5: The Axial Skeleton

Information

The bones of the human body can be divided into two broad groups, the **axial skeleton** and the **appendicular skeleton**. The axial skeleton comprises the bones found along the central axis traveling down the center of the body. The appendicular skeleton comprises the bones appended to the central axis.
Figure 5-1 The axial skeleton highlighted in blue.

The axial skeleton consists of the bones of the **skull**, the bones of the **inner ear** (known as ossicles), the **hyoid bone** in the throat, and the bones of the **vertebral column**, including the **sacrum and coccyx** bones in the center of the pelvic girdle.

**LICENSES AND ATTRIBUTIONS**

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Figure 5-1 The axial skeleton highlighted in blue. **Authored by**: Axial_skeleton_diagram.svg: LadyofHats Mariana Ruiz Villarreal. **Located at**: [https://commons.wikimedia.org/wiki/...gram_blank.svg](https://commons.wikimedia.org/wiki/...gram_blank.svg). **License**: [Public Domain: No Known Copyright](http://www.copyright.com).
The Bones of the Skull

Information

There is only one movable joint in the skull. That is the joint connecting the lower jaw, or mandible, to the rest of the skull. All the other bones in the skull are firmly attached to one another by sutures.

Sutures are rigid immovable connections holding bones tightly to one another. Some of the sutures in the skull take a few months-to-years after birth to completely form.

The brain is encased in the cranium of the skull. The bones that make up the cranium are called the cranial bones. The remainder of the bones in the skull are the facial bones.

Temporal

Figure 5.2 and Figure 5.3 show all the bones of the skull, as they appear from the outside. In Figure 5.4, some of the bones of the hard palate forming the roof of the mouth are visible because the mandible is not present. Figure 5.9 also shows the foramen magnum, the large hole at the base of the skull that allows the spinal cord to attach to the brain.
Figure 5.3. The bones of the skull, anterior view.
The sphenoid bone, from the outside, appears to contribute to only a small portion of the cranium, but when the parietal bones are removed and the interior of the cranial cavity (where the brain would be housed) is viewed, you can see the butterfly-like shape of the sphenoid bone makes a large contribution to the floor of the cranial cavity. The ethmoid bone, which from the outside is only visible in the eye sockets and as the upper conchae (internal bumps) of the nasal cavity, also contributes to the floor of the cranial cavity. The contributions of these two bones to the floor of the cranial cavity are shown in Figure 5.5.

What is commonly referred to as the “cheekbone” is really the processes of two bones connected together: the zygomatic process of the temporal bone is sutured to the temporal process of the zygomatic bone to produce the zygomatic arch.
There are three prominent bone markings on the temporal bones. The **external acoustic meatus** is the opening that leads to the organs of the inner ear. The **styloid process** is a thin, pen-like projection where muscles and ligaments of the neck are attached. The **mastoid process** is a wide and rough projection that serves as another attachment point for neck muscles.

While all the bones of the skull, other than the mandible, are sutured to one another, the flat bones of the cranium are visibly sutured where they articulate to another. There are four different cranial sutures.

The **coronal suture** is the articulation point of the frontal bone with the two parietal bones. The **sagittal suture** is the articulation point between the two parietal bones.

The **squamous sutures** are the articulation points between the each temporal bone and the parietal bone superior to it.

The **lambdoid suture** is the articulation point between the occipital bone and the two parietal bones.

Figure 5.6 The cranial sutures.

**LAB 5 EXERCISE 5-1**
1. Models of human skulls may be found in the cabinets. **On the models** identify all of the following and on the diagrams below be able to label and/or color in all the following bones, processes, and foramina:

<table>
<thead>
<tr>
<th>Bones</th>
<th>Sutures</th>
<th>Foramina</th>
<th>Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 – frontal</td>
<td>S1 – coronal</td>
<td>F1 – supraorbital</td>
<td>P1 – mastoid</td>
</tr>
<tr>
<td>B2 – parietal</td>
<td>S2 – squamous</td>
<td>F2 – infraorbital</td>
<td>P2 – styloid</td>
</tr>
<tr>
<td>B3 – occipital</td>
<td>S3 – lambdoid</td>
<td>F3 – mental</td>
<td>P3 – zygomatic</td>
</tr>
<tr>
<td>B4 – temporal</td>
<td></td>
<td></td>
<td>P4 temporal</td>
</tr>
<tr>
<td>B5 – sphenoid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B6 – ethmoid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B7 – lacrimal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B8 – nasal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bones</td>
<td>Sutures</td>
<td>Foramina</td>
<td>Processes</td>
</tr>
<tr>
<td>-----------</td>
<td>---------</td>
<td>----------</td>
<td>-----------</td>
</tr>
<tr>
<td>B9 – maxilla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B10 – zygomatic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B11 – mandible</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B12 – vomer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B13 – palatine (not visible here)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**LICENCES AND ATTRACTIONS**

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**CC LICENSED CONTENT, SPECIFIC ATTRIBUTION**

- Figure 5-2. The bones of the skull, inferior view, looking up. Mandible removed. **Authored by**: Made out of, or made from, content published in a BodyParts3D/Anatomography web site. The content of their website is published under the Creative Commons Attribution 2.1 Japan license. **Located at**: http://lifesciencedb.jp/bp3d/?lng=en. **License**: [CC BY-SA: Attribution-ShareAlike](http://lifesciencedb.jp/bp3d/?lng=en).

- Figure 5-3. The interior of the cranial cavity, viewed from above and behind, with the parietal bones removed. **Authored by**: Made out of, or made from, content published in a BodyParts3D/Anatomography web site. The content of their website is published under the Creative Commons Attribution 2.1 Japan license. The author and licensor of the contents is [http://lifesciencedb.jp/bp3d/?lng=en](http://lifesciencedb.jp/bp3d/?lng=en). **Located at**: [http://lifesciencedb.jp/bp3d/?lng=en](http://lifesciencedb.jp/bp3d/?lng=en). **License**: [CC BY-SA: Attribution-ShareAlike](http://lifesciencedb.jp/bp3d/?lng=en).

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- Figure 5-4. The cranial sutures. **Authored by**: Made out of, or made from, content published in a BodyParts3D/Anatomography web site. The content of their website is published under the Creative Commons Attribution 2.1 Japan license. The author and licensor of the contents is [http://lifesciencedb.jp/bp3d/?lng=en](http://lifesciencedb.jp/bp3d/?lng=en). **Located at**: [http://lifesciencedb.jp/bp3d/?lng=en](http://lifesciencedb.jp/bp3d/?lng=en). **License**: [Public Domain: No Known Copyright](http://lifesciencedb.jp/bp3d/?lng=en).

The Hyoid Bone

Information

The **hyoid** bone in the neck is the only bone in the body that does not articulate directly with at least one other bone. It is U-shaped and is held in place by, and helps anchor, muscles that connect to the floor of the mouth and the tongue. It helps provide greater movement of the tongue and larynx, and so is crucial to human speech.

In about 50% of strangulations, the hyoid bone is fractured.

Figure 5. 7 The hyoid bone.

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- Figure 5-7. The hyoid bone. **Authored by:** Was a bee. **Located at:** [commons.wikimedia.org/wiki/File:Hyoid_bone_-_animation.gif](https://commons.wikimedia.org/wiki/File:Hyoid_bone_-_animation.gif). **License:** [CC BY-SA: Attribution-ShareAlike](https://creativecommons.org/licenses/by-sa/4.0/)
The Vertebral Column

Information

The vertebral column is more colloquially called the backbone or the spine. It consists of

24 vertebrae bones, and two bones from the axial section of the pelvic girdle, the sacrum and the coccyx.

The vertebrae are divided into three groups. There are seven cervical vertebrae (names C1 through C7), twelve thoracic vertebrae (named T1 through T12), and five lumbar vertebrae (named L1 through L5).

You can use a meal-related mnemonic to remember them – imagine a crunchy breakfast at 7 am (7 cervical vertebrae), a tasty lunch at 12 noon (12 thoracic vertebrae), and a light dinner at 5 pm (5 lumbar vertebrae).
The first two cervical vertebrae have alternate names to C1 and C2. C1 is also called the atlas. In Greek mythology, Atlas was a titan who held the entire world on his shoulders. As the first vertebra in the column, Atlas in a sense holds up the skull. C2 is also called the axis. The axis allows both the skull and the atlas to rotate, so the head can be turned from side to side by neck muscles.

All three types of vertebrae have some structural features in common and some features that should allow you to readily distinguish vertebrae in one category from another.

All vertebrae, except C1 and C2, the atlas and axis, have a solid round portion on their anterior side called the body of the vertebra. The body is what allows the vertebrae in the vertebral column to be stacked upon one another, separated by pads of fibrocartilage called the intervertebral discs. The lower you go in the vertebral column, the larger the vertebrae’s bodies become.
The axis, or C2 vertebra, also has a bulbous vertical process not found in any of the other vertebrae. This is called the **dens** and it is what allows the axis vertebra above it to rotate.

Posterior to the vertebral body is a large opening in each vertebra called the **vertebral foramen**. This is the hole through which the spinal cord passes.

Posterior to the vertebral foramen there is a central process jutting out of each vertebra. This is the **spinous process**. It points more or less downwards when the vertebrae are correctly stacked into their column.

Surrounding the central spinous processes, there are other processes whose position and number vary depending on whether a vertebra is cervical, thoracic, or lumbar. Some of these processes allow a vertebra to articulate with the vertebrae superior and inferior to it, others, found only on thoracic vertebrae, allow a pair of ribs to articulate with the vertebra.

Figure 5.9 The three types of vertebrae. All are being viewed from behind. Note that C1 and C2 vertebrae, the atlas and axis, do not have vertebral bodies.

The **sacrum** is part of both the vertebral column and the pelvic girdle. It articulates with the intervertebral disc under the L5 vertebra above it, and with two coxal bones lateral to it.

The sacrum starts out as five vertebrae that fuse to form the one structure. This fusion is not complete until somewhere between the 18th and 30th year.

The **coccyx** is a vestigial tailbone. It is the evolutionary remnant of an ancestral species to humans that did have tails. It no longer serves as a functional tail, but some muscles, tendons, and ligaments do attach to it, making it useful. It forms from the fusion of usually three vertebrae, but a small proportion of the population have four or even five vertebrae in
their coccyx.

LAB 5 EXERCISE 5-2

1. Real or replica vertebrae bones may be found in the cabinets and on the back counters. Identify which in your group are the atlas, axis, cervical vertebrae, thoracic vertebrae, and lumbar vertebrae.

2. Stack your vertebrae in the correct order and in the correct orientation.

LICENSES AND ATTRIBUTIONS

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CC LICENSED CONTENT, SHARED PREVIOUSLY

- Figure 5-9. The three types of vertebrae. All are being viewed from behind. Note that C1 and C2 vertebrae, the atlas and axis, do not have vertebral bodies. Authored by: Anatomist90. Located at: commons.wikimedia.org/wiki/F...l_vertebra.jpg. License: CC BY-SA: Attribution-ShareAlike

Figure 5.10 The sacrum and coccyx.
The Thoracic Cage – ribs and sternum

Information

There is one last component of the axial skeleton we did not cover last lab: the thoracic cage, also called the rib cage. The thoracic cage surrounds and protects the heart and lungs in the thoracic cavity. It consists of the ribs, the sternum, and the thoracic vertebrae, to which the ribs articulate.

We examined the thoracic vertebrae last lab, so here we will only examine the ribs and sternum.

There are twelve pairs of ribs. The number is the same in both males and females. Each pair articulates with a different thoracic vertebra on the posterior side of the body. The most superior rib is designated rib 1 and it articulates with the T1 thoracic vertebrae. The rib below that is rib 2, and it connects to the T2 thoracic vertebra, and so on. Ten of the twelve ribs connect to strips of hyaline cartilage on the anterior side of the body. The cartilage strips are called costal cartilage ("costal" is the anatomical adjective that refers to the rib) and connect on their other end to the sternum.

On an individual rib, one end has various processes, facets, and bumps. This is the end that articulates with the vertebra. The other end is blunt and smooth. This is the end that connects to costal cartilage (unless it is a floating rib. See below.)

Ribs 1-7 are called the true ribs. Each true rib connects to its own strip of costal cartilage, which in turn connects to the sternum. Ribs 8-12 are called the false ribs. Ribs 8, 9, and 10 do connect to the sternum, but the costal cartilage of each of these ribs connects to the costal cartilage of the rib above it, rather than directly to the sternum. Ribs 11 and 12 do not have any costal cartilage connected to them at all, and in addition to being grouped in the false ribs, these two are also called floating ribs, to reflect that fact.

The sternum has three parts. The manubrium, at the superior end of the sternum, and wider than the rest of the bone, provides articulation points for the clavicles and for the costal cartilage extending from rib 1. The central, thin
**body** provides articulation points for costal cartilage from ribs 2 through 7. The **xiphoid process** which hangs down at the inferior end of the process ("xiphoid" is from the Greek for sword), starts out as cartilage, and does not typically ossify into bone until an individual is about 40 years old.

Figure 5.11. Ribs and sternum.

Figure 5.12. True, false, and floating ribs.
Figure 5.13. The parts of a rib.

LAB 5 EXERCISE 5-3

1. Ribs may be found in the cabinets. On an individual rib, identify which end is the head and which is the anterior end.

2. On one of the intact skeletons in the lab, identify all the following components of the thoracic cage:
   - the true ribs
   - the false ribs
   - the floating ribs
   - costal cartilage
   - sternum
   - xiphoid process
   - manubrium
   - sternal body

LICENSES AND ATTRIBUTIONS

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- Figure 5-1. Ribs and sternum. Authored by: OpenStax College. Provided by: Anatomy & Physiology, Connexions Web site. Located at: https://cnx.org/contents/FPlK1zmh@8....-Thoracic-Cage. License: CC BY-SA: Attribution-ShareAlike

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- Figure 7-2. True, false, and floating ribs. Authored by: Cristobal carrasco. Located at: https://commons.wikimedia.org/wiki/File:Costillas.png. License: CC BY-SA: Attribution-ShareAlike
- Figure 7-3. The parts of a rib. **Authored by:** Henry Vandyke Carter. **Located** at: commons.wikimedia.org/wiki/File:Image122.gif. License: **CC BY-SA: Attribution-ShareAlike**

Identify the bones

**LAB 5 EXERCISE 5-4**

image
LAB 5 EXERCISE 5-5

Label the following:

Note: for all slides, you may wish to color, outline or otherwise enhance these images to make your job of labelling easier

Sutural bones.

LAB 5 EXERCISE 5-6

Label the following:

Occipital bone * Temporal bone * Sphenoid bone * Maxilla * Mandible * External acoustic meatus * Mastoid process *
Styloid process * Lambdoid suture * Zygomatic process of the temporal bone * Temporal process of the zygomatic bone *
LAB 5 EXERCISE 5-7

Label the following:


LAB 5 EXERCISE 5-8

Label the following:

Ethmoid bone * Perpendicular plate * Crista galli * Lateral masses.

Sphenoid bone * Lesser wing * Greater wing * Sella turcica * Pterygoid plates * Hypophyseal fossa.
LAB 5 EXERCISE 5-9

Label the following:

Maxilla * Palatine bone * Pterygoid plates * Vomer * Greater palatine foramen * Incisive foramen Mandible * Condylar process * Coronoid process * Mental foramen * Body of mandible * Ramus of mandible * Mandibular notch
& Physiology La

image

image

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LAB 5 EXERCISE 5-10

Label the following:

- Cervical vertebrae
- Cervical curvature
- Thoracic vertebrae
- Thoracic curvature
- Lumbar vertebrae
- Lumbar curvature
- Atlas
- Axis
- Dens
- C1
- C2
- 7
- 12
- 5
- 1#
- 4
- 7
- 2#
- 5
- 8
- 12
LAB 5 EXERCISE 5-11
Label the following:

Cervical vertebrae * Thoracic vertebrae * Lumbar vertebrae * Transverse foramen * Superior articular process * Inferior articular process * Costal demi-facet * Vertebral foramen * Body * Spine * Arch * Transverse process * Transverse facet
Label the following:

Sacrum * Sacral foramen * Ala (of the sacrum).

Coccyx


7
4
8
13
2
5
6
9
14
In the photomicrograph below of compact bone tissue, find and label the indicated structures.

1. Obtain a slide of ground compact bone connective tissue from the slide box.
2. View the slide on an appropriate objective.
3. Fill out the blanks next to your drawing.
4. In the circle below, draw a representative sample of key features you identified, taking care to correctly and clearly draw their true shapes and directions. Draw your structures proportionately to their size in your microscope’s field of view.

<table>
<thead>
<tr>
<th>Easy difficulty</th>
<th>Medium difficulty</th>
<th>Hard difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occipital, Frontal</td>
<td>(sphenoid and ethmoid)</td>
<td></td>
</tr>
</tbody>
</table>
my pet zebra laugh)

- **Bones:**
  - Identify from external views:
    - Parietal, Ethmoid, Sphenoid, Temporal,
    - Vomer, Inferior nasal concha, Nasal, Maxilla, Mandible, Palatine, Zygomatic, Lacrimal
  - **Bones:**
    - Identify bones than can be seen from the internal view (occipital, temporal, ethmoid, sphenoid, frontal)
  - Identify disarticulated skull bones

- **Bones:**
- **Landmarks:**
  - Mastoid Process, Mandibular Fossa,
  - Sphenoid: Greater & lesser wings
  - Sutures: sagittal, coronal, squamous, lambdoid.
  - **Landmarks:**
  - Face: Alveolar processes of maxilla & mandible. lacrimal fossa
  - Understand the difference between the zygomatic bone, zygomatic arch & zygomatic process (of the temporal bone).
  - Temporal process of zygomatic bone
  - Sphenoid: sella turcica, pterygoid plates.
  - Mandible: ramus, condyle, body, coronoid process.
  - **Landmarks:**
  - Sinuses: frontal, sphenoid, maxillary.
  - Petrous & squamous part of temporal bone
  - Palatine process of maxilla
  - orbital margins
  - Sphenoid: Hypophysal fossa
  - Ethmoid: lateral masses, superior & middle nasal concha, crista galli, perpendicular plate, cribiform plates.
  - **Foramen**
  - Foramen magnum
  - External acoustic meatus
  - **Foramen:**
    - mental, optic canal, superior orbital notch/foramen, infraorbital, olfactory foramina, carotid canal, jugular, ovale, lacerum, spinosum.
- stylomastoid, internal acoustic meatus, rotundum, hypoglossal, condylar canal, incisive, greater palatine.
- **Areas:**
  - Cranium (*mnemonic: Pest of 6*)
  - Face (*mnemonic: Virgil cannot make*)
- **Areas:**
  - Cranial fossa: anterior, middle, posterior.

### TABLE 5.1: SKULL

<table>
<thead>
<tr>
<th>Easy difficulty</th>
<th>Medium difficulty</th>
<th>Hard difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>atlas/axis/cervical/thoracic or lumbar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>foramenl, Vertebral foramen,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>surface</td>
</tr>
</tbody>
</table>

- **Bones:**
  - 7 cervical, 12 thoracic, 5 lumbar vertebrae
  - Atlas & axis
  - Sacrum & coccyx
  - Sternum
  - Hyoid
- **Bones:**
  - *Identify disarticulated vertebrae as*
- **Vertebrae landmarks:**
  - Body
  - Transverse process, spinous process
  - Transverse foramen, Intervertebra
  - Superior & inferior articular processes
- **Vertebrae landmarks:**
  - Costal facets
  - Costal demifacets: inferior & superior.
  - Dens of axis
- **Vertebrae landmarks:**
  - Pedicles, Arch, Lamina, Superior & inferior notch
- **Sternum landmarks**
- manubrium, body, xiphoid process
- **Sternal landmarks**
  - Jugular notch, sternal angle.
- **Sacrum landmarks**
  - Sacral foramen, Ala, Body, Auricular
- Misc:
  - Identify true/false/floating ribs on articulated spine.
  - Know number of ribs.
  - List 1 identifying characteristic of the 3 different types of vertebrae
- Misc:
- Misc:
  - Spinal curves: cervical, thoracic, lumbar, sacral

**TABLE 5.2: SPINE / AXIAL SKELETON**