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UNIT
05

Support and Movement

Axial Skeleton

SAMPATH
LANKADHEERA

B.Sc. (Hons), M.Sc.



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SAMPATH LANKADHEERA

Unit
05

Support and Movement
Axial Skeleton

ADVANCED LEVEL

Biology

Unit - 05

Support and Movement

- Axial Skeleton

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**Unit
05**

Support and Movement

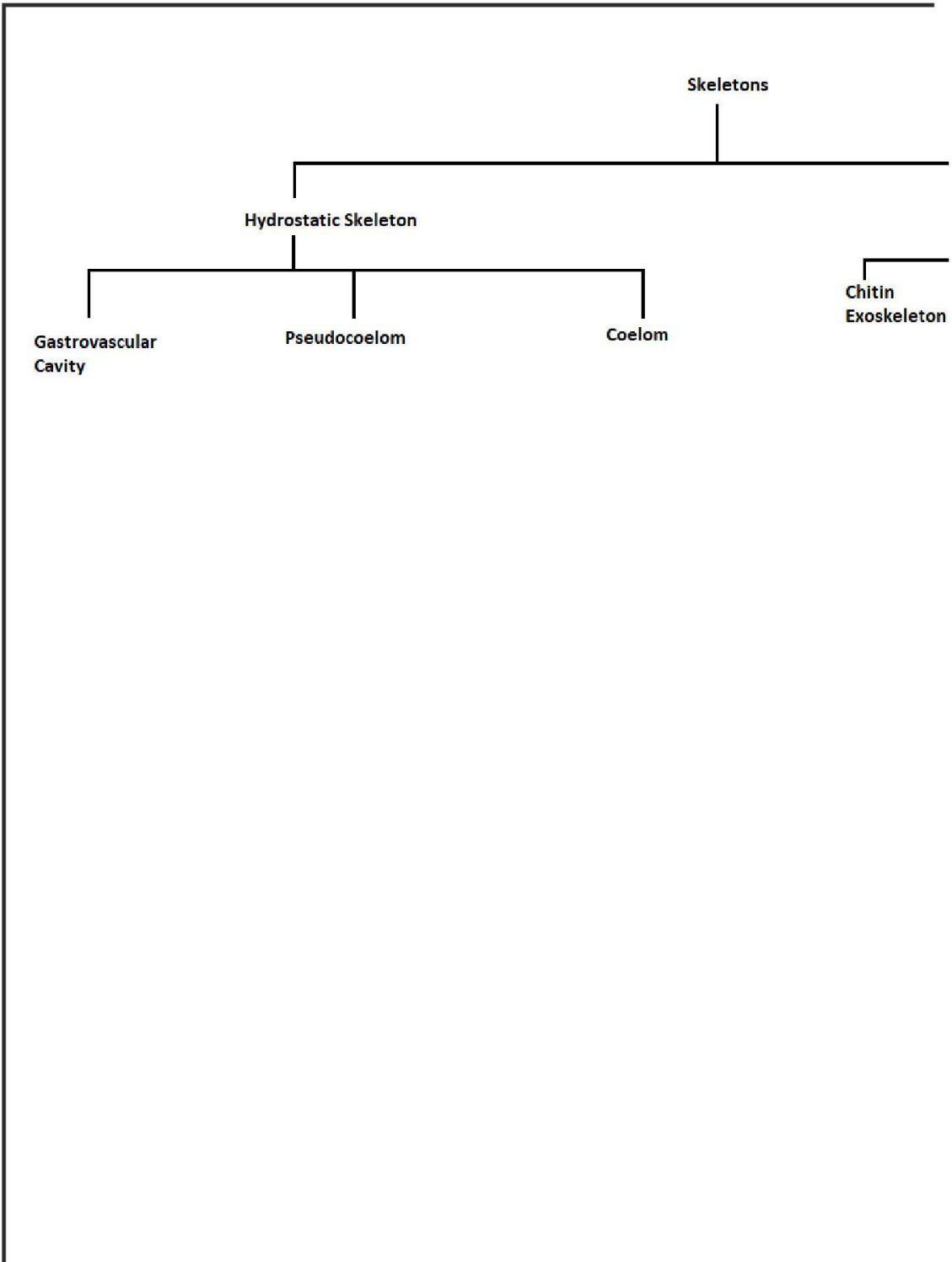
○ Axial Skeleton

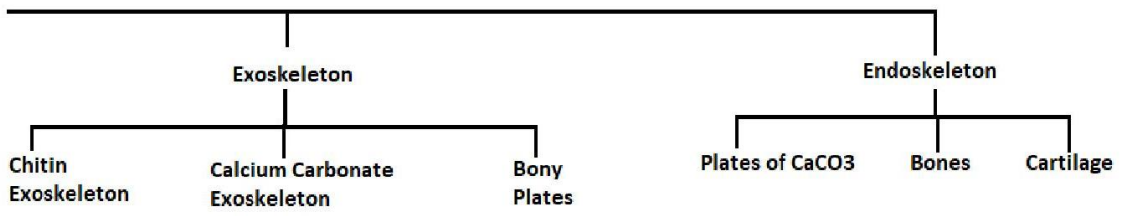
Smart Note

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5.9.0 : Inquires into the types of supporting systems and movement in animals

5.9.1 : Inquires into the structure and functions of the skeletal systems and movement of animals

- Lists the main types of skeletons of animals
- Briefly describes the organization of the hydrostatic skeleton
- Names the different types of hydrostatic skeleton using phyla or classes as examples
- States the organization of different exoskeletons with examples
- States the organization of different endoskeletons with examples
- States the common functions of the skeletal system
- States the functions of the human skeletal system
- Briefly describes how animals move through water and air
- Appreciates the skeletal system in relation to survival of organisms in their environment

Support and Movement

The structure and functions of the skeletal systems of animals

- In the animal kingdom, three major types of skeletons are found.
- They are
 1. Hydrostatic skeletons
 2. Exoskeletons and
 3. Endoskeletons.

Hydrostatic skeleton

- It is a fluid filled body cavity which is enclosed by the body wall.
- In cnidarians, gastrovascular cavity acts as the hydrostatic skeleton.
- In some animals such as nematodes and annelids, the fluid filled cavity enclosed by the body wall (Eg. Pseudo-coelom in Nematoda, Coelom in Annelida) consists of two muscle layers (longitudinal and circular muscles) which act antagonistically.
- The combined effect of muscle contraction and fluid pressure aids in locomotion and maintain the shape and form of the animal.
- In many animals, the spaces between cells are filled with fluid called interstitial fluid which provides support to these cells.

Exoskeleton

- Exoskeleton is a rigid outer covering of the body of the animal which acts as a skeleton.
- Different types of exoskeletons are seen in the animal kingdom: Chitinous exoskeleton, calcium carbonate exoskeleton and bony plates. Arthropods possess the exoskeleton which is mainly composed of a non-cellular material, chitin.
- The chitinous exoskeleton is hardened by proteins or calcium carbonate.
- Exoskeletons that are made up of calcium carbonate are seen in the molluscs. In some reptiles, bony plates serve as the exoskeleton.

Endoskeleton

- Endoskeleton is a hard skeleton which is buried in the soft tissues of the animal.
- Different types of endoskeletons are seen in the animal kingdom. These include plates of calcium carbonate (in echinodermites), bones and cartilage (in chordates).

Common functions of the skeletal systems in animals

1. Support All skeletons provide a rigid framework for the body and are resistant to compression and tension forces. They help to maintain the shape of body.
2. Protection The skeleton protects the delicate internal organs.
3. Movement Most skeletons are composed of rigid materials which provide a means of attachment for the muscles of the body. Parts of the skeleton operate as levers on which the muscles can pull. When this occurs, movement takes place.

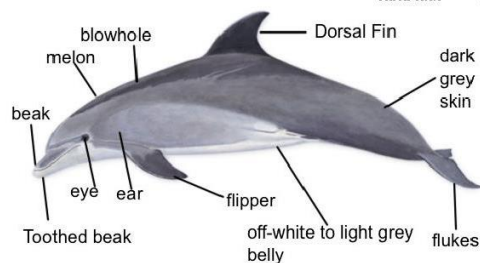
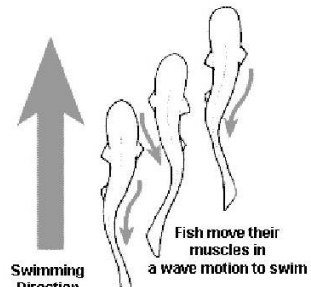
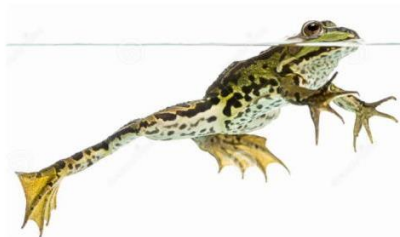
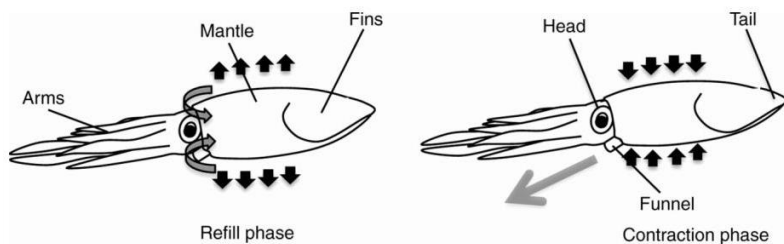


Functions of the human skeletal systems

How animals move through water and air

Swimming:

- Different groups of animals swim in different ways.
- Some animals use their legs as oars to push against the water (Eg. insects and four legged vertebrates).
- Some animals are jet propelled taking water into the body and squirting it out in bursts (e.g. squids).
- Fishes swim by moving their body and tail from side to side.
- Aquatic mammals move by undulating their body and tail up and down (e.g. whales and dolphins).
- Fusiform body shape is a common adaptation for fast swimming animals.

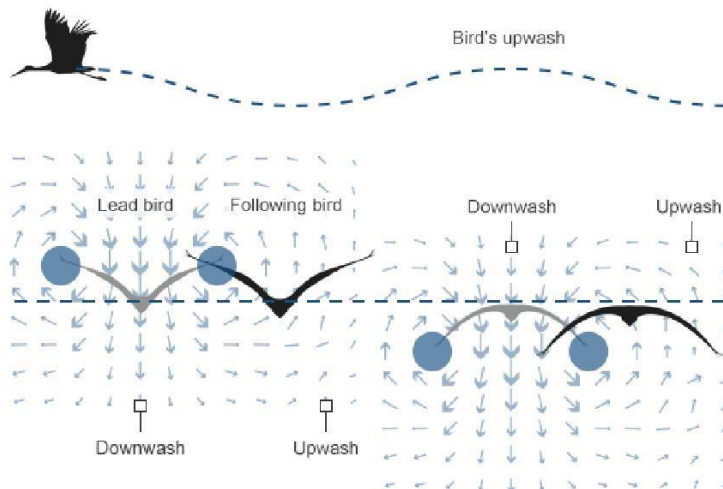


Movement through air:

- *Animals move through air mostly by flying.*
- *Gliding downward can occur in some instances.*
- *Flying animals use wings to lift the body against the gravity.*
- *Wings act as air foil: their shapes alter air currents in a way that helps flying.*
- *Fusiform shape of the wings helps to reduce drag force in air.*



How birds take advantage of the V formation



5.9.2 : Investigates the structure and functions of the axial skeleton of man

Learning Outcomes:

- *names the two main parts of the human skeleton*
- *describes the organization of the human skeleton*
- *names the bones in the skull*
- *lists the main parts of the axial skeleton*
- *describe significant parts and functions of skull*
- *explains curvatures of the vertebral column and their importance*
- *describes the structure of a typical vertebra*
- *names different types of vertebrae with number*
- *states special features of each type of vertebrae in relation to function*
- *states the structure and importance of ribs and sternum*
- *states how the human axial skeleton contributes to maintain upright posture*



Terminology	Meaning
Articulation surface	
Articulation	
Bony sinus	
Border	
Condyle	
Facet	
Foramen	
Meatus	
Septum	
Spine	
Styloid process	
Suture	

Types of Bones

Long Bones	
Short Bones	
Flat Bones	
Irregular bones	
Sesamoid Bones	



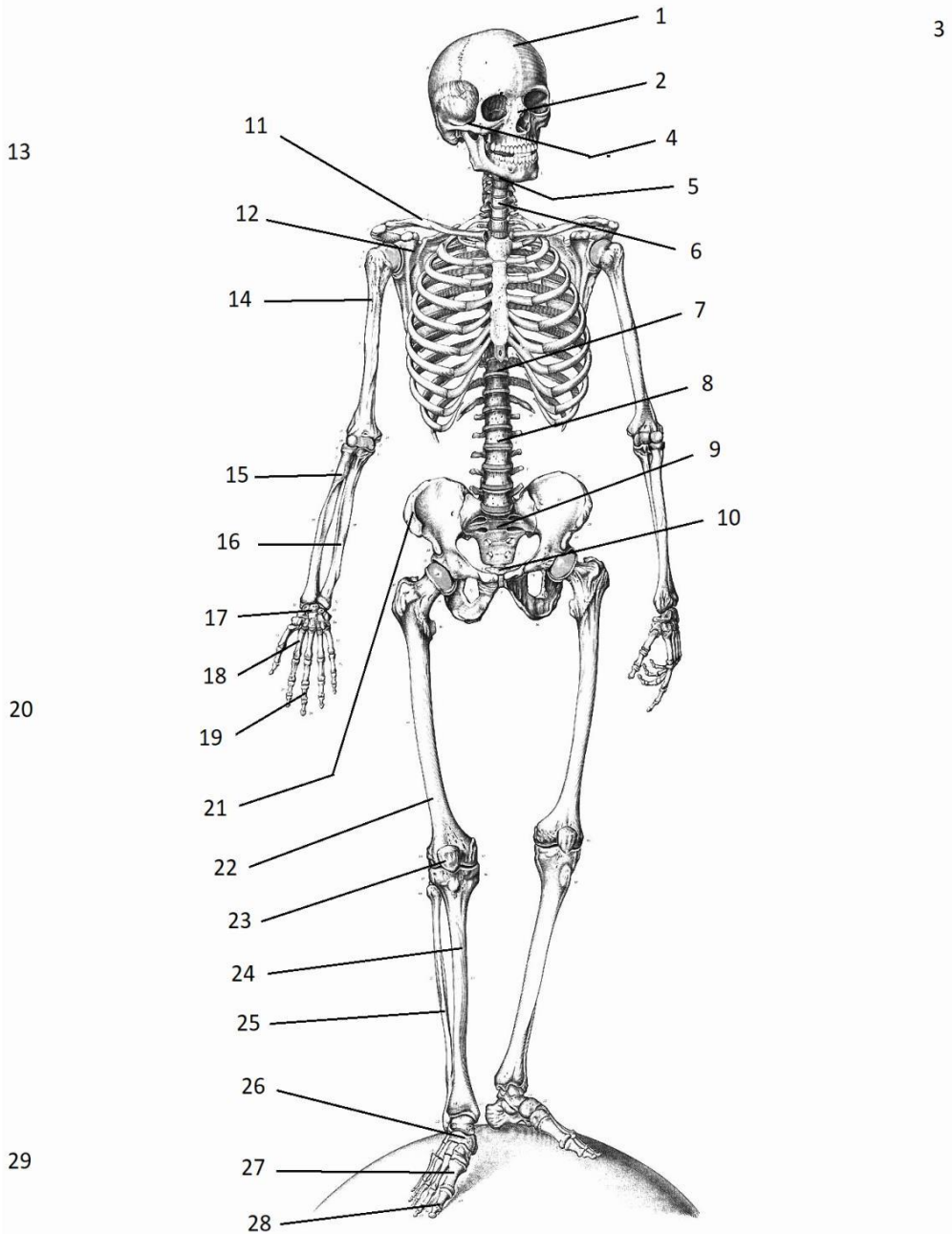
General Plan of Vertebrate Skeleton

Axial Skeleton	Appendicular Skeleton
<ul style="list-style-type: none">The axial skeleton's bones form the axis of the body and support and protect the organs of the head, neck, and chest.The human axial skeleton is made up of the following parts.<ol style="list-style-type: none">..............................	<ul style="list-style-type: none">The appendicular skeleton's bones include the bones of the limbs, and the pectoral and pelvic girdles that attach them to the axial skeleton.The human appendicular skeleton, is made of the following parts.<ol style="list-style-type: none">....................



The human skeleton

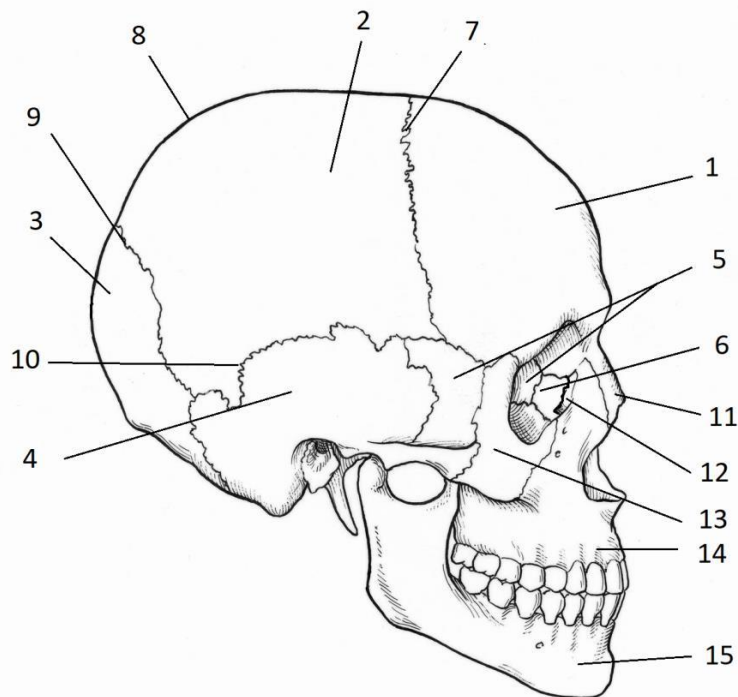
- Human skeleton is divided into two main parts: axial skeleton and appendicular skeleton.
- Axial skeleton consists of skull, vertebral column, sternum and ribs.
- Appendicular skeleton consists of girdles (pectoral and pelvic) and limb bones.

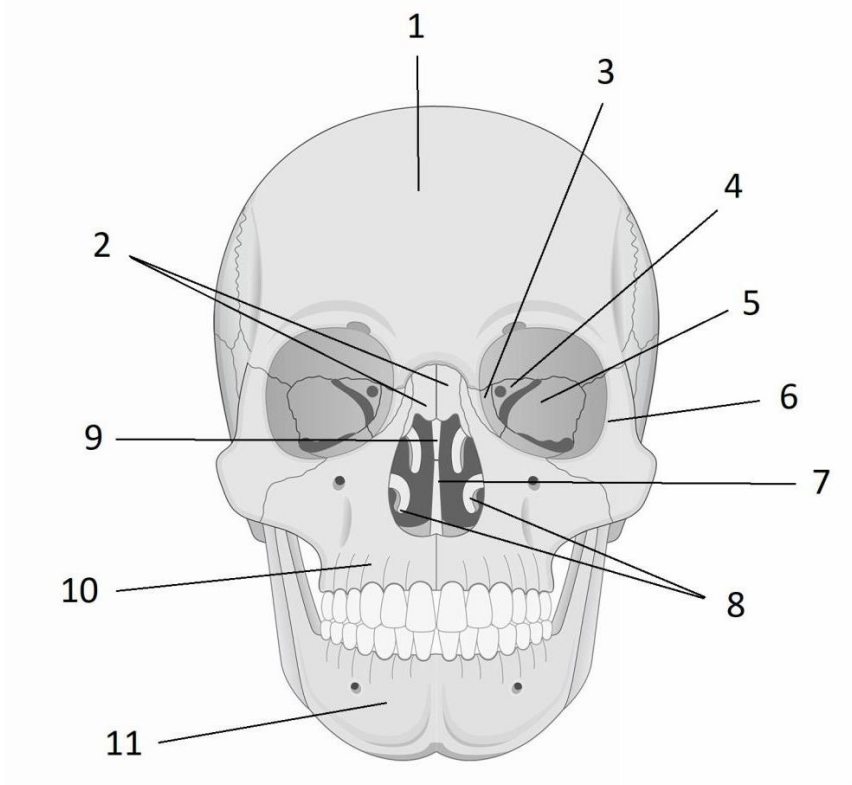


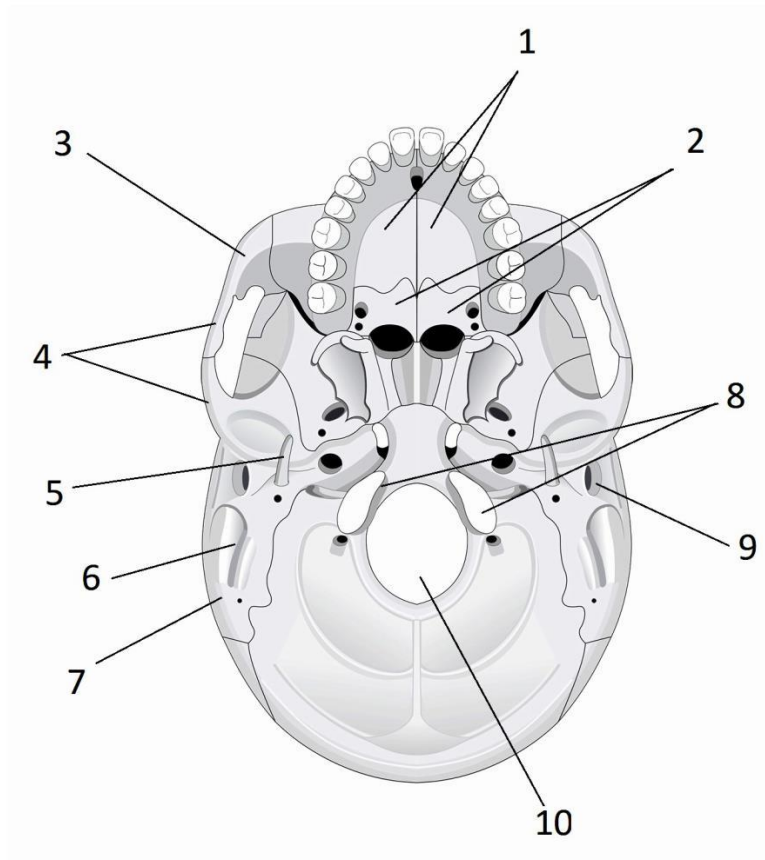
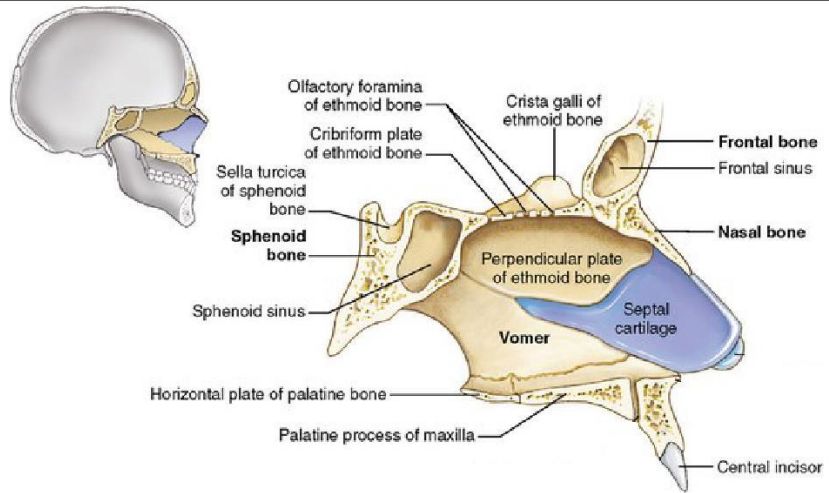
Structure and function of axial skeleton

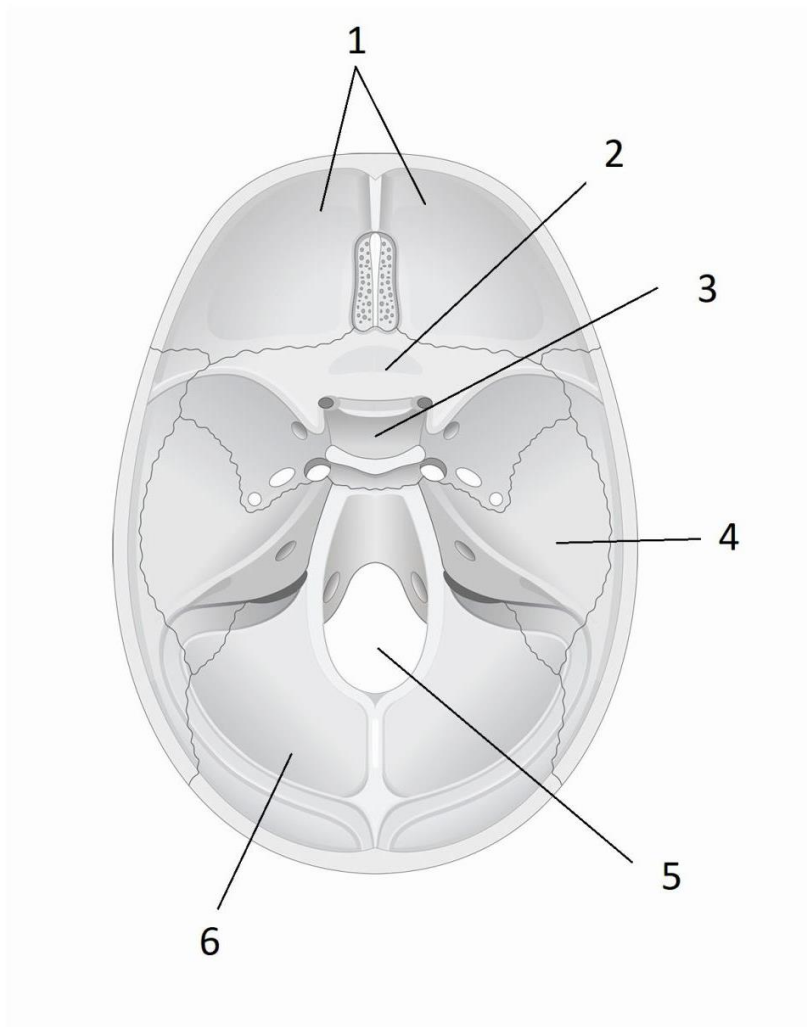
Skull

- In humans, the skull rests on the upper end of the vertebral column. The human skull consists of 22 bones which are mostly connected together by ossified joints (sutures). Skull is divided into the cranium (brain case) and the face.
- The bones in the cranium are the frontal bone, two parietal bones, the occipital bone, two temporal bones, the ethmoid bone and the sphenoid bone. In addition to the frontal bone, fourteen other bones form the skeleton of the face. They are two zygomatic bones (cheek), pair of maxillae (upper jaw bone fused with one another), two nasal bones, two lacrimal bones, the vomer, two palatine bones, two inferior conchae and the mandible (lower jaw bone).

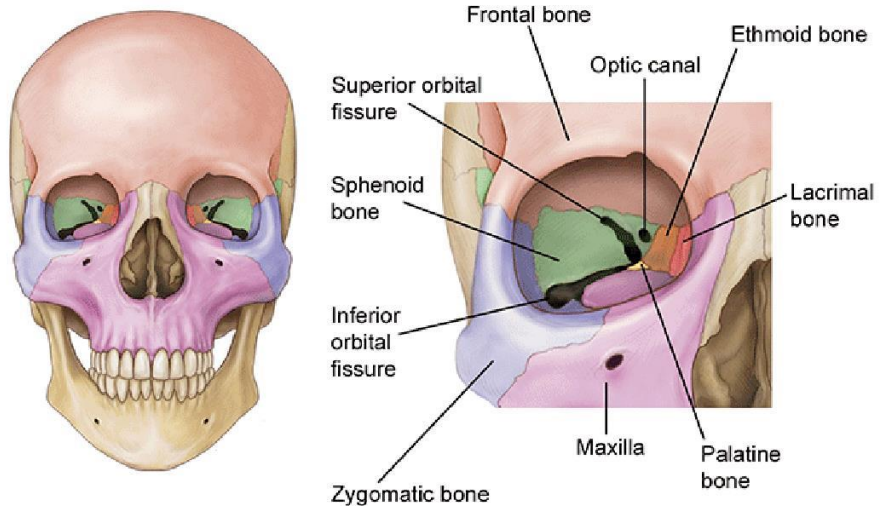




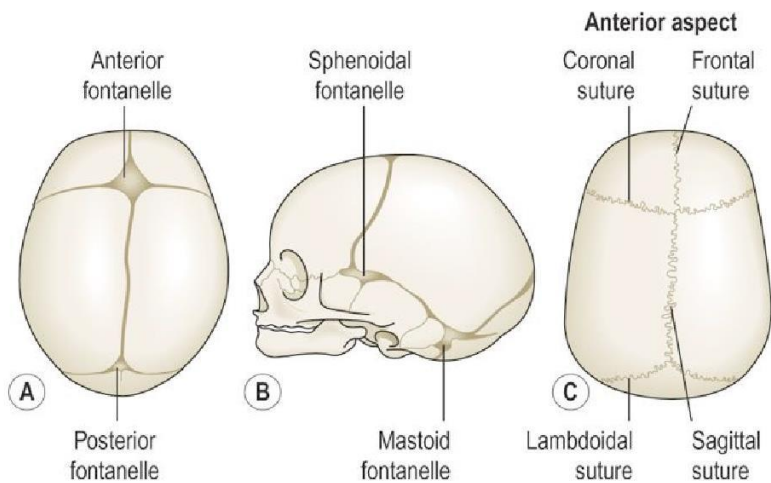


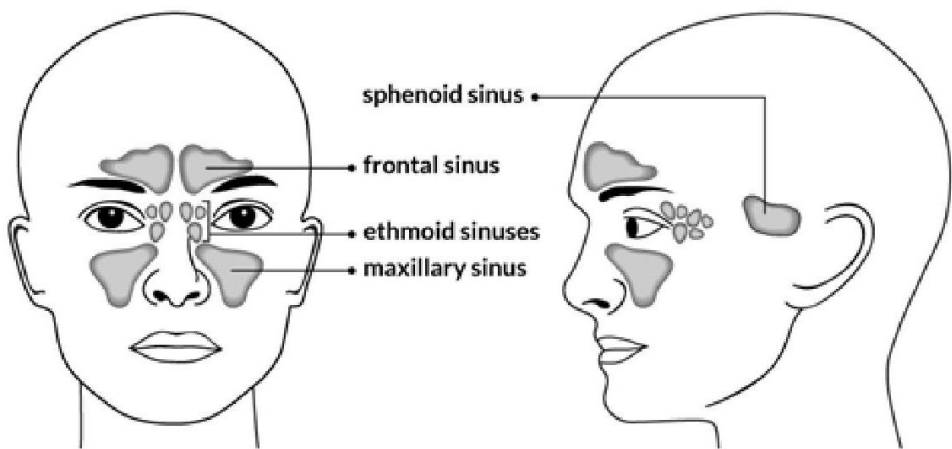
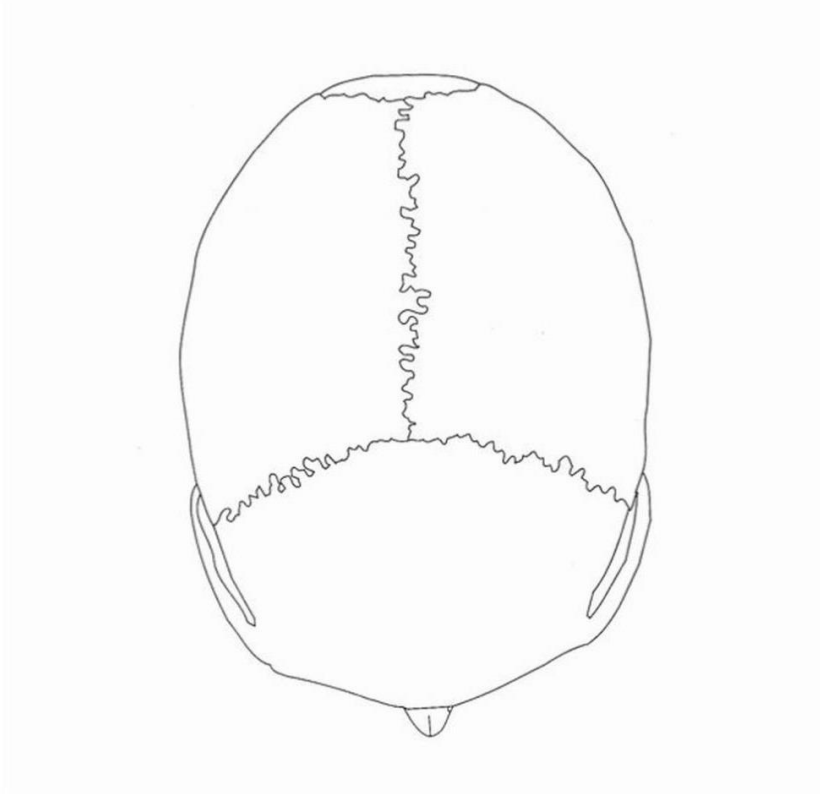


- Human cranial capacity is nearly 1.5 L. Cranium protects and encloses the brain. It also protects the inner ear, middle ear, olfactory organs and eyes.
- Bony eye sockets provide attachment to the eye muscles that move them.
- On the inferior surface of the cranium there is foramen magnum to provide passage to spinal cord.
- Two smooth rounded knobs (Occipital condyles) on either side of the foramen magnum articulates with the first vertebrae (atlas vertebrae) which permits nodding movements.

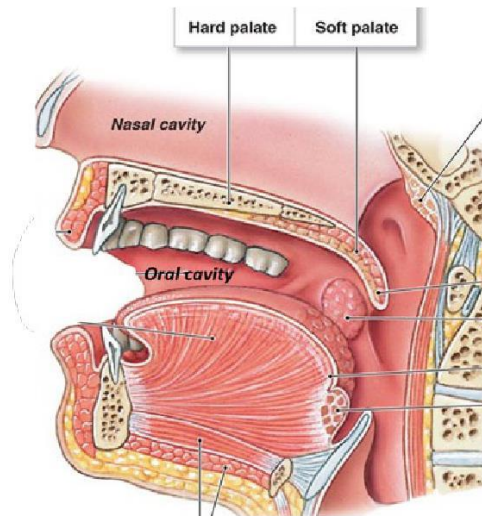


- In the cranium, soft membranous regions called fontanelles are present which allow slight compressions at birth facilitating parturition. Fontanelles become replaced by bones within 1-2 years of life.
- Immovable joints (sutures) are present between the skull bones to provide more protection.
- Several air filled cavities lined by ciliated mucous membrane are present in the skull (in the sphenoid, ethmoid, maxillary and frontal bones). They are called sinuses. They all communicate with the nasal cavity. Sinuses provide resonance to voice and reduce the weight of the skull.

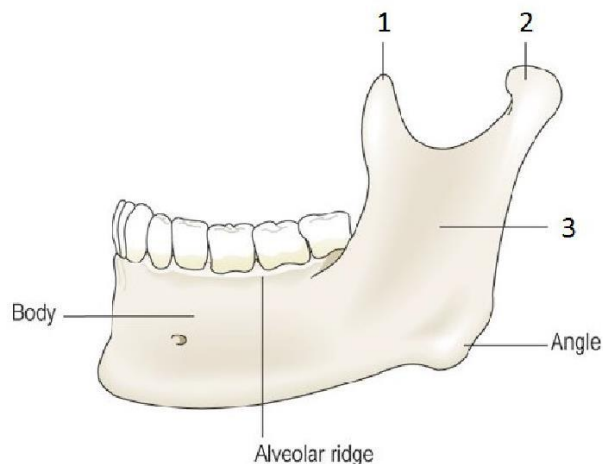




- Facial region is situated below the cranium.
- Some facial bones form the walls of the posterior part of the nasal cavity and form the upper part of the air passages.
- Maxilla and mandible provide ridges in which teeth are embedded. Upper jaw (maxilla) is fused with cranium. Lower jaw (mandible) is movable.
- Hard palate (bony) and soft palate (cartilaginous) separate the buccal cavity from nasal cavity.

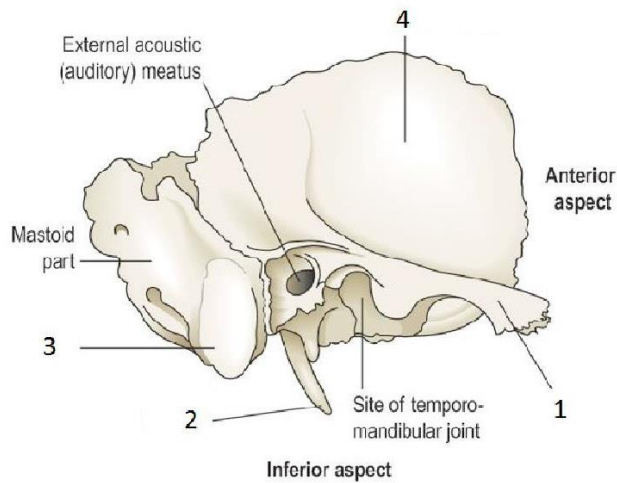


- Lower jaw articulates with the cranium. Zygomatic arch (formed from parts of zygomatic bone and temporal bone) provides the surface for muscular attachment for moving the lower jaw.
- Lower jaw (mandible) contains two processes: Condyloid process which articulates with the temporal bone to form the temporal-mandibular joint; Coronoid process which gives attachment to muscles and the ligaments.



- At the base of the skull, occipital condyles (1 pair) are present on the two occipital bones to form a hinge joint with atlas vertebrae.
- Temporal bone contains three processes: zygomatic process (which forms part of the zygomatic arch), mastoid process and styloid process. They provide surfaces for muscle attachment.





Vertebral column (Spinal Column, Spine or Backbone)

- There are 4 distinct regions:
 1. Cervical spine (formed by 7 vertebrae in the neck),
 2. Thoracic spine (formed by next 12 vertebrae),
 3. Lumbar spine (formed by next 5 vertebrae),
 4. Sacrum to which the lowest vertebrae of lumbar spine is articulated; the coccyx is situated at the end.

Curvatures of the vertebral column

- In humans, there are 4 curves in the vertebral column: cervical, thoracic, lumbar and sacral.
- They can be categorized into two main types: two primary curvatures and two secondary curvatures.
- Main function of the curvatures is the maintenance of the erect posture.

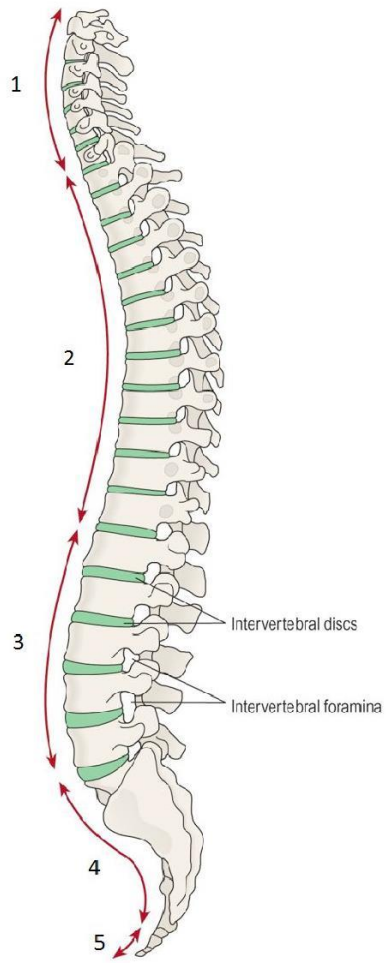
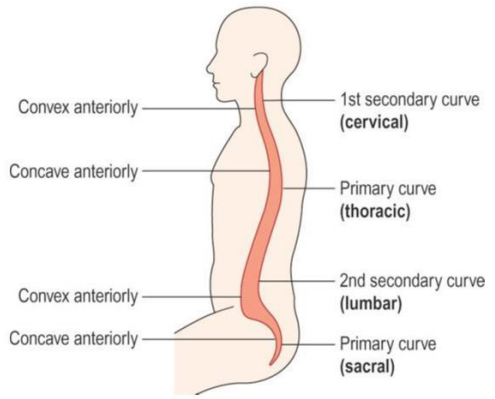
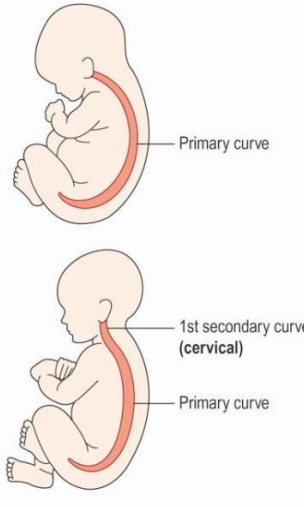
Primary curvatures:

- In the foetus, there is only one curvature in the vertebral column.
- When secondary curvatures are formed the primary curvature is retained only in thoracic and sacral regions which are known as primary curvatures. They are concave anteriorly.

Secondary curvatures:

- Formed after birth, first cervical curvature develops at about 03 months of birth.
- Then the child can hold his head upright.
- Second, lumbar curvature develops when the child is around 7-8 months.
- Then the child can hold his body upright. These secondary curvatures are convex towards the anterior.

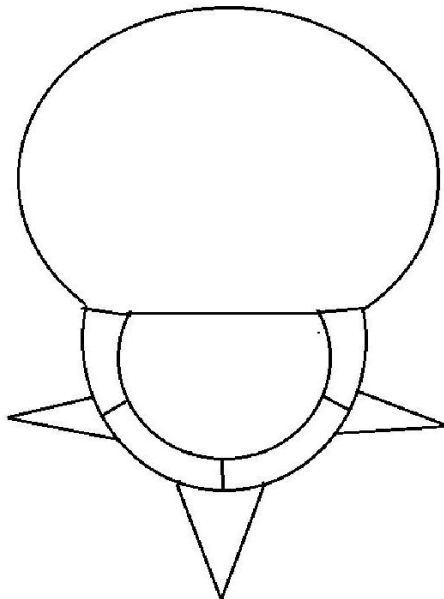




Types of vertebrae

Structure of the typical vertebra

- A lumbar vertebra can be considered a typical vertebra.
- A typical vertebra consists of the body and the vertebral arch.
- The body is the largest, broad and flattened part of the vertebrae.
- The flattened surface of the body of each vertebra articulates with the corresponding surface of the adjacent vertebra so that vertebrae are stacked together in the vertebral column.
- However the adjacent two vertebrae are not in direct contact with each other as there is a tough pad of cartilage called intervertebral disc between the two vertebrae.
- The size of the body of the vertebra increases downwards of the vertebral column to support the body weight.
- Vertebral arch encloses vertebral foramen which provides passage way for the spinal cord.
- Processes arising from the neural arch provide surfaces for muscle attachment.
- Two lateral processes are called transverse processes and the posterior process is called spinous process.
- The vertebral arch has four articular surfaces:
 1. two superior articular surfaces (articulate with the adjacent vertebrae above)
 2. two inferior articular surfaces (articulate with the adjacent vertebrae below).



Region specific vertebral characteristics

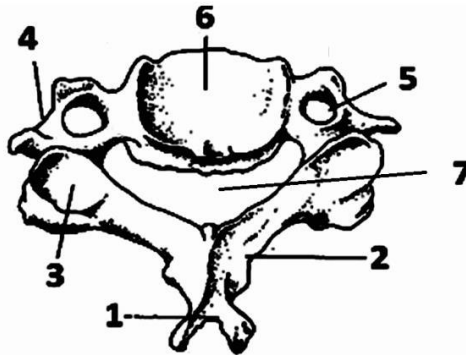
Cervical vertebrae:

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- In addition, transverse processes of cervical vertebrae have a foramen on each side to provide passage for the vertebral artery.
- The spinous process of these vertebrae is bifid.



The Atlas

- The first cervical vertebrae is the atlas which is the bone on which the skull rests.
- It is a ring shaped vertebrae with no distinct body or spinous processes.
- It has two short transverse processes.

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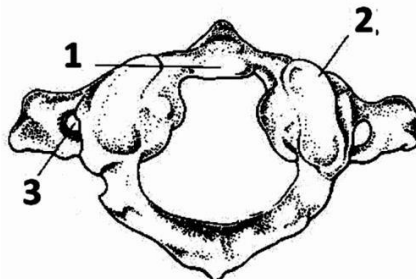
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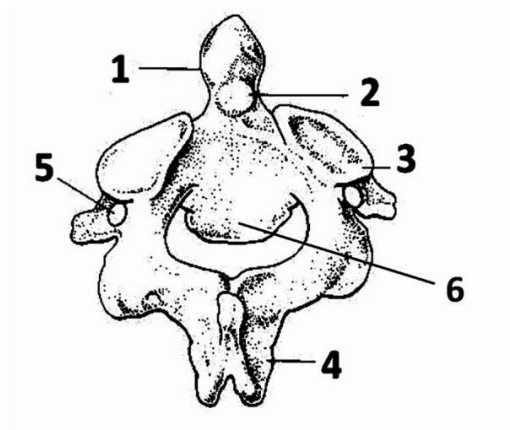
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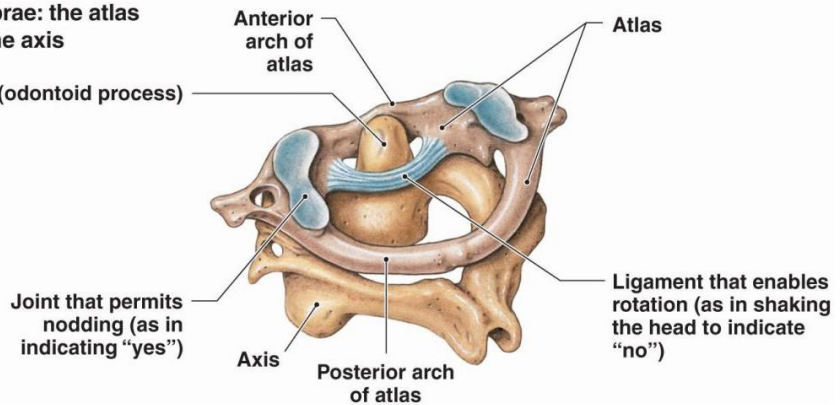
The Axis

- The second cervical vertebra is the axis.
- It has a small body with a superior projections called odontoid process which articulates with the atlas vertebrae above.
- The head pivots (turns on side to side) on this joint.



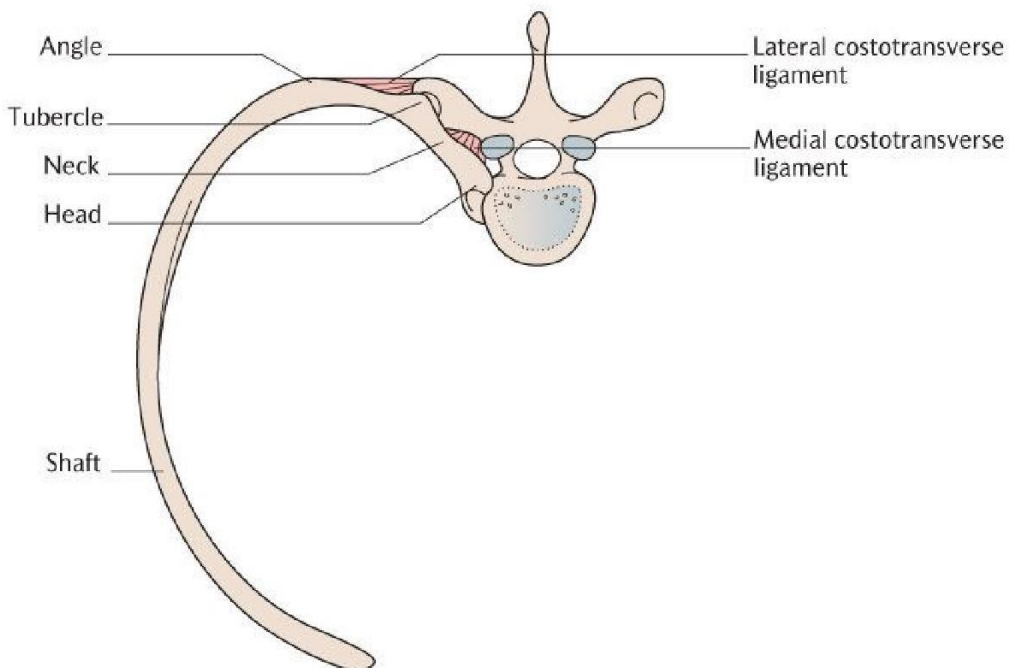
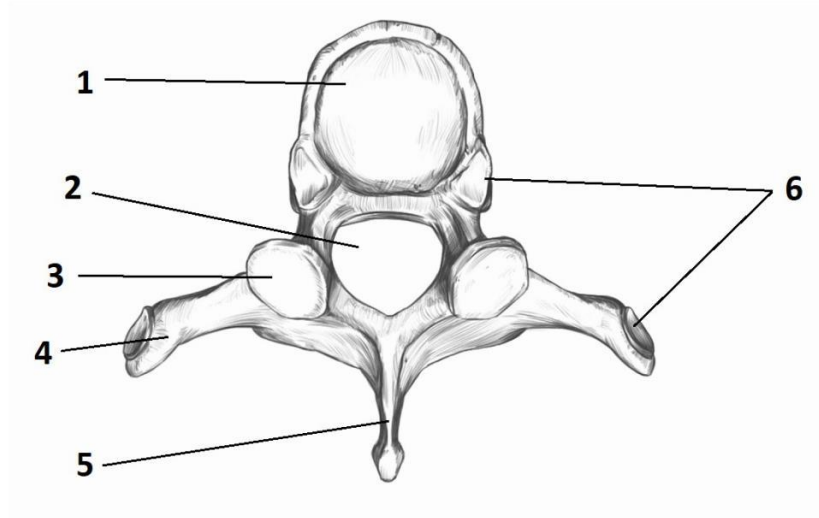
The first two cervical vertebrae: the atlas and the axis

Dens (odontoid process)

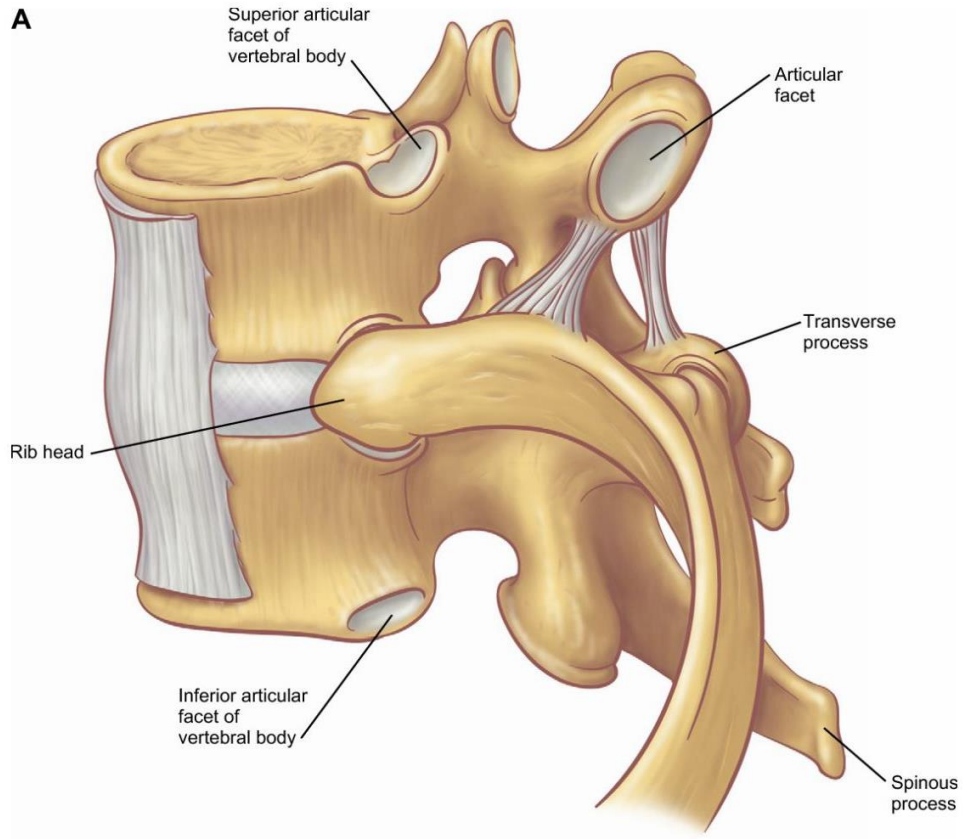


Thoracic vertebra: (Dorsal Vertebra)

- The twelve thoracic vertebrae are larger than cervical vertebrae as this region of the vertebral column has to support more body weight.
- The body and transverse processes of thoracic vertebrae have facets for articulation with the ribs.

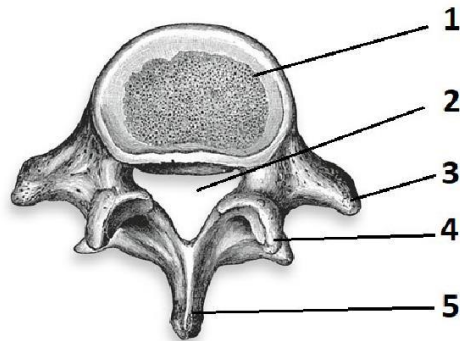


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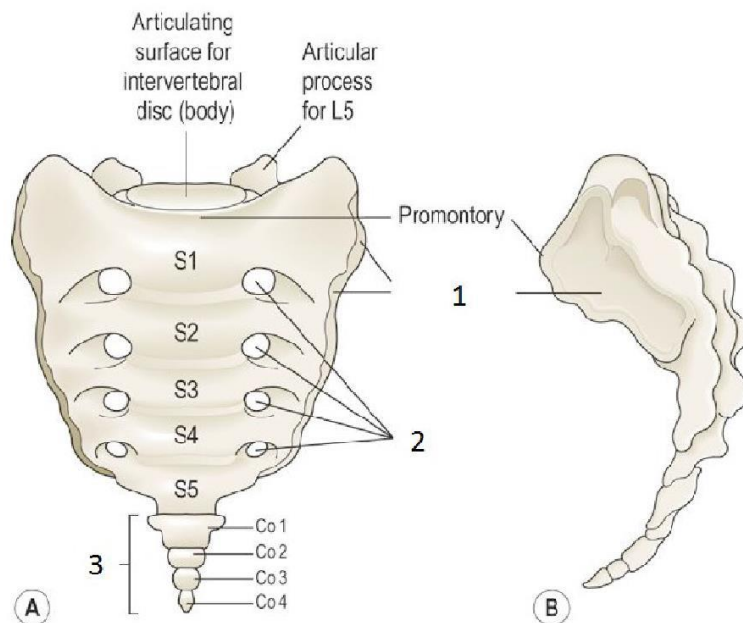
Lumbar vertebrae:

- The five lumbar vertebrae are the largest of the vertebrae because they have to support the weight of the upper body.
- The size of the body of the lumbar vertebrae is larger compared to the other vertebrae.
- For attachment of the muscles of lower back the lumbar vertebrae have a relatively large spinal processes.



Sacrum and Coccyx:

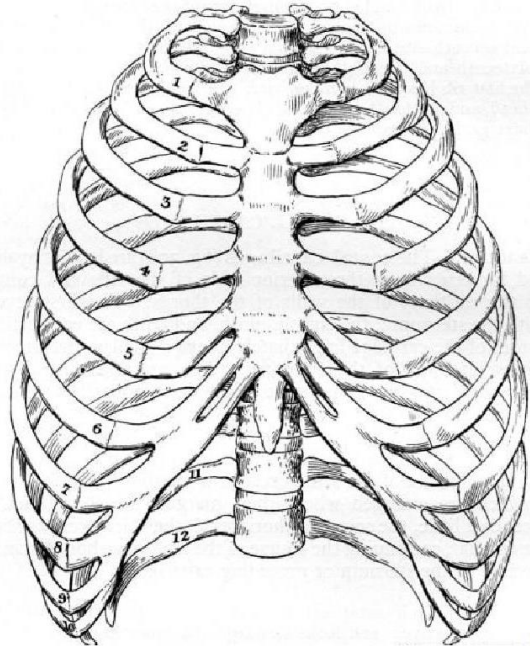
- Sacrum is a triangular shaped large bone consisting of five fused rudimentary vertebrae.
- It has a concave anterior surface.
- The upper part articulates with the fifth lumbar vertebrae.
- On each side, sacrum articulates with the pelvic girdle.
- Inferior tip of the sacrum articulates with coccyx.
- A series of vertebral foramina are present on each side for passage of nerves.
- Coccyx consists of fused four terminal vertebrae to form a small triangular bone.
- The broad base of the coccyx articulates with the tip of the sacrum.



Common functions of the human vertebral column

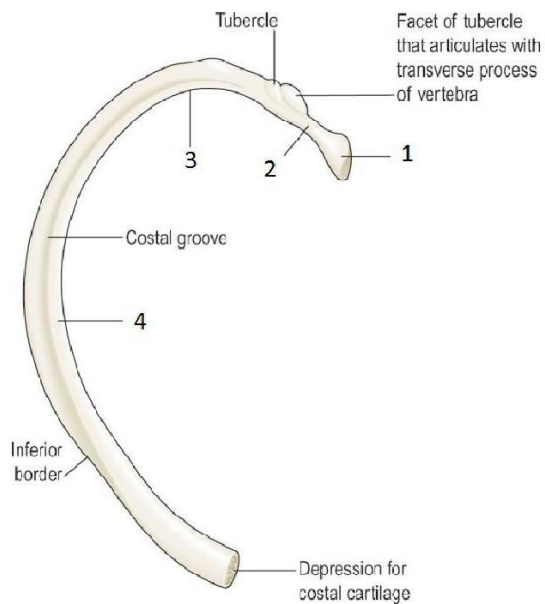
1. The vertebral column helps to maintain the erect posture.
2. It supports the skull and gives attachment to ribs and girdles.
3. It also provides the protection for the spinal cord.
4. Vertebral foramens provide spaces for spinal nerves and blood vessels and lymph vessels.
5. The vertebral column allows flexibility in the body movements.
6. The intervertebral discs act as shock absorbers and protect the spinal cord.

Bones of the Thorax



Ribs

- The twelve pairs of ribs form the lateral walls of the thoracic cage.
- They are elongated curved bones.
- They articulate posteriorly with the thoracic vertebrae of vertebral column.
- Anteriorly 7 pairs of ribs articulate with the sternum (true ribs), next 3 pairs articulate with sternum indirectly.
- In both cases costal cartilages attach the ribs to the sternum. The lowest 2 pairs do not join the sternum (floating ribs).
- Head of the rib articulates with vertebral bodies, facets of tubercle articulate with transverse process of vertebrae.
- The thoracic cage which includes the ribs and sternum plays an important role in the mechanism of breathing.
- Between each ribs intercostal muscles are present which move the rib cage during breathing.
- The first rib is firmly fixed to the sternum and to the first thoracic vertebrae. Therefore it does not move during inspiration.
- Because it is a fixed point when the intercostal muscle contract they pull the entire rib cage upwards and towards the first ribs.
- Presence of 12 pairs of ribs and sternum provide protection to the organs such as lungs and heart in the thoracic cavity.



Contribution of human axial skeleton to maintain the upright posture

- Presence of two primary curvatures and two secondary curvatures in the vertebral column.
- Development of the two secondary curvatures in the vertebral column mainly contribute to maintain the erect posture. (Refer the section on curvatures of vertebral column).
- The size of the vertebrae (especially the body of the vertebrae) become larger towards the end of the vertebral column as they have to support the weight of the upper body (Refer the section on vertebrae).
- The sacral vertebrae are fused to form a triangular shaped large sacrum to support the weight of the vertebral column and internal organs of the body.
- The two occipital condyles (and the foramen magnum) are located inferiorly at the base of the skull close to the center. In the upright position, this arrangement permits proper balancing of the skull on the vertebral column.



PRACTICAL NO. 27

Study of the gross structure of the human skull and vertebral column in relation to their functions of the various parts using models/diagrams/specimens.

Expected Learning Outcomes

1. Describes the morphology of the skull and vertebral column.
2. Relates the structure of the skull to its functions.
3. Analyzes the structure and articulation of the vertebral column in relation to weight bearing and erect posture.
4. Makes appropriate drawings and sketches to highlight prominent and distinctive features of the skull and the various parts of the vertebral column.

Materials and Equipment

- Diagrams/models/charts of the human skull and vertebral column with articulations

Instructions

- Make the students observe the following features in the skull: -
 1. Shape, smooth surface and volume
 2. Frontal view with prominent forehead, flattened face, forwardly directed orbits, well formed chin.
 3. Mandible, articulation with skull and dentition.
 4. Inferior, superior, posterior and anterior views of the skull, position of foramen magnum, occipital condyles and articulation with atlas vertebra
 5. Location of auditory apparatus
 6. Nasal region and turbinals (Nasal conchae)
- Ask students to make observations on themselves and on other students and note
 1. three dimensional range of mobility of head and how it moves in relation to the atlas and axis vertebrae
 2. Range of movement of mandible and movements during mastication of solid food material
 3. Instruct them to observe the following features of the vertebral column
 4. The curvatures of the vertebral column as seen in lateral view
 5. The increase in size of vertebrae from the superior to the inferior part of the vertebral column
 6. Vertebrae in the cervical, thoracic, lumbar and sacral regions and the coccyx and the number of vertebrae in each region
 7. The relationship of the thoracic vertebrae to the ribs and the nature of the articulation of each rib to the corresponding vertebra
 8. The inter – vertebral discs
 9. The sacral vertebrae and their relationship to the pelvic girdle
- Instruct to make appropriate drawings and sketches.



MCQ

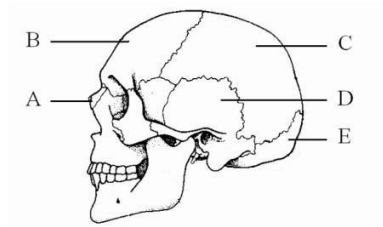
1. Which of the following statements regarding the exoskeleton of animals is correct?
(1) Mollusks are the major group of animals that possess an exoskeleton.
(2) Sea urchins are different from other echinoderms as they have an exoskeleton.
(3) Body of some reptiles is supported only by the exoskeleton.
(4) Exoskeleton of arthropods contains carbohydrates, proteins and calcium carbonate.
(5) Body of some free living nematodes are covered by an exoskeleton. (2015)
2. Which one of the following phyla does not include members having an exoskeleton?
(1) Coelenterate (2) Arthropoda (3) Mollusca (4) Echinodermata (5) Chordata (1995)
3. Which one of the following statements is correct regarding animal skeletal systems?
(1) Arthropod skeleton is mainly composed of keratin. (2) An endoskeleton is found only in vertebrates.
(3) In man occipital condyles articulate with axis vertebra. (4) Femur is the longest bone in the human body.
(5) Intervertebral discs of man are mainly composed of elastic cartilage (2007)
4. If a person falls and knocks the back of his head on the ground which one of the following bones is most likely to be damaged?
(1) Parietal (2) temporal (3) Basisphenoid (4) Occipital (5) Mastoid (1992)
5. Which one of the following is not a bone of the human cranium?
(1) Frontal (2) Parietal. (3) Sphenoid. (4) Nasal. (5) Temporal. (1993)
6. In man, the number of vertebrae that bear ribs is,
(1) 4 (2) 5 (3) 7 (4) 10 (5) 12 (1994)
7. In the human skull the coronal suture is located between the
(1) Frontal and parietal. (2) Parietal and occipital (3) Right and left parietals. (4) Temporal and parietal.
(5) Frontal and sphenoid. (1996)
8. A bone which is not involved in the formation of the human cranium is the
(1) frontal bone. (2) temporal bone. (3) ethmoid bone. (4) sphenoid bone. (5) zygomatic bone. (1998)
9. Which of the following statements is incorrect regarding adult human skull
(1) It is made up of 22 bones. (2) Its capacity is about 1550ml (3) It protects the middle ear.
(4) It articulates with the axis vertebra. (5) Its bones are joined together by sutures. (2005)
10. Which one of the following statements regarding the adult human skull is **incorrect**?
(1) It is made up of 22 bones. (2) It has a capacity of around 2 litres. (3) It protects the middle ear.
(4) Foramen magnum is located at its base (5) Mandible articulates with the cranium. (2003)
11. In man, a pair of foramen in the transverse processes can be seen in
(1) cervical vertebrae. (2) thoracic vertebrae. (3) lumbar vertebrae. (4) sacral vertebrae. (5) vertebrae of coccyx. (2006)
12. The vertebral column of man
(1) provides surfaces for articulation of clavicles and ribs, and attachment of muscles.
(2) consists of 33 vertebrae of which 26 are movable.
(3) produces red blood corpuscles throughout the life in the red bone marrow contained within it.
(4) consists of four arches of which three are primary arches.
(5) contains intervertebral discs made up of cartilage and gelatinous material to absorb shocks. (2004)
13. Which one of the following statements is correct regarding human vertebral column?
(1) It consists of 35 linearly arranged vertebrae. (2) The sacral curve appears after birth,
(3) The first cervical vertebra is the axis. (4) Lumbar vertebrae are the largest and the strongest.
(5) Sacrum is formed by the fusion of four vertebrae and three intervertebral discs. (2008)
14. Which one of the following statement regarding lumbar vertebrae of man is correct?
(1) There are seven lumbar vertebrae. (2) They have two vertebral canals.
(3) They are the largest and strongest vertebrae. (4) Each vertebra minimizes forward and backward bending of the body.
(5) They have very long neural spines. (2009)



15. In man, a well developed centrum a long neural spine and long transverse processes could be seen in
 (1) Lumbar vertebrae only (2) thoracic vertebrae only (3) lumbar and thoracic vertebrae only
 (4) 6th cervical, lumbar and thoracic vertebrae only. (5) thoracic, lumbar and sacral vertebrae only. (2011)
16. Which one of the following features contributes most to support the body?
 (1) increase the size of the body of the vertebrae in downwards of vertebral column. (2) presence of intervertebral discs
 (3) flat face with vertical frontal region (4) smooth surface of the cranium (5) forwardly directed orbits (1998)
17. In a typical vertebra of man
 (1) two processes that originate from the vertebral body project laterally forming transverse processes.
 (2) each transverse process bears an articular surface. (3) two pairs of articular processes are present in the neural arch.
 (4) each transverse process contains a foramen for the vertebral artery. (5) neural spine is bifid. (2015)

Exam Questions

A/L 1982



- Name the structures labeled as A, B, C, D.
 A B..... C.....
 D E
- Forehead is formed from

- Chin is formed from

- State the dental formula of human

- What is the type of teeth absent in milk teeth

- Give two features of the diagram present in all mammals.

- What is the position of foramen magnum on the skull

- What is the structure pass through it?

- What is the part of the skull articulate with the 1st vertebra?

- Name the part on the 1st vertebra articulate with the skull.

12. What is the capacity of the cranium of adult *Homo sapiens*.

.....

13. Describe the movements between skull and vertebrae when Head move up and down to say yes.

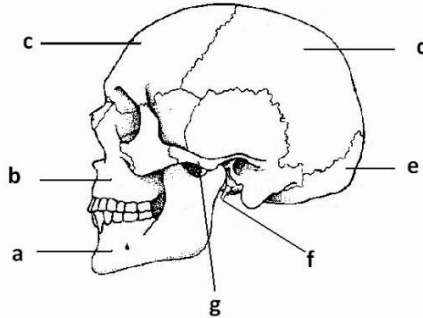
.....

Head move side wise to say no

.....

A/L 2011

B Questions of this section are based on the diagram of the human skull given below



(i) Name the bones labeled a — e.

.....
.....

(ii) What are functions of the bone labeled as e.

.....
.....

(iii) Name f and g and state their functions.

.....
.....

(iv) (a) Of the bones labeled a — e, name two bones that contains sinuses.

.....
.....

(b) What are functions of these sinuses.

.....
.....
.....

AL/ 2002

1. What is a cytoskeleton?

.....

2. State function of cytoskeleton than other than providing support.

.....
.....

3. Name supporting tissues of plants

.....

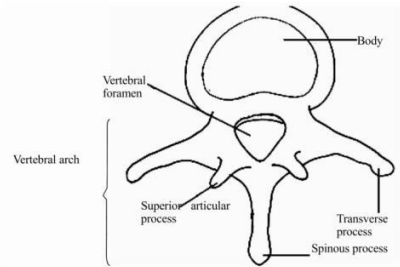
4. State the major chemical constituent which determines the rigidity of each of the supporting tissue in (3).
.....
5. State the major types of skeletons among animals.
.....
.....
6. What are the main functions of skeletal systems of animals, other than providing support?
.....
.....
7. Name major non cellular substance found in the arthropod skeleton.
.....
8. In man, state how the atlas vertebra differs from a typical cervical vertebra.
.....
9. Give reasons for the differences stated in (22)
.....
10. What are the secondary curves of the vertebral column of man?
.....
11. State the functions of each of the answers in (24).
.....
.....
12. What are the functions of intervertebral discs?
.....
.....
13. How should a heavy object be lifted by man to minimize the risk of slip-disk?
.....



Model Answer

(a)

1. A lumbar vertebra can be considered a typical vertebra.
2. A typical vertebra consists of the body and the vertebral arch.
3. The body is the largest, broad and flattened part of the vertebrae.
4. The flattened surface of the body of each vertebra articulates with the corresponding surface of the adjacent vertebra so that vertebrae are stacked together in the vertebral column.
5. Adjacent two vertebrae are not in direct contact with each other as there is a tough pad of cartilage called intervertebral disc between vertebrae.
6. The size of the body of the vertebra increases downwards of the vertebral column to support the body weight.
7. Vertebral arch encloses vertebral foramen which provides passage way for the spinal cord.
8. Processes arising from the neural arch provide surfaces for muscle attachment.
9. Two lateral processes are called transverse processes and the posterior process is called spinous process.
10. The vertebral arch has four articular surfaces: two superior articular surfaces (articulate with the adjacent vertebrae above)
11. and two inferior articular surfaces (articulate with the adjacent vertebrae below).



(b)

1. The first cervical vertebra is the atlas which is the bone on which the skull rests.
2. It is a ring shaped vertebra with no distinct body or spinous processes.
3. It has two short transverse processes.
4. The atlas contains two flattened facets which articulate with the occipital bone of the skull (condyloid joints), permitting nodding movements.
5. Vertebral foramen of this vertebra is relatively larger to provide the passage of the larger anterior part of the spinal cord .
6. The two occipital condyles (and the foramen magnum) are located inferiorly at the base of the skull close to the center.
7. In the upright position, this arrangement permits proper balancing of the skull on the vertebral column.
8. Sacrum is a triangular shaped large bone consisting of five fused rudimentary vertebrae.
9. It has a concave anterior surface.
10. The upper part articulates with the fifth lumbar vertebrae.
11. On each side, sacrum articulates with the pelvic girdle.
12. Inferior tip of the sacrum articulates with coccyx.
13. A series of vertebral foramina are present on each side for passage of nerves.
14. The sacral vertebrae are fused to form a triangular shaped large sacrum to support the weight of the vertebral column and internal organs of the body.

