The Skeletal System

HASPI Medical Anatomy & Physiology 08a

Lab Activity

Name(s): _____

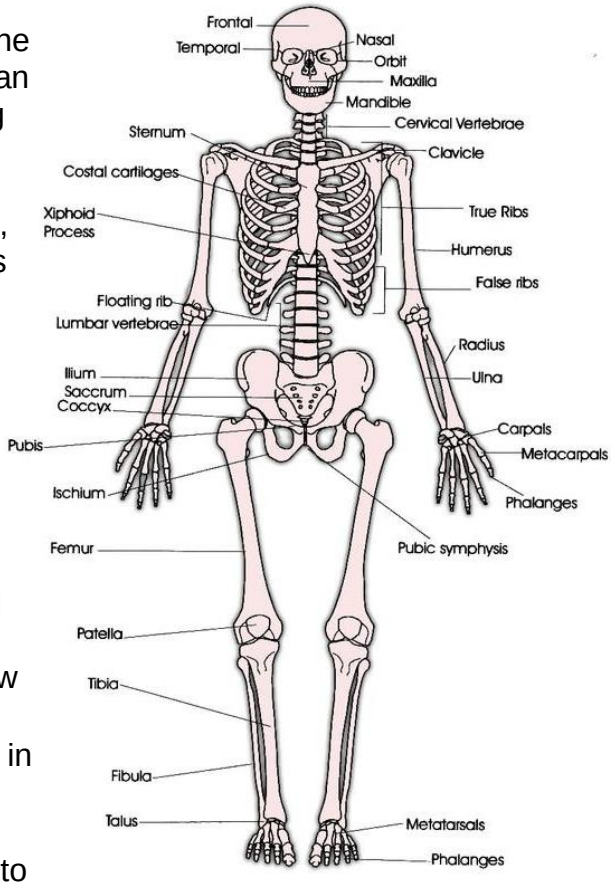
Period: _____ **Date:** _____

Background

The Skeletal System

The skeletal system is primarily responsible for supporting the body and protecting vital organs. We are born with more than 270 bones that eventually fuse together as we grow, leaving adult humans with 206 bones. Bones are made up of a complex arrangement of inorganic minerals and a variety of tissues including bone, bone marrow, nerves, blood vessels, endothelial, and cartilage. They come in a variety of shapes and sizes depending on their location and function, but all bones are lightweight, strong, and hard. Bone has a variety of functions that include:

- **Protection** of organs (skull protects brain, ribs protect the heart, etc.)
- **Support** and framework for the human body
- **Movement** by providing attachment points for muscles
- **pH balance** of the blood by absorbing or releasing bone minerals
- **Hematopoiesis** (blood production) in blood marrow
- **Fat storage** in yellow bone marrow
- **Sound transduction** through small bones located in the ear canal
- **Storage of growth factor** in bone matrix
- **Removal of heavy metals or foreign chemicals** to detoxify blood and release slowly for excretion
- **Mineral storage** of calcium and phosphorous
- **Production of hormones** such as osteocalcin



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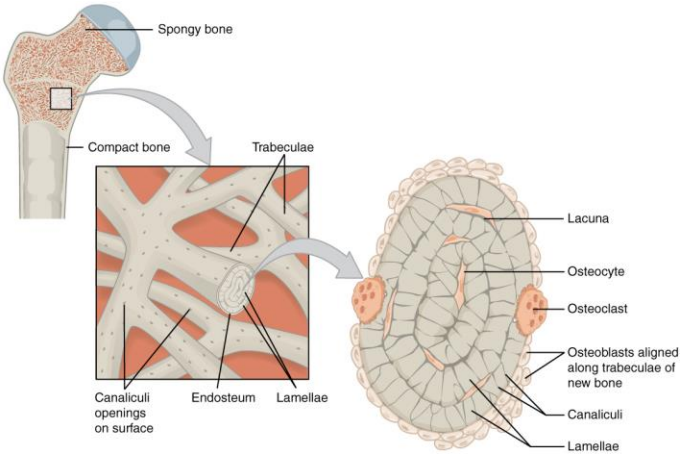


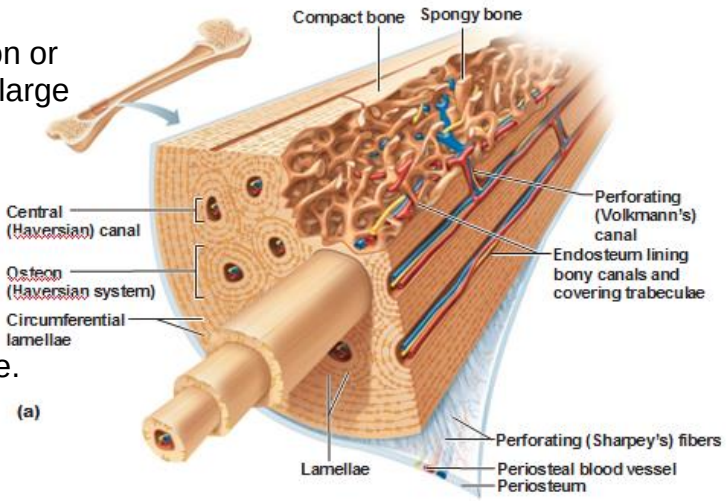
https://www.anatomylibrary99.com/wp-content/uploads/2016/08/cross-section-of-a-long-bone-63-bone-structure-anatomy-and-physiology.jpg

Bone Structure

Bone tissue is created from several minerals, most notably calcium and phosphorous, that form carbonated hydroxyapatite with the chemical formula $Ca_{10}(PO_4)_6(OH)_2$. Bone mineral is created by osteoblasts and allows bones to withstand large amounts of compressional force. The other major component of bone matrix is organic collagen, which is a protein that gives bone the ability to withstand stretching forces.

The major cells that contribute to building and breaking down bone structure are osteoblasts, osteocytes, and osteoclasts. Osteoblasts are responsible for creating bone matrix and, therefore, building bone. Once osteoblasts have become trapped in the bone matrix that they have created,

they become osteocytes. Osteocytes function to maintain the bone matrix and calcium homeostasis. They are unable to move from their assigned location or space which is called the lacunae. Osteoclasts are large cells that are capable of reabsorbing bone minerals and, therefore, remodeling bone structure. Osteoclasts also remove minerals to the bloodstream for a variety of bodily functions, such as muscle contraction.



http://antranik.org/wp-content/uploads/2011/09/microscopic-structure-of-compact-bone.png

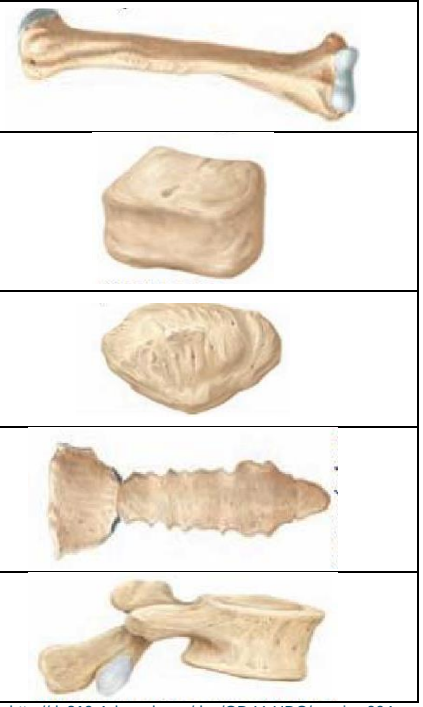
The bone matrix can be arranged into two classifications of bone; compact and trabecular bone. Compact bone, also known as dense or cortical bone, is extremely hard and compact with very little space. Bone mineral in compact bone is arranged into tight circles called osteons, with nerves and blood vessels passing through the center. Compact bone accounts for 80% of the total bone mass.

Trabecular bone, also known as spongy or cancellous bone, is porous and more like a network that allows nerves, blood vessels, and bone marrow to easily fill trabecular bone. Stress on trabecular bone causes it to create new and stronger networks, making it extremely adaptable. Although trabecular bone only accounts for 20% of the total bone mass, it has a much greater surface area than compact bone.

Bone Types

There are five main types of bone based on their shape. These include long bones, short bones, irregular bones, sesamoid bones, and flat bones. The following table provides examples of these bone types.

Bone Type	Description and Examples
Long Bones	Bones which are longer than they are wide and made up primarily of compact bone. Examples include arm bones, leg bones, and phalanges.
Short Bones	Cube-shaped with a thin layer of compact bone. Examples include wrist and ankle bones.
Sesamoid Bones	Bones embedded in tendons. Examples include the patella and pisiform.
Flat Bones	Thin and curved with parallel layers of compact bone. Examples include the sternum and bones of the skull.
Irregular Bones	Bones that do not fit in any of the other categories. Examples include the vertebra and bones of the sinus.


http://dc219.4shared.com/doc/QD-VsUDC/preview004.png

Saladin, K. 2012. The Skeletal System. Anatomy and Physiology: The Unity of Form and Function. New York, McGraw-Hill Publishing.

Materials

Station 1: Anatomy Posters (5)
Station 2: Paper, tape, string, bags, textbooks, scale
Station 3: Histology Posters (4)
Station 4: Tape measure, calculator
Station 5: Disease Posters (5)
Station 6: Tape measure, calculator

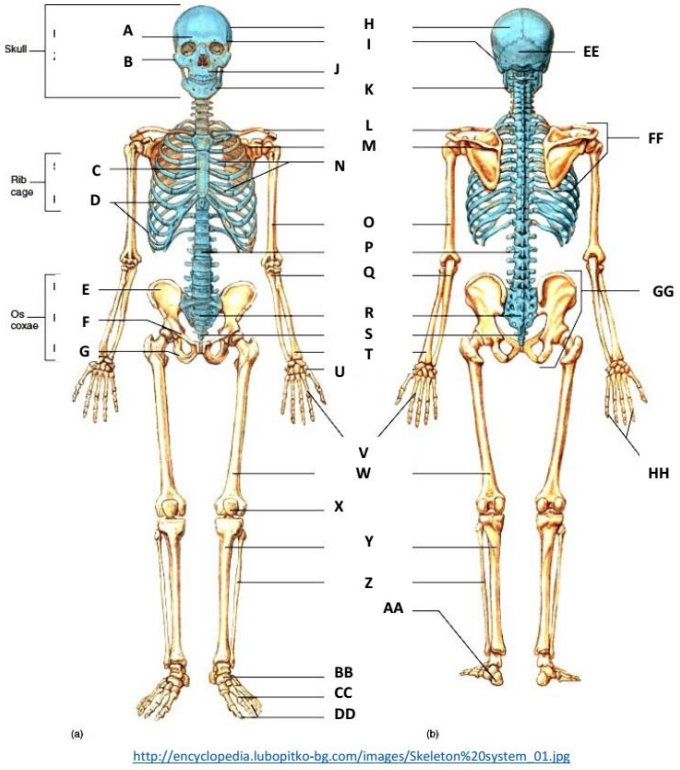
Procedure

This is a station lab activity. There are 6 stations set up around the classroom. Each station will take approximately 10-15 minutes.

Station 1: The Skeletal System

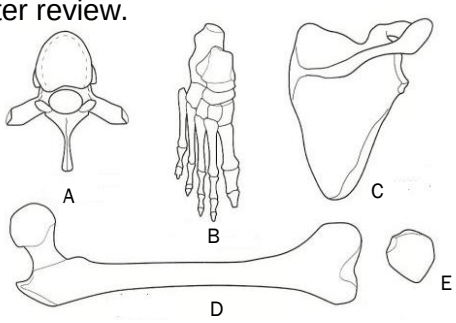
The Skeleton – Using "The Skeleton" chart, identify the bones labeled A-HH in Table 1 below. If there are any that you cannot identify, use a textbook or online resource. A smaller version of this chart is included here for later review.

Table 1: The Skeleton	
A	R
B	S
C	T
D	U
E	V
F	W
G	X
H	Y
I	Z
J	AA
K	BB
L	CC
M	DD
N	EE
O	FF
P	GG
Q	HH



http://encyclopedia.lubopitko-bg.com/images/Skeleton%20system_01.jpg

Bone Types – Using the "Bone Types" chart, identify the bone types A-E in Table 2 below. If there are any parts you cannot identify, use a textbook or online resource. A smaller version of this chart is included here for later review.

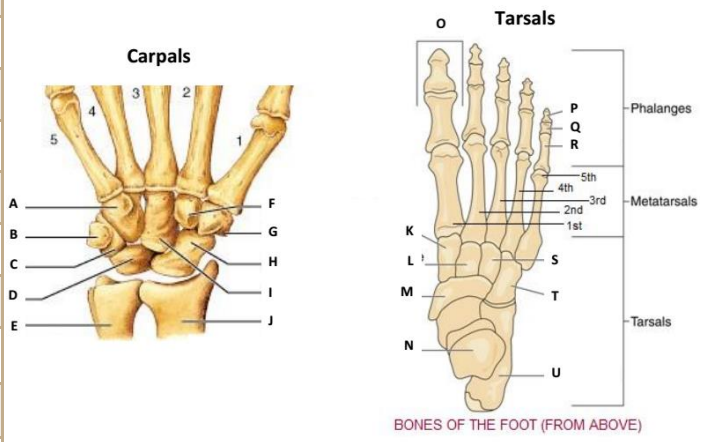


http://nrmrsgren.weebly.com/uploads/2/1/8/9/21891420/977719834.jpg

Table 2: Bone Types
A
B
C
D
E

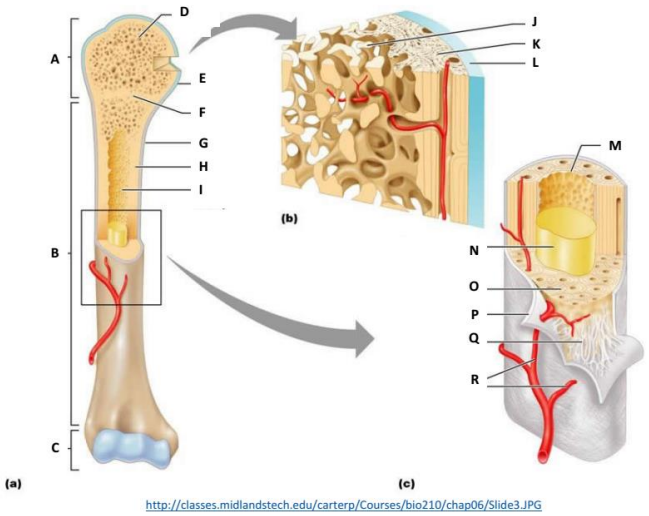
Carpals & Tarsals – Using the "Carpals & Tarsals" chart, identify the bone types A-U in Table 3 below. If there are any parts you cannot identify, use a textbook or online resource. A smaller version of this chart is included here for later review.

Table 3: Carpals & Tarsals	
A	L
B	M
C	N
D	O
E	P
F	Q
G	R
H	S
I	T
J	U
K	



http://www.joint-pain-expert.net/images/foot_bones_dorsal3.jpg
http://classconnection.s3.amazonaws.com/50/flashcards/669050/jpg/carpals1320510905151.jpg

Long Bone Structure – Using the "Long Bone Structure" chart, identify the bone types A-R in Table 4 below. If there are any parts you cannot identify, use a textbook or online resource. A smaller version of this chart is included here for later review.

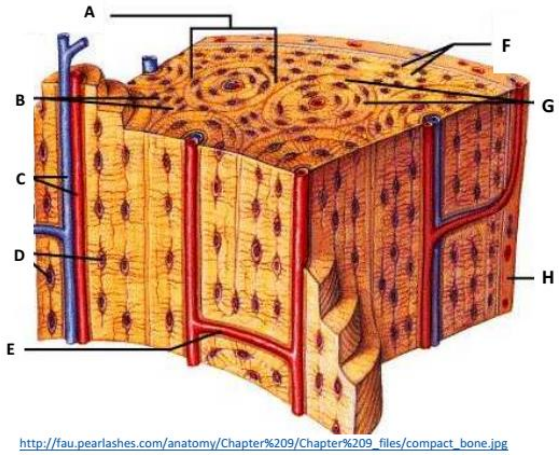


http://classes.midlandstech.edu/carterp/Courses/bio210/chap06/Slide3.JPG

Table 4: Long Bone Structure	
A	J
B	K
C	L
D	M
E	N
F	O
G	P
H	Q
I	R

Compact Bone – Using the "Compact Bone" chart, identify the bone types A-H in Table 5 below. If there are any parts you cannot identify, use a textbook or online resource. A smaller version of this chart is included here for later review.

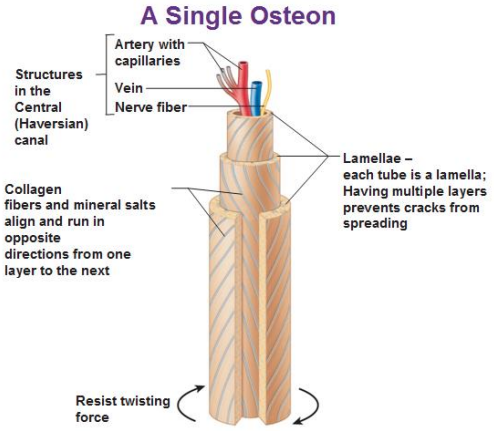
Table 5: Compact Bone	
A	E
B	F
C	G
D	H



http://fau.pearlashes.com/anatomy/Chapter%209/Chapter%209_files/compact_bone.jpg

Station 2: Long Bone Strength

The construction materials and shape of bone give it its strength and the ability to withstand great amounts of force. The presence of collagen fibers allow bone to endure stretching forces, while the harder mineral salts allow bone to endure compression forces. Bone construction is similar to that of reinforced concrete in that steel rebar allows concrete to resist stretching forces, while the cement resists compression. In addition to the construction materials, the circular shape of osteons, and therefore bone, are able to resist greater amounts of force. Unfortunately, this construction does not tend to resist twisting forces, and in fact this is the primary cause of bone fractures. In this activity, you will examine the ability of the concentric circular shape of bone to withstand direct forces.



http://antranik.org/wp-content/uploads/2011/09/a-single-osteon.png

Directions

		✓ when complete
Step 1	Obtain 20 sheets of paper, tape, and string.	
Step 2	Starting with the first sheet of paper, roll it longwise as tightly as possible. The paper roll should be 11“ long. If needed, use a small piece of tape to hold it together.	
Step 3	Roll the second sheet of paper around the first as tightly as possible. If needed, use a small piece of tape to hold it together.	
Step 4	Continue rolling the sheets of paper around the paper roll using tape as needed, until all 20 sheets have been added, to create a very thick roll of paper. This paper represents the concentric shape of a long bone and/or osteon.	
Step 5	Cut approximately a 24” section of string and tie it tightly around the center of the paper roll. Tie the other end of the string around the handles of the bag. Make sure there is enough room to fit textbooks in the bag.	
Step 6	Place the very ends of the paper roll (long bone) at the ends of two desks or two chairs so the bag hangs between the desks/chairs and does not touch the ground.	
Step 7	Place a textbook into the bag. Continue to place textbooks into the bag until the paper roll (long bone) bends and falls off the desks/chairs. If you completely fill the bag and the paper roll still has not bent, add another string and bag to the paper roll and continue filling the bag with textbooks.	
Step 8	Record the number of textbooks before the paper roll (long bone) bent in Table 6 below.	
Step 9	Use the scale to weigh one of the textbooks and record its weight in Table 6.	
Step 10	Multiply the number of textbooks it took to bend the paper roll by the textbook weight to determine how much total weight the paper roll was able to withstand before bending.	

Table 6. Long Bone Strength

Number of Textbooks	Weight of Each Textbook	Total Weight to Bend Paper Roll (Long Bone)

Station 3: Skeletal System Histology

The cell and tissue structure of skeletal organs are suited for the functions performed. Redraw and label Image B below. Image A on each chart is for reference!

Compact Bone

Using colored pens/pencils, draw the histology Image B from the "Compact Bone" chart in the space below. Using Image A as a reference, label your drawing with the canaliculi, osteocyte lacunae, and Haversian canal.

Red Bone Marrow

Using colored pens/pencils, draw the histology Image B from the "Red Bone Marrow" chart in the space below. Using Image A as a reference, label your drawing with the compact bone, megakaryocytes, developing blood cells, and vascular sinus.

Trabecular Bone

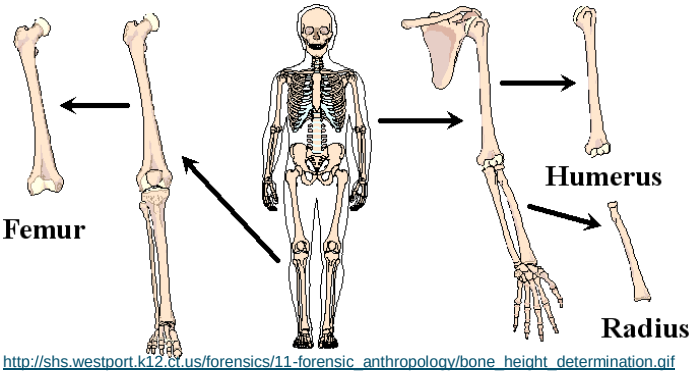
Using colored pens/pencils, draw the histology Image B from the "Trabecular Bone" chart in the space below. Using Image A as a reference, label your drawing with the yellow bone marrow and trabeculae.

Periosteum

Using colored pens/pencils, draw the histology Image B from the "Periosteum" chart in the space below. Using Image A as a reference, label your drawing with the bone and periosteum.

Station 4: Bone Length & Height

Inferring the height of an individual based on the length of long bones is common in forensic pathology. When skeletal remains are found, the sex, race, and height can be crucial clues to identify the victim. In fact, a single long bone can be used to calculate approximate height. Gender and race also contribute to these numbers to give a close approximation of height. In this activity, you will calculate your height using the length of your long bones.



http://shs.westport.k12.ct.us/forensics/11-forensic_anthropology/bone_height_determination.gif

Directions

✓ when complete

Step 1	Select a partner and a tape measure.	
Step 2	Use the tape measure to determine the length of the radius on your partner. To do this, measure from the wrist to the elbow. Have your partner also find the length of your radius. Record the measurement in inches in Table 7 on each of your lab sheets.	
Step 3	Determine the length of the humerus by measuring from the elbow to the shoulder on both you and your partner. Record the measurement in inches in Table 7.	
Step 4	Determine the length of the femur by measuring from the hip to the knee on both you and your partner. Record the measurement in inches in Table 7.	
Step 5	Using the following formulas, calculate your approximate height from your radius, humerus, and femur measurements. Record your calculations in Table 7.	

Male

(Length of Radius x 3.3) + 34 = Height
(Length of Humerus x 2.9) + 27.8 = Height
(Length of Femur x 1.9) + 32 = Height

Female

(Length of Radius x 3.3) + 32 = Height
(Length of Humerus x 2.8) + 28.1 = Height
(Length of Femur x 2.0) + 28.7 = Height

Step 6	Use the tape measure to measure you and your partner's actual heights. Record in Table 7.	
Step 7	Use the following formula to calculate the percent of error for each of your calculated height measurements from your actual heights.	

(Calculated Height ÷ Measured Height) x 100 – 100 = Percent Error

For Example: (60 ÷ 65) x 100 – 100 = 7.69% Error
This means that the calculated height was 7.69% off of the actual height

Table 7. Bone Length & Height

	Bone Length (inches)	Calculated Height (inches)	Measured Height (inches)	Percent Error (%)
Radius				
Humerus				
Femur				

Station 5: Skeletal Disease

Using the skeletal disease charts complete the following table. List ONLY THREE Causes or Risk Factors, Symptoms, and Treatment Options for each disease.

Osteoarthritis			
Description	Causes or Risk Factors (3)	Symptoms (3)	Treatment Options (3)
Approximately how many MORE people are expected to be diagnosed with osteoarthritis in 2030 than 2005? Hypothesize why.			

Osteogenesis Imperfecta			
Description	Causes or Risk Factors (3)	Symptoms (3)	Treatment Options (3)
From Table 3-4, which type of OI is the worst? Is it dominant or recessive?			

Osteosarcoma			
Description	Causes or Risk Factors (3)	Symptoms (3)	Treatment Options (3)
According to the graph, what is the most common age for males to be diagnosed with osteosarcoma? Females?			

Osteomyelitis			
Description	Causes or Risk Factors (3)	Symptoms (3)	Treatment Options (3)
What is the most common bone site of osteomyelitis?			

Paget's Disease			
Description	Causes or Risk Factors (3)	Symptoms (3)	Treatment Options (3)
What is the most common age for males to be diagnosed with Paget's disease? Females?			

Station 6: Skeletal Proportions

Humans have used the proportions of skeleton throughout history to predict adult height or even to determine the size of the "ideal man." The scientific accuracy of these proportions is questionable. In this activity you will look at three common skeletal proportions and determine whether they have any accuracy in determining your actual height.

Directions

✓when complete

Wing Span	The wingspan measurement from fingertip to fingertip is the same as the measurement of an individual's height.	
Step 1	Get a partner and a tape measure.	
Step 2	Use the tape measure to determine the heights of you and your partner. Record your height in inches in Table 8.	
Step 3	Spread your arms to the side and measure the wingspans from fingertip to fingertip of you and your partner. Record your wingspan in Table 8.	
Step 4	Use the following formula to calculate the percent of error of your wingspan measurement from your measured height. Record in Table 8.	

(Wingspan ÷ Measured Height) x 100 – 100 = Percent Error

Skull Circumference	The height of an individual should be 3x the circumference of an average-sized head.	
Step 1	Get a partner and a tape measure.	
Step 2	Use the tape measure to measure the circumference around the foreheads of you and your partner. Record your skull circumference in Table 8.	
Step 3	Multiply the skull circumference by 3 and record for calculated height in Table 8.	
Step 4	Use the following formula to calculate the percent of error of your calculated height from your measured height. Record in Table 8.	

(Calculated Height ÷ Measured Height) x 100 – 100 = Percent Error

Perfect Man	…or woman! The Greeks decided that the ideal man's body would be seven heads tall. Only the "perfect man" proportions were used in their artwork.	
Step 1	Get a partner and a tape measure.	
Step 2	Use the tape measure to measure the height of the head from chin to top of the head, of you and your partner. Record your head height in Table 8.	
Step 3	Multiply the head height by seven and record for calculated height in Table 8.	
Step 4	Use the following formula to calculate the percent of error of your calculated height from your measured height. Record in Table 8.	

(Calculated Height ÷ Measured Height) x 100 – 100 = Percent Error

Table 8. Skeleton Proportions

Measured Height	Wingspan		Percent of Error
	Skull Circumference	Calculated Height (x3)	Percent Error
	Head Height	Calculated Height (x7)	Percent Error

Analysis Questions - *on a separate sheet of paper complete the following*

Station 1

1. What are the five types of bone? Give an example of each.
2. What type of bone is the humerus? The vertebrae? The carpals?
3. How many carpal bones are there?
4. How many tarsal bones are there?
5. What are the three parts of a long bone?
6. Where is bone marrow located?

Station 2

7. Explain how the structure of bone is similar to reinforced concrete?
8. What types of force do collagen and bone mineral resist?
9. How much weight was your paper roll (long bone) able to hold? Hypothesize how much more weight it would be able to hold if you taped 5 of the paper rolls together.

Station 3

10. What passes through the Haversian canal?
11. What is created in red bone marrow?
12. What is found throughout trabecular bone?
13. What is the function of the periosteum?

Station 4

14. Explain why calculating height from bone length is useful to a forensic pathologist.
15. Compare the heights you calculated and measured. How accurate were the calculations?
16. Which bone most accurately calculated height? Hypothesize why.

Station 5

17. What were the common causes & risk factors found among the majority of the skeletal disorders?
18. What were the common symptoms found among the majority of the skeletal disorders?

Station 6

19. How close was your wingspan measurement to your actual height?
20. How close was your height calculated from your skull circumference to your height?
21. How close was your height calculated from your head height to your height?
22. Explain how you could set up an experiment to determine whether the wingspan measurement is scientifically accurate.
23. **CONCLUSION**: In 1-2 paragraphs, summarize the procedure and results of this lab.

Review Questions - *on a separate sheet of paper complete the following*

1. How many bones are you born with?
2. How many bones are in an adult skeleton?
3. What types of tissues are found in bone?
4. What are the functions of the skeletal system?
5. What are the components of bone matrix?
6. What are the functions of osteoblasts, osteocytes, and osteoclasts?
7. What is the difference between compact and trabecular bone?
8. What are the five main bone types?