Sometimes only a few bones are found in a location in an archeological dig. A few bones can tell about the height of a person. This is possible due to the ratios of the bones. It has been determined that there are relationships between the femur, tibia, humerus, and radius and a person's height.

Here is a little help to identify these four bones and formulas to assist with determining the height of a person based on bone length.

**Femur:**
The thigh is the region of the femur. From the hip bone to the knee bone.

**Humerus:**
The arm bone most people call the upper arm. It is found from the elbow to the shoulder joints.

**Tibia:**
The larger and stronger of the two bones in the leg below the knee bone. In vertebrates it is recognized as the strongest weight bearing bone in the body.

**Radius:**
The bone found in the forearm that extends from the side of the elbow to the wrist.


Activity: Bone Relationships

**Materials Needed**

- Skeleton
- Tape Measure
- Directions and formulas
- Calculator

**Students should be able to:**

- Identify and measure the length of a major bone
- Determine the height of person using a formula and the bone length
- Convert centimeters to feet

**Formulas:**

Bone relationship is represented by the following formulas:

P represents the person's height. The last letter of each formula stands for the known length of the bone (femur, tibia, humerus, or radius) through measurement.

- **Femur:**
  \[ P = 61.412 + 2.31F \]

- **Tibia:**
  \[ P = 72.572 + 2.533T \]

- **Humerus:**
  \[ P = 64.977 + 3.144H \]

- **Radius:**
  \[ P = 73.502 + 3.876R \]

**Helpful Conversions:**

- Centimeters (cm) x 0.3937 = inches (in)
- Meters (m) x 3.281 = feet (ft)

**Try this:**

The tibia of a 22-year-old female measured 31.5 cm. How tall was she?

\[ P = 72.572 + 2.533(31.5\text{cm}) \]

\[ 152.36\text{cm} \times .3937 = 59.98\text{ in} \]

\[ 59.98\text{in} / 12\text{in} = 4.99\text{ ft} \]
Activity: Bone Relationships

Name: _______________________________   Date: ________________

Name of bone measured: _______________________

Calculations for the height of the body:

The class will share the following information with each other.

Femur length in cm:   ________________
Tibia length in cm:    ________________
Humerus length in cm: ________________
Radius length in cm:   ________________

Height of skeleton based on class calculations:

Height of skeleton using the femur:   ________________
Height of skeleton using the tibia:    ________________
Height of skeleton using the humerus: ________________
Height of skeleton using the radius:   ________________
Measure the skeleton's height in cm:  ________________
Which bone appears most accurate?     ________________

How close were your estimates based on calculations? ________________________________

What are possible sources of error in this process? How could you get better results?
________________________________________________________________________
________________________________________________________________________

Do we need bones or can we use measurements from living people?
________________________________________________________________________
________________________________________________________________________

Does this work for children/youth/young adults or just fully grown people?
________________________________________________________________________
________________________________________________________________________

How could you test the above two ideas?
________________________________________________________________________
________________________________________________________________________
Activity: Bone Relationships

Name: _______________________________   Date: ________________

Extending the Problem:
Can you use the same measuring method to determine the height of individuals not fully grown?

Prediction (Hypothesis):

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Procedure: Include variable and controls.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Testing Data: Organize your measurements into a chart or form to share.

Calculations:
Activity: Bone Relationships
Name: _______________________________   Date: ________________

Conclusions:
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Questions:
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Sources of Error: How can you improve on the data collection process?
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Accept or Reject Hypothesis: Provide reasons why.
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Data for the MOST Skeleton:

The samples are completed below for the skeleton at the museum.

Femur: 40cm
61.412 + 2.317(40) = 154cm or 154 x .3937/12 = 5.05 ft

Tibia: 34cm
72.572 + 2.533(34) = 158cm or 158 x .3937/12 = 5.18 ft

Radius: 24.5 cm
73.502 + 3.876(24.5) = 168.5 cm or 168.5 x .3937/12 = 5.53 ft

Humerus: 27cm
64.977 + 3.144(27) = 149.9 cm or 149.9 x .3937/12 = 4.92

Total height of the skeleton by measuring is 165 cm.
165cm x .3937 = 64.96 in /12 = 5.41 ft

Percent error for the above data:

Femur: |165-154|/165 x 100 = 6.7%

Tibia: |165—158|/165 x 100 = 4.24%

Radius: |168.5-165|/165 x 100 = 2.12%

Humerus: |165-149.9|/165 x 100 = 9.2%

Source Material
Marilyn Fenichel, educational writer; Wendy Goldfein, sixth-grade teacher, Fairfax County School District, Virginia
http://school.discovery.com/lessonplans/programs/forensics/

Patricia Roberto’s “Forensic Science in the Middle School Math Classroom.” Roberto is a math teacher at Rogers Middle School (Pittsburgh Public Schools).