoidal): at 2 temples, closes at 2-3 months
 - d. Posterolateral (Mastoidal): behind ears (2), closes at 1 year
- C. Facial Bones: guard and support the eyes, ears, nose, and mouth; 14 bones
 1. Nasal bones (2): form bridge of nose
 2. Vomer: forms central nasal septum
 3. Maxillary (2): upper jaw bones, fusion occurs before birth (if not, cleft palate occurs), forms roof of mouth, walls of nose, floor of orbitals; body has maxillary sinuses, alveolar process → upper teeth, palatine process → anterior palate; largest bone of the upper face
 4. Mandible: lower jawbone, largest bone of face, two perpendicular portions called rami (have 2 processes: condylar process → posterior forms temporal-mandibular joint; coronoid process → anterior for muscle attachment)
 5. Zygoma (2): cheek bones
 6. Lacrimal (2): small bones form medial wall of eye socket, tear duct passes through, smallest, fragile
 7. Palatine (2): forms back roof of mouth and floor of nose, L-shaped
 8. Inferior turbinate (2): forms curved ledge inside side wall of nose
- D. Ear Bones: tiny bones in middle ear cavity in temporal bone
 1. Malleus (2): the hammer
 2. Incus (2): the anvil
 3. Stapes (2): the stirrups
- E. Hyoid Bone: u-shaped bone in the neck at the base of the tongue; the only bone that does not touch another bone.
- F. Cranial Sinuses: cavities within the cranium, function as resonance chambers in the production of the voice, decrease weight of skull, lined with mucous membrane
 1. Frontal sinuses (2): above eyebrows, open into nasal cavity

2. Ethmoid sinuses (2): between eyes
3. Sphenoidal sinus (1): posterior to ethmoidal sinuses, opens into nasopharynx
4. Maxillary sinuses (2): on either side of nose, opens on lateral wall of nasal cavity

G. Vertebral Column

1. Functions
 - a. Supports trunk and neck
 - b. Protects spinal cord
 - c. Multiple joint spaces allow for bending and twisting
2. Curves: (lateral view) allow for resilience and spring for walking
 - a. Thoracic: present at birth
 - b. Sacral: bow back
 - c. Cervical: begins at 3 months when infant first begins to lift head
 - d. Lumbar: begins when child first walks
3. Vertebrae: 26 separated by intervertebral disk to cushion joints for movement
 - a. Body: thick, disk-shaped anterior portion
 - b. Arch: encloses space for spinal cord (neural canal); has 3 processes for muscle attachment (spinous process → dorsally directed, 2 transverse processes)
 - c. Articular processes: provide for articulation with other vertebrae (2 superior and 2 inferior)
 - d. Pedicles (2): originate from body of vertebrae notched to allow spinal cord nerves to pass
 - e. Lamina: posterior wall of vertebrae, weakest point
4. Sections
 - a. Cervical (7): smallest, oblong bodies, wide transverse processes
 - (1) Atlas: 1st cervical vertebra; supports head by articulating with condyles of occipital bone; bony ring with no body; has short wing-like transverse processes; allows forward and backward motion
 - (2) Axis: 2nd vertebra; small body with projection called the odontoid process that acts as the axis of rotation of the skull
 - (3) 3rd, 4th, 5th, and 6th vertebrae forked to cradle strong ligaments of head
 - (4) 7th vertebra has very prominent spinous process called the vertebral prominence that can be felt at the base of the neck
 - b. Thoracic (12): progressively increase in size from neck; have long spinous process (pointed downward), 6 articular facets for rib attachment

- c. Lumbar (5): largest and strongest, have short projections for muscle attachment
 - d. Sacral: 5 fused bones, triangular, forms dorsal part of pelvis, joins ileum bone at iliosacral joint
 - e. Coccyx: 3-4 fused bones, articulates with tip of sacrum, slightly movable (to assist in childbirth)
 - 5. Injuries and Diseases
 - a. Kyphosis: hunchback, posterior thoracic exaggerated
 - b. Lordosis: swayback, exaggerated anterior curve of lumbar region
 - c. Scoliosis: lateral curvature of the spine
 - d. Fractures & Dislocations: most often if fracture of lamina, can cause spinal cord damage, paralysis
 - e. Intervertebral disk herniation: causes pressure on spinal nerve, pain
 - f. Tuberculosis of spine: by tubercle bacillus, destroys body of vertebrae
- H. Thorax: 25 bones and cartilage, walls covered by skin and muscles, floor is formed by the diaphragm
 - 1. Functions
 - a. Protect and support heart and lungs
 - b. Supports bones of pectoral girdle
 - c. Plays a leading role in respiration
 - d. Ribs and sternum aid in RBC formation
 - 2. Sternum: breast bone, sword and handle shape
 - a. Manubrium: handle, notched for 1st 7 costal cartilage, articulates with acromium end of clavicle and 1st rib
 - b. Body: blade, notched for 1st 7 costal cartilage
 - c. Xiphoid process: tip, attachment site for diaphragm
 - 3. Costal cartilages: hyaline cartilage connecting ribs to sternum in 1-7 and to anterior ribs in 8-10
 - 4. Ribs (12 pairs): attached posteriorly with vertebrae and anteriorly with costal cartilage
 - a. True ribs: 1st seven pairs
 - b. False ribs: 8-12 (11 and 12 are floating ribs)
- X. Appendicular Skeleton (126 bones)
 - A. Shoulder Girdle
 - 1. Clavicles (2): collar bones
 - 2. Scapulas (2): shoulder blade
 - B. Upper Extremities
 - 1. Humerus: upper arm
 - 2. Radius: thumb side of forearm
 - 3. Ulna: little finger side of forearm
 - 4. Carpals (8): wrist bones
 - 5. Metacarpals (5): hand bones
 - 6. Phalanges (14): finger bones

C. Pelvic Girdle

1. Os coxae (2): contains the acetabulum (hip socket)
 - a. Ilium
 - b. Ischium
 - c. Pubis
2. Sacrum

D. Lower Extremities

1. Femur: thigh bone
2. Patella: kneecap
3. Tibia: shin bone
4. Fibula: lateral bone of lower leg
5. Tarsals (7): ankle bones
 - a. Talus
 - b. Calcaneus
6. Metatarsals (5): foot bones
7. Phalanges (14): toe bones

XI. Articulations

- A. Synarthrotic: immovable
- B. Amphiarthrotic: limited movement i.e. pubic symphysis, vertebral joints, sacroiliac joint
- C. Diarthrotic: freely movable
 1. Gliding: wrist
 2. Pivot: between radius and ulna
 3. Ball and socket: hip
 4. Hinge: elbow

XII. Diseases/Disorders

- A. Arthritis: inflammation of the bones at the joints, usually with pain and changes in bone structure
- B. Bunion: abnormal lateral displacement of big toe causing inflammation and thickening of the bursae
- C. Bursitis: inflammation of the bursa, which is a sac or cavity filled with synovial fluid
- D. Dislocation: the displacement of a bone from a joint, tearing ligaments, tendons, and capsules
- E. Fracture: a break in a bone
 1. Simple
 2. Compound
 3. Spiral
 4. Comminuted
 5. Greenstick
- F. Osteitis: inflammation or infection of the bone
- G. Osteomyelitis: bone infection that involves the bone marrow
- H. Osteoporosis: condition in which bones become softer and more brittle, and thus more liable to fracture due to loss of mineral content; associated with aging

- I. Rickets: condition in which bones fail to calcify and growth is hampered usually due to a deficiency of vitamin D and phosphorus in the diet
- J. Spina bifida: congenital defect in which the vertebrae fail to unite in the midline
- K. Sprain: wrenching of a joint with injury to ligaments

ACTIVITIES

- I. Color code a diagram of the skeleton (axial and appendicular) then label the structures.
- II. Participate in the Hokie-Pokie Osteokey.
- III. Construct a working knee joint.
- IV. Practice range of motion exercises ([Body Mechanics Lesson](#)).
- V. Participate in Paper Bones Game.
- VI. Participate in Bag o' Bones Game.
- VII. Participate in Skeletonary Game.

MATERIALS NEEDED

Diagram of skeleton
Arts and crafts materials
Skeletal System Terminology

ASSESSMENT

Completion of diagram
Completion of knee joint

ACCOMMODATIONS

For reinforcement, the student will make flashcards of key terms

For enrichment, the student will research and report on how forensic scientists use the skeletal system when investigating homicides.

REFLECTIONS

Activity: Hokie-Pokie Osteokey

Objective:

Help students practice location of bones.

Instructions:

1. Write the following anatomical terms on the board:

Phalanges (hands)
Left patella
Right humeral head
Olecranon
Coccyx
Left ulna
Right tarsals
Left innominate
Cranium
Right tibia
Left calcaneus
Mandible
Right radius
Left great toe
Right parietal
Right carpals
skeleton

2. Ask students to stand. (It's fun to get everyone in a circle.)
3. Have everyone sing Hokey-pokey song and substitute bones on board for usual body parts.

“Put your phalanges in. Take your phalanges out.
Put your phalanges in and shake them all about.
Do the hokey-pokey and turn yourself around. That's what it's all about!”

Clap, Clap.

Paper Bones

Objective: Label bones on a cardboard “Halloween-type” skeleton

Materials: Each group of students will need the following:

1. Cardboard Halloween skeleton about four feet long
2. Post-it stickers (1/2” x 2”) – 25
3. List of bones and labeled atlas (from text)

Warm-up

1. Break the class into groups of 3 or 4 (no more)
2. Give each group the materials above and tell them to choose a place to work together (table top or floor)
3. Give them ten minutes to correctly label all the bones they can find on the list
4. Have each group present their labeled skeleton while the class critiques and gives feedback. The students are encouraged to defend their choices using the reference atlas. The instructor is the referee.
5. Repetition of this process for each group reinforces the learning.

Competition

1. Have each group choose a team name (related to anatomy, e.g., Patellas)
2. Each group prepares to start the exercise over but without the atlas.
3. This time they must label the skeleton as quickly as possible while they are being timed. Give them a few minutes to organize task assignments before starting. Be sure they do not fill out the label beforehand.
4. Give the starting signal and keep track of the time.
5. Instruct them that when finished they should signal completion by standing up and holding the labeled skeleton up.
6. Note times and finishing order on the board.
7. Have the groups represent their labeling results in order with group critique.
8. Score by adding 10-15 seconds per error to their elapsed time.
9. The team with the fastest resulting time wins.
10. Present an award.

Comment

Be certain that most of the bones are accurately portrayed on the cardboard skeleton. If there is an error, point it out before play starts and agree to call it something.

Bag o' Bones

Objective: Identify a bone in a bag by touch only

Materials: 1. A set of disarticulated bones
2. Pillowcase

1. Divide the students randomly into two teams and decide on team names (anatomy names)
2. The instructor places a bone into the pillowcase in such a manner that the students cannot see it (students can be asked to put their heads down, or the instructor can select the bone behind a cabinet door).
3. Flip a coin to determine which team starts. That team puts forth the first player to represent them.
4. The student player is given the choice of feeling the bone inside the bag or feeling the bone from the outside (which is more difficult through the cloth). Award one point for inside and two points for outside examination.
5. Give the student only 10 seconds (you can vary this according to the skill of your students) to feel the bone, counting during the examination.
6. After withdrawing his hand, the student is given another 10 seconds to announce the name of the bone.
7. If the student chooses to examine the bone from outside the bag, he is given only 5 seconds and then 5 seconds to announce the bone name.
8. If correct, the instructor takes the bone out of the bag and awards the points accordingly (1 point for in-bag exam or 2 points for external exam).
9. Ask the student to point out what features caused them to decide on the bone name.
10. If the bone named is incorrect, the instructor give an opportunity to a student on the other team and that team may now reap the points. The process continues to alternate from one team to the other until it is correctly identified. Obviously the chance for success becomes greater with each wrong answer put forth. Eventually someone will identify the bone.
11. The instructor (or a designated student) keeps track of the team scores.
12. After every student has had at least one turn, the game is finished and a winner declared.

Comments

This game should only be played when the class is fairly familiar with the bones and their surface features. It is a good opportunity to point out features like the hinge-like joint on the proximal end of the ulna that help differentiate this bone from the radius. The process also reinforces some of the anatomic features like the tibia is much thicker than fibula. It is best to use the long bones and the irregular bones. Small bones (carpals, tarsals, and phalanges) are difficult to exactly identify. Vertebrae can be a challenge, but it is possible to state from what region on the spine the bone comes from (cervical, thoracic).

Skeletonary

Objective: Make clay images of the bones

- Materials:
1. Modeling clay (2 sticks)
 2. Deck of cards (1 set) with the name of a bone on each
 3. Desk and chair in front of room
 4. List of bones and atlas

Competition

1. Divide the class into two equal groups and have them sit on opposing sides
2. Have each team choose a name
3. Flip a coin to decide which team will go first and then have the team choose one member to start. This person comes to the front of the class.
4. The student randomly chooses a card from the deck of bones and shows it to the teacher.
5. For one point, the student must identify the bone on the atlas (unseen by the class)
6. Sitting at the desk, in front of the room, the student has 30 –40 seconds to mold the clay into a suitable representation of the selected bone.
7. The team members then have 30 seconds to make three guesses. If correct, the team gets one more point.
8. If not guessed correctly, the other team has an opportunity to guess once and get the point.
9. Then the student-sculptor is given an additional question by the teacher related to the selected bone. If answered correctly, the team gets one more point. Maximum points are three per turn.
10. The other team then takes a turn.
11. The team with the highest score wins and each team member gets an award.

Additional Rules

1. The sculptor may not speak during their clay rendition. Speaking nullifies the point.
2. The sculptor may hold the clay model to their body to show its location.
3. Any sculpted form is allowable to give the hint. More than one bone may be made and the sculptor can then point to the unknown bone.

Comments

This game develops psychomotor skills and encourages creativity in remembering features of the bones. For instance, the sculptor with the task of communicating the metacarpal may take all five of them with the attached phalanges or carpal bones and then point to the metacarpals. Kids get creative.