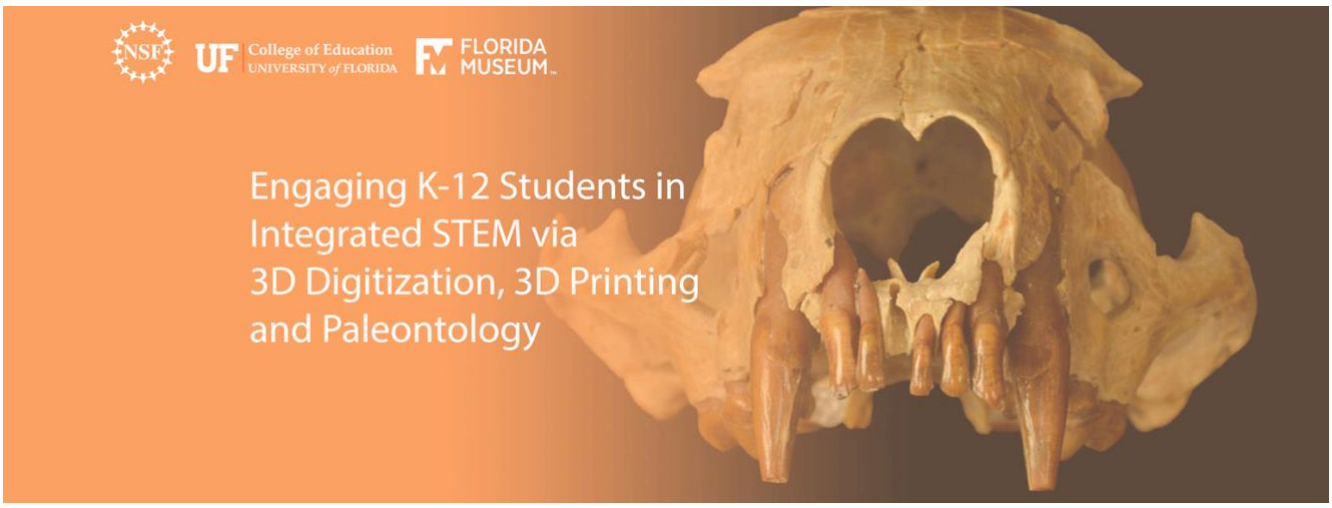

AUTHOR (S)

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Acknowledgements: Parts of this lab activity have been adapted from the Collin College Lab on "Primate-Human Skull Differences" by Sukanya Subramanian, available at http://iws.collin.edu/ssubramanian/1409/Primate-HumanEvolution2.pdf

LESSON TITLE

Apes Through the Ages: Comparing Hominid Relatives through 3D-Printed Skull Models

GRADE LEVEL

9th-10th Grade Introductory Biology

TIME FRAME

One-Two 50-minute class periods

DRIVING QUESTION

How has skull morphology and size in hominids changed over time, and how do these changes relate to human evolution?

LEARNING GOALS

By the end of this lesson, students will be able to…

- …compare and contrast key aspects of hominid and Hominin skull morphology.
- …measure using digital calipers.
- …describe how various skull features contribute to ecological niche.
- …analyze a phylogeny of human evolutionary ancestors.

ANCHORING EVENT

The anchoring event for this lesson can be varied given the amount of time available. Ideally, this lesson would be anchored by showing the History Channel documentary, *From Ape to Man.* This documentary details not only the history of human evolution, but also the history of the major discoveries in human evolutionary theory. With engaging reenactments and expert descriptions, this documentary does an excellent job of introducing the history of human evolution and visualizing the changes in the hominid evolutionary tree over time.

With less time, anchor this lesson with the following YouTube video: "Human Evolution: Crash Course Big History #6" https://www.youtube.com/watch?v=UPggkvB9_dc

COLLABORATIONS

During this activity, students will work in groups of 2-4 to collect data, analyze that data, and draw conclusions about human evolution. It is important to monitor students for equal participation in partnered activities such as these, so all students should complete their own record sheets.

Student grouping for this activity should be based on what is best for the specific class. Higher level or more mature students may be allowed to choose their own lab partners while other groups may need to be pre-grouped into teams of 2-4. Group size should be as small as possible to divide students amongst the 5 skulls. Ideally, 2 of each skull should be printed in order to minimize the number of students working on a given skull at any time.

STEM INTEGRATION

Science: Students will mirror real-life science process skills through the completion of this activity. Students will measure key skull features using rules and digital calipers and will then compare data to interpret how different skull morphology may affect ecological niche or provide evolutionary advantages to some species over others.

Math: Students will measure, calculate means, and mathematically compare the skulls they are investigating. These math skills are essential to scientists in all fields, but especially in comparing physical artifacts or fossils in fields such as paleontology or paleoanthropology.

Engineering: Though this activity does not specifically focus on engineering skills, the ability to collect, assess, and analyze data is important in engineering-based problem solving as well as in natural science contexts.

Technology: Technological applications of this lab include the use of digital calipers but could be expanded to include computer measuring of models using programs such as Morphosource or Meshmixer. Teachers with access to computers but no 3D printers can have students download this activity and accompanying files to complete it digitally.

ASSESSMENT

Students can complete the attached worksheets while working in the lab on their skull observations and measurements. Lab handouts may be graded for completion or correctness as appropriate.

Additional assessment options:

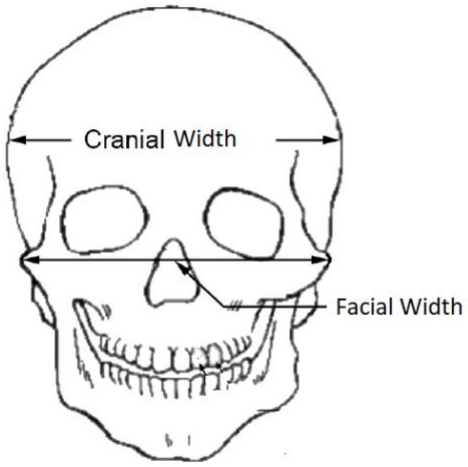
- Have students build a phylogenetic tree of the hominids analyzed in this activity using their collected data
- Have students graph cranial indices of all species
- Measurements on the skulls can be expanded to include additional data and indices: measure vertebral attachment length to calculate vertebral attachment index, measure incisor and canine tooth lengths, measure facial projection length to calculate facial projection index, etc.
- Higher order thinking questions to be used as discussion or as additional in class or homework analysis questions:
    - What problems might arise from using a single fossil as a representation of an entire species?
    - Why might paleontologists prefer indices over individual fossil measurements?
    - Why is it wrong to say that humans "evolved from monkeys"?
    - Other than skull morphology, what other characteristics do humans and the great apes have in common?
    - Other than changes in brain size, what else can we learn about hominid evolution from fossil hominid skulls?
    - Scientists studying human evolution have long sought "missing links" in our evolutionary lineage. Is looking for a "missing link" a productive way to do human evolution research? Why or why not?

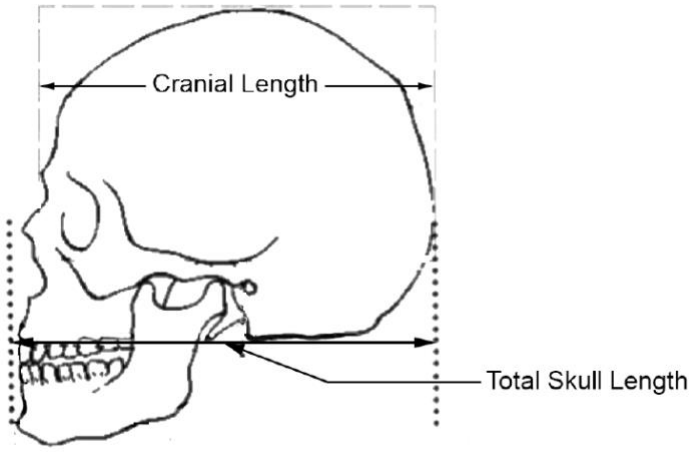
PROCEDURE

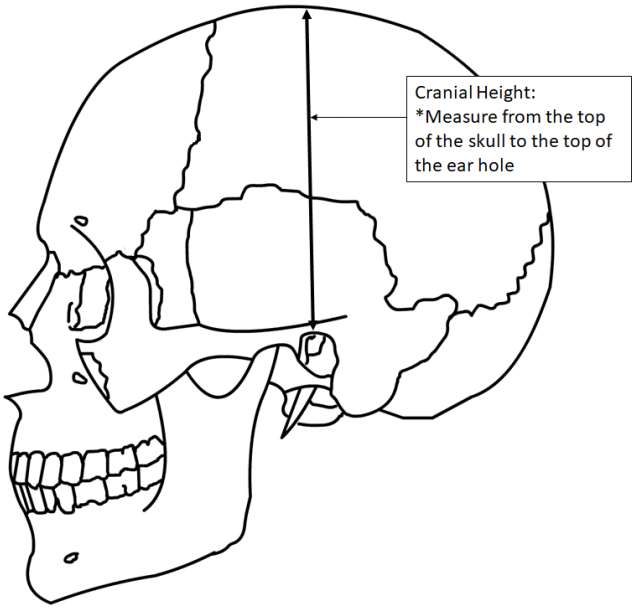
In this lesson, students will take various measurements of 5 different hominid species skulls. This lesson is best sequenced in the middle of a lesson on evolution, or at the end in order to review key concepts.

Introduction (10 minutes): Tell students that they have been hired by the American Museum of Natural History as researchers for the Human Evolution Research Unit. Their job is to take measurements of five different hominid skulls in order to compare them. Instruct students on how they will be measuring their skulls. Ideally, each pair or trio of students should receive a set of digital calipers, but rulers may also be used to measure. Clarify any questions regarding skull measurements and demonstrate how measurements shall be taken. Use the chart below to demonstrate where skull measurements shall be taken:

Skull Measurements (40-60+ minutes): Students should move from one station to the next recording measurements on the provided worksheet. Time should be varied based on how much additional time or help individual students may need. For example, while 8 minutes per station would likely be adequate for an honors course, standard or remedial level students may need as much as 12-15 minutes per station.







At each station, students will use their worksheet and handouts to measure the following:

- Cranial Width: The widest part of the top of the skull
- Facial Width: The distance across the face as measured from cheekbone to cheekbone
- Cranial Length: The length of the top of the skull from front to back midline
- Total Skull Length: The distance from the front of the upper jaw to the back of the skull
- Length of upper right canine tooth: If you are looking at the front of the skull, this tooth is on the upper jaw and to the right of the incisors
- Cranial Height: Measure from the top of the left earhole to the top of the skull

In addition to these measurements, students will also create a drawing of each skull and a drawing of the upper right canine tooth.

Stations should be laid out as follows:

- Station 1: *Australopithecus africanus*

- Station 2: *Homo erectus*
- Station 3: *Homo sapiens*
- Station 4: *Pan troglodytes*
- Station 5: *Paranthropus boisei*

Pace students so that they spend between 8 and 12 minutes at each station. Advise students to take their measurements first and complete their drawings second. Depending on station timing, this may take two class periods to complete.

Wrap-Up and Calculations (30 minutes): Students should transcribe the measurements for each skull into their final table on their worksheet (below). Depending on time availability, indices may be plotted in graphs or used directly to draw comparisons. Students may work on assessment questions in class or finish for homework. The advanced version of the worksheet (provided at the end of this document) includes a graphing activity as well as additional higher order questions. Advanced students can build a phylogenetic tree of their five measured species and five species for which data has been provided.

Student Figures:

Species	Cranial Width (CW)	Cranial Length (CL)	Cranial Index (CW/CLx100)
Australopithecus africanus			
Homo erectus			
Homo sapiens			
Pan troglodytes			
Paranthropus boisei			

Species	Cranial Width (CW) (mm)	Cranial Length (CL) (mm)	Cranial Height (CH) (mm)	Cranial Volume = CW x CL x CH (mm^3)
Australopithecus africanus				
Homo erectus				
Homo sapiens				
Pan troglodytes				
Paranthropus boisei				

Species	Cranial Width (CW)	Facial Width (FW)	Skull Proportion Index (CW/FWx100)
Australopithecus africanus			
Homo erectus			
Homo sapiens			
Pan troglodytes			
Paranthropus boisei			

STANDARDS

NEXT GENERATION SCIENCE STANDARDS (NGSS)

HS-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

Science Practices	Connection to the Lesson
Obtaining, Evaluating, and Communicating Information: Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.	Students will collect data using rulers or calipers, and will link these data to trends in hominid evolution.
Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically)	Students will communicate scientific information through collaborative group work and their assessment sheets afterwards.
Disciplinary Core Ideas	**Connection to the Lesson**
LS4.A: Evidence of Common Ancestry and Diversity LS4.C: Adaptation	Students are examining fossil evidence of human evolutionary lineage. This evidence will be linked to principles of adaptation, natural selection, and evolution.
Crosscutting Concepts	**Connection to the Lesson**
Patterns: Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.	Students will look for patterns in skull length, cranial length and width, and facial width. These trends will then be linked to evolution over time.

CCSS STANDARDS

ELA/Literacy -	
RST-11.12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-LS4-1)*
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. *(HS-LS4-1)*
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. *(HS-LS4-1)*

SL.11-12.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. *(HS-LS4-1)*
Mathematics -	
MP.2	Reason abstractly and quantitatively.

RESOURCES & MATERIALS

STL Resources:

- "How To Print Your Own 3D Replicas Of Homo Naledi And Other Hominin Fossils," by Kristina Killgrove: https://www.forbes.com/sites/kristinakillgrove/2015/09/19/how-to-print-your-own-3d-replicas-of-homo-naledi-and-other-hominin-fossils/#42b69a7012c0
- AfricanFossils: Most STLs as well as many more are available here: https://africanfossils.org/
- Specific list of STL locations:
    - Station 1: *Australopithecus africanus*: https://www.thingiverse.com/thing:2553455
    - Station 2: *Homo erectus*: https://africanfossils.org/hominids/knmwt-15000-b?o=1 https://africanfossils.org/hominids/knmwt-15000-c?o=1 https://africanfossils.org/hominids/knmer-3733?o=1
    - Station 3: *Homo sapiens*: https://africanfossils.org/hominids/modern-human?o=1
        - Slightly older, incomplete human: https://africanfossils.org/hominids/knmer-5306?o=1
    - Station 4: *Pan troglodytes*
    - Station 5: *Paranthropus boisei*: https://africanfossils.org/hominids/knmwt-17400?o=1 https://africanfossils.org/hominids/knmer-406?o=1
    - Additional possible models for this lab:
        - *Afropithecus turkanensis,* with STL*: https://africanfossils.org/hominids/knmwk-16999?o=1*
        - *Paranthropus aethiopicus:* https://africanfossils.org/hominids/knmwt-17000?o=1
        - *Homo rudolfensis:* https://africanfossils.org/hominids/knmer-1470?o=1
        - *Homo habilis:* https://africanfossils.org/hominids/knmer-1813?o=1
        - *Kenyanthropus platyops:* https://africanfossils.org/hominids/knmwt-40000-?o=1

Evolution Teaching Resources

- PBS Evolution Resources: http://www.pbs.org/wgbh/evolution/
- University of California Berkley Evolution teaching resources: http://evolution.berkeley.edu/evolibrary/teach/
- Excellent game-style simulator for natural selection from the University of Colorado, Boulder, PHET: https://phet.colorado.edu/en/simulation/natural-selection

Teaching Human Evolution:

- Y Manjunath, K. (2002). Estimation Of Cranial Volume-an Overview Of Methodologies. J Anat Soc India. 51. Available here:

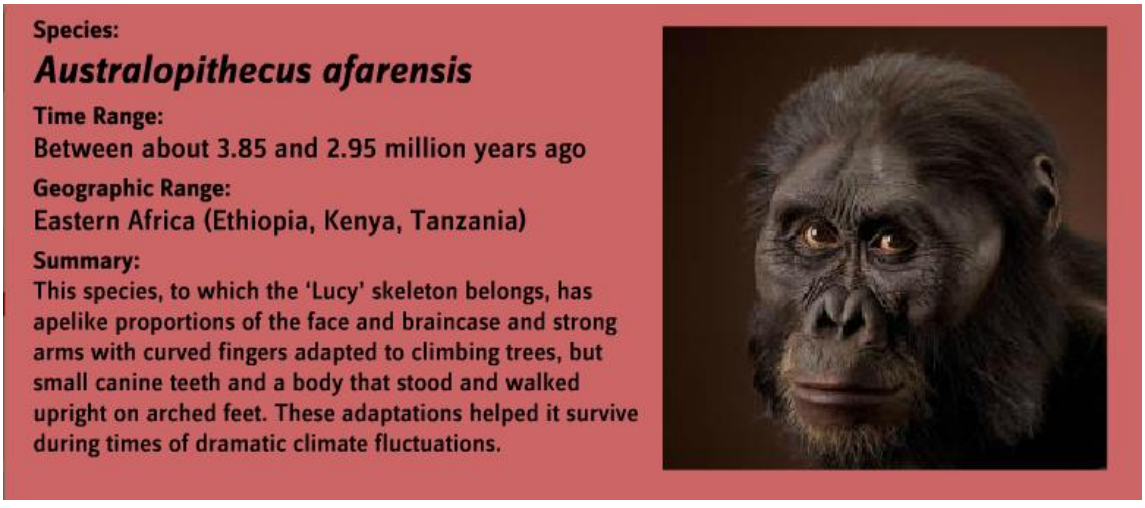
https://www.researchgate.net/publication/266584078_Estimation_Of_Cranial_Volume-an_Overview_Of_Methodologies

- Smithsonian Institute: Teaching Evolution, "What does it mean to be human?": http://humanorigins.si.edu/education/teaching-evolution-through-human-examples
- Smithsonian Interactive Timeline of Human Evolution: http://humanorigins.si.edu/evidence/human-evolution-timeline-interactive
- 3D Models of hundreds of African fossils here: https://africanfossils.org/search
- The history of human evolution studies, from UC Berkeley: https://evolution.berkeley.edu/evolibrary/article/history_17
- Encyclopedia Britannica entry on Human Evolution (Figure credit here): https://www.britannica.com/science/human-evolution
- Yale-New Haven Teachers Institute publication on teaching human evolution and understanding geologic time: http://teachersinstitute.yale.edu/curriculum/units/1979/6/79.06.02.x.html

Helpful videos:

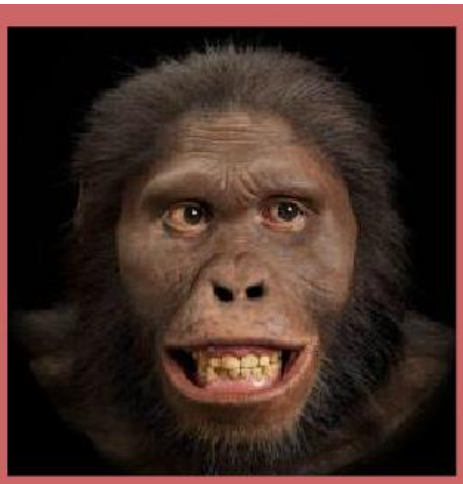
- Crash Course, "Human Evolution: Crash Course Big History #6": Excellent video by Hank and John Green summarizing not only human evolution and anatomical trends, but some of the cultural evolutions that have enabled us to be successful as a species. https://www.youtube.com/watch?v=UPggkvB9_dc
- National Geographic Documentary, "Origin of Humans": https://www.youtube.com/watch?v=QTU353BN-wM
- Ted Talk by Svante Paeaebo, "DNA Clues to Our inner Neanderthal": interesting talk on vestiges of Neanderthal DNA in modern human populations. This is also a nice link to gene and biotechnology units as well. https://www.ted.com/talks/svante_paeaebo_dna_clues_to_our_inner_neanderthal

Individual Species Info Cards: Source: "Human Evolution Interactive Timeline," Smithsonian Institute, Available here: http://humanorigins.si.edu/evidence/human-evolution-timeline-interactive



Species:

Australopithecus africanus



Time Range:
About 3.3 to 2.1 million years ago

Geographic Range:
Southern Africa (South Africa)

Summary:
Discovered in 1924, this was the first early human species to be found on the continent of Africa. Members of this species were mostly vegetarian, with a diet similar to modern chimpanzees consisting of fruit, vegetables, nuts, seeds, and eggs. Based on microscopic wear on their molar teeth we know they ate tough foods.

Species:

Paranthropus aethiopicus

Time Range:
About 2.7 to 2.3 million years ago

Geographic Range:
Eastern Africa (Turkana basin of northern Kenya, southern Ethiopia)

Summary:
The bony ridge (sagittal crest) on the midline of the top of the skull in this species indicates huge chewing muscles, with a strong emphasis on the muscles that connect toward the back of the crest and created strong chewing forces on the front teeth. It is likely to be the ancestor of *Paranthropus boisei.*

Species:

Homo habilis

Time Range:
2.4 million to 1.4 million years ago

Geographic Range:
Eastern and Southern Africa

Summary:
Its name, which means 'handy man', was given because when it was discovered at Olduvai Gorge in the early 1960s, this species was thought to represent the first stone toolmaker. Currently, the oldest stone tools are dated slightly older than the oldest evidence of the genus *Homo.*

Species:

Australopithecus sediba

Time Range:
Between 1.977 and 1.98 million years ago

Geographic Range:
Southern Africa (South Africa)

Species:

Paranthropus boisei

Time Range:
About 2.3 to 1.2 million years ago

Geographic Range:
Eastern Africa (Ethiopia, Kenya, Tanzania, Malawi)

Summary:
Members of this species had a bony ridge (sagittal crest) on the midline of the top of the skull. This crest anchored the large chewing muscles from the top and side of the braincase to the lower jaw, and thus moved the massive jaw up and down. The force was focused on the large molars and premolars. For most of its time range, members of this species lived alongside *Homo erectus* in East Africa; sometimes they were even found at the same sites.

Species:

Homo heidelbergensis

Time Range:
About 700,000 to 200,000 years ago

Geographic Range:
Europe; possibly Asia (China); Africa (eastern and southern)

Summary:
These were the first early humans to venture into the cold latitudes of Europe, where there is evidence that they were the first species to build shelters and hunt big game animals with wooden spears. European populations of this species were the direct ancestors of the Neanderthals, while African populations likely gave rise to our species. The African fossils are considered by some researchers distinct enough to place in a different species, *Homo rhodesiensis.*

Species:

Homo erectus

Time Range:
Between about 1.89 million and 143,000 years ago

Geographic Range:
Northern, Eastern, and Southern Africa; Western Asia (Dmanisi, Republic of Georgia); East Asia (China and Indonesia)

Summary:
This species is commonly known as *Homo erectus*, but some of the oldest African specimens are thought to represent a related species, *Homo ergaster*. There is evidence that individuals of *Homo erectus* were the first early humans to make hearths, to eat significant amount of animal meat and bone marrow, and to care for the old and weak. It was the longest-lived species on our family tree, surviving more than nine times as long as our own species.

Species:

Homo neanderthalensis

Time Range:
About 400,000 - 40,000 years ago

Geographic Range:
Europe and southwestern to central Asia

Summary:
Defining features of the skull of this species include the large middle part of the face, angled cheek bones, and a huge nose for humidifying and warming cold, dry air. Their bodies were also shaped for heat conservation, with shorter limb extremities. Neanderthals were the first early humans to wear clothing, necessary since they lived in glacial environments. They may have been the first early human species to have language, bury their dead, and exhibit symbolic behavior.

Species:

Homo sapiens

Time Range:
About 200,000 years ago to present

Geographic Range:
Evolved in Africa, now worldwide

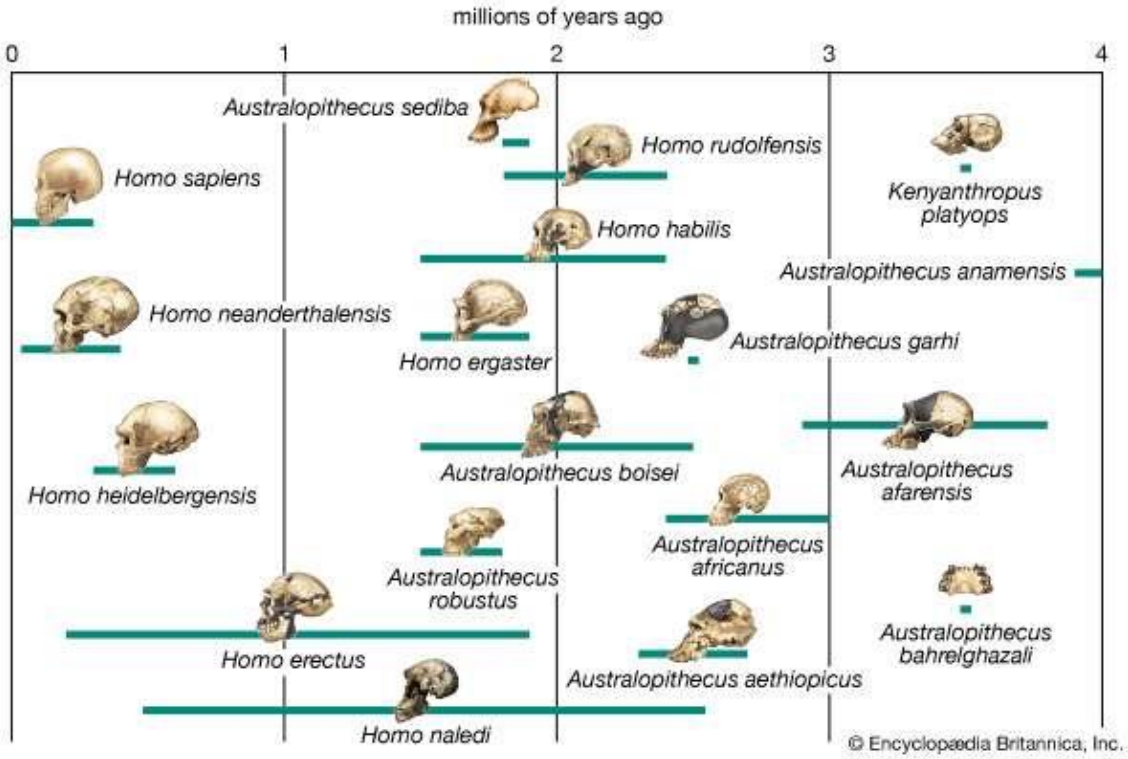
Summary:
Fossils and genetics evidence shows that our species, *Homo sapiens*, evolved in Africa about 200,000 years ago and began to spread out from there by at least 100,000 years ago. We now live in all parts of the world, and are the sole surviving species left in our once diverse family tree.

KEY ACADEMIC AND/OR SCIENTIFIC LANGUAGE

Adaptation: a change or the process of change by which an organism or species becomes better suited to its environment
Ape: a large primate that lacks a tail, including the gorilla, chimpanzees, orangutan, and gibbons
Bipedal: using only two legs for walking
Canine: a pointed tooth between the incisors and premolars of a mammal, often greatly enlarged in carnivores.
Cranium: the skull, especially the part enclosing the brain
Distal: situated away from the center of the body or from the point of attachment
Evolution: the process by which different kinds of living organisms are thought to have developed and diversified from earlier forms during the history of the earth
Foramen: an opening, hole, or passage, especially in a bone
Foramen magnum: the hole in the base of the skull through which the spinal cord passes
Hominid: a primate of a family (*Hominidae*) that includes humans and their fossil ancestors and also (in recent systems) at least some of the great apes
Hominin: a primate of a taxonomic tribe (*Hominini*), which comprises those species regarded as human, directly ancestral to humans, or very closely related to humans.
Incisor: a narrow-edged tooth at the front of the mouth, adapted for cutting. In humans there are four incisors in each jaw
Mandible: the jaw or a jawbone, especially the lower jawbone in mammals and fishes
Morphology: the branch of biology that deals with the form of living organisms, and with relationships between their structures
Natural selection: the process whereby organisms better adapted to their environment tend to survive and produce more offspring. The theory of its action was first fully expounded by Charles Darwin and is now believed to be the main process that brings about evolution
Niche: a position or role taken by a kind of organism within its community. Such a position may be occupied by different organisms in different localities, e.g., antelopes in Africa and kangaroos in Australia
Occipital bone: the bone that forms the back and base of the skull, and through which the spinal cord passes
Orbit: the cavity in the skull of a vertebrate that contains the eye; the eye socket
Osteology: the study of the structure and function of the skeleton and bony structures
Phylogeny: the evolutionary development and diversification of a species or group of organisms, or of a particular feature of an organism
Proximal: situated nearer to the center of the body or the point of attachment
Zygomatic bone: the bone that forms the prominent part of the cheek and the outer side of the eye socket
Zygomatic process: a projection of the temporal bone that forms part of the zygoma

PRIOR KNOWLEDGE

Students should already be familiar with the principles of evolution by natural selection, competition, and adaptation. While discussion on human evolution and the traits the likely led to success of *Homo sapiens* as a species (bipedalism, larger cranial capacity, complex social hierarchies, etc.), it is not necessary for this lesson to be successful. The teacher should be well familiar with the timeline on human evolutionary history (below), as students will be building a phylogenetic tree using their data and observations.



DIFFERENTIATION

Provided with this lab are two versions of the "Apes Through the Ages" lab handouts. The first is geared towards a standard level course and is shorter. The second handout includes additional comprehension questions and an additional set of calculations for a more advanced group of students. These labs can also be differentiated based on Kagan grouping strategies, additional time, or scaffolded reading activities.

Name:_____ **Period:**_____
Partner(s):_____ **Date:**_____

Apes Through The Ages

Congratulations! You have received an offer from the American Museum of Natural History to join the Human Evolution Research Unit! As part of this group, you will be responsible for comparing and contrasting different hominid relatives throughout Earth's recent history. A *hominid* is a member of the group of organisms known as "Great Apes." The Great Apes include modern animals like chimpanzees, gorillas, and orangutans, as well as modern humans and all of the extinct ancestors of humans. Today you will be measuring important characteristics of different hominid skulls. Skulls are incredibly useful fossils to scientists; we can use skulls to learn about an animal's diet, whether it walked upright or on all four legs, and how big its brain was among many other things.

Comparing Hominid Skulls

You will have ten minutes to complete your drawings and measurements at each skull. Try to include as much detail as you can in your drawing and do your best! Start by measuring each skull with your partner(s) to make sure you have plenty of time to collect your data. Use the following figure in determining where to measure:

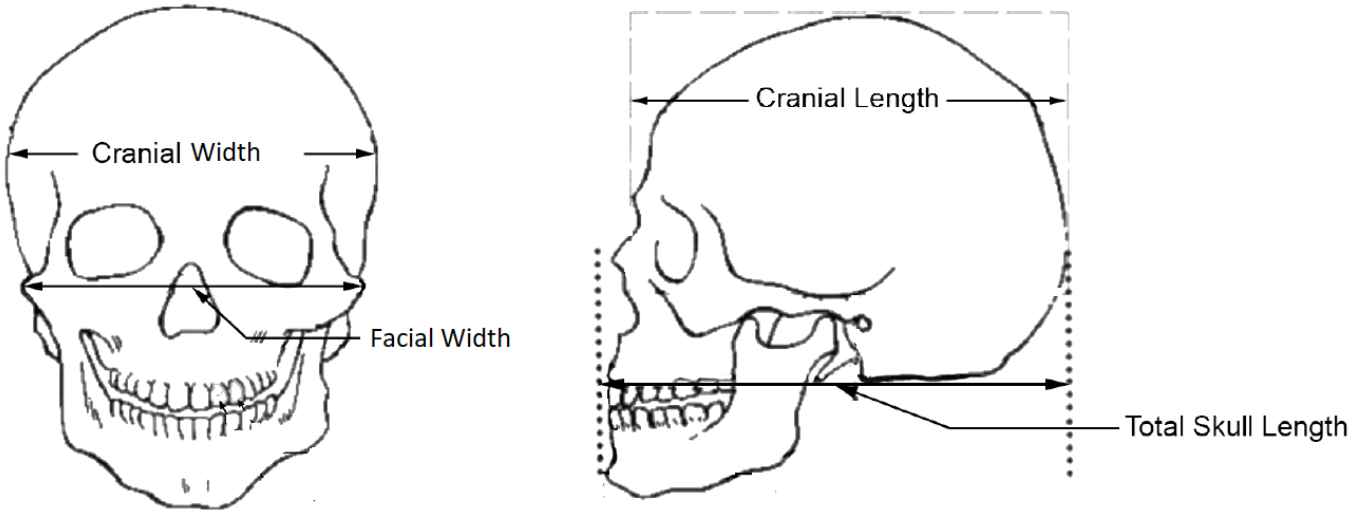


Figure 1

As you work through the stations, you will be taking the following measurements for each skull:

- Cranial Width: The widest part of the top of the skull (Fig. 1)
- Facial Width: The distance across the face as measured from cheekbone to cheekbone (Fig. 1)
- Cranial Length: The length of the top of the skull from front to back midline (Fig. 1)
- Total Skull Length: The distance from the front of the upper jaw to the back of the skull (Fig. 1)
- Length of upper right canine tooth: If you are looking at the front of the skull, this tooth is on the upper jaw and to the right of the incisors
- Cranial Height: Measure from the top of the left earhole to the top of the skull (Fig. 2)

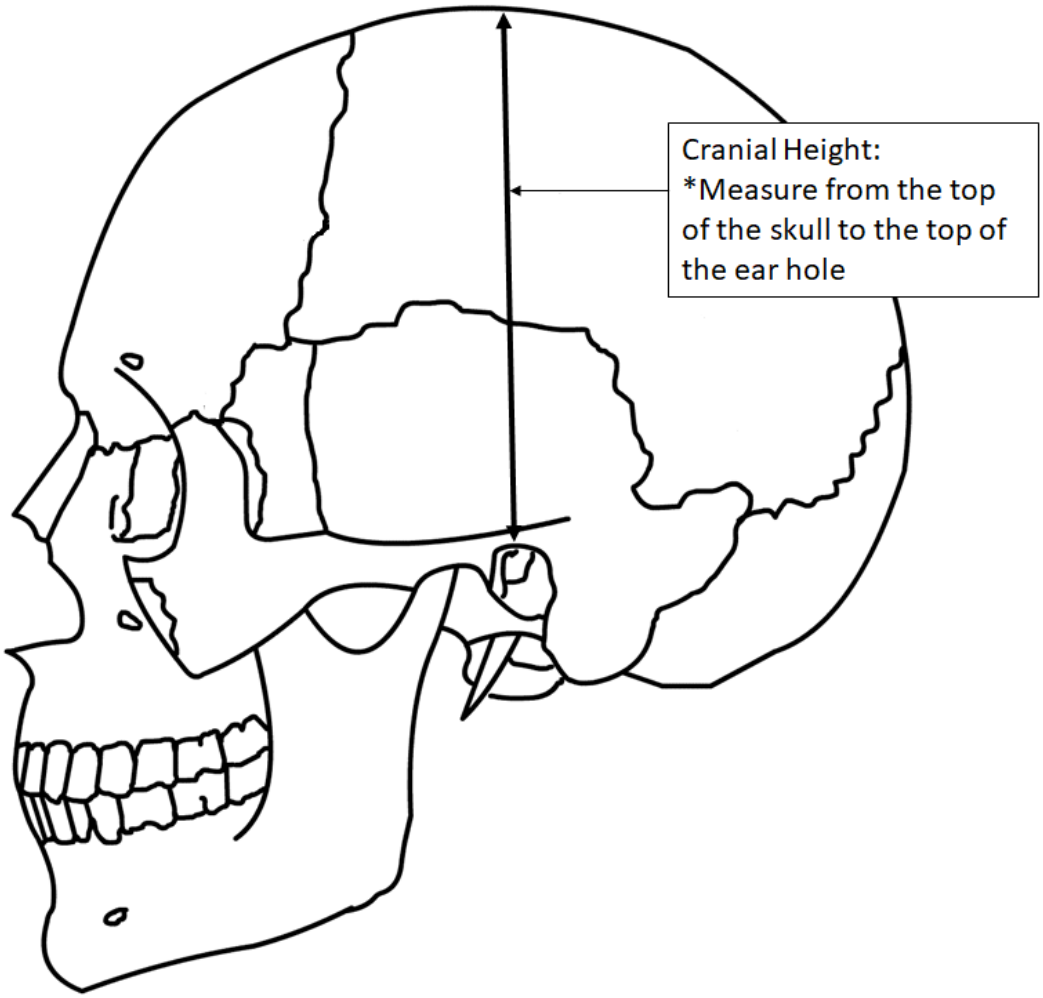


Figure 2

Please be careful not to overtighten any of the digital calipers! Please ask your teacher for help if you need any assistance!

Station 1: *Australopithecus africanus*

	Measurement (mm)
Cranial width	
Cranial length	
Total skull length	
Facial length	
Length of upper right canine tooth	
Cranial height	

Drawing of canine tooth:

Station 2: *Homo erectus*

	Measurement (mm)
Cranial width	
Cranial length	
Total skull length	
Facial length	
Length of upper right canine tooth	
Cranial height	

Drawing of canine tooth:

Station 3: *Homo sapiens*

	Measurement (mm)
Cranial width	
Cranial length	
Total skull length	
Facial length	
Length of upper right canine tooth	
Cranial height	

Drawing of canine tooth:

Station 4: *Pan troglodytes*

	Measurement (mm)
Cranial width	
Cranial length	
Total skull length	
Facial length	
Length of upper right canine tooth	
Cranial height	

Drawing of canine tooth:

Station 5: *Paranthropus boisei*

	Measurement (mm)
Cranial width	
Cranial length	
Total skull length	
Facial length	
Length of upper right canine tooth	
Cranial height	

Drawing of canine tooth:

Questions:

1. Which of the skulls looks the most like the *Homo sapiens* skull? What does this tell you about that skull?

2. Which skull do you think is the oldest? Why?

Calculations:

You are now going to calculate the "Cranial Index" of each skull. The Cranial Index can tell us if the hominid's skull was more rounded or more elongated. In primates, rounded skulls like those found in humans are more evolved characteristics. Complete the table below using the following formula:

Cranial index = (Cranial width/Cranial Length)

Species	Cranial Width (CW)	Cranial Length (CL)	Cranial Index (CW/CLx100)
Australopithecus africanus			
Homo erectus			
Homo sapiens			
Pan troglodytes			
Paranthropus boisei			

You are now going to calculate the "Cranial Volume" of each skull. The cranial volume tells us how much space is inside of the skull. Because of this, the larger the cranial volume, the larger the primate's brain was. Complete the table below using the following formula:

Cranial Volume = Cranial Width (CW) x Cranial Length (CL) x Cranial Height (CH)

Species	Cranial Width (CW) (mm)	Cranial Length (CL) (mm)	Cranial Height (CH) (mm)	Cranial Volume = CW x CL x CH (mm^3)
Australopithecus africanus				
Homo erectus				
Homo sapiens				
Pan troglodytes				
Paranthropus boisei				

Questions:

1. Using your data collected above, which hominid do you think is the closest relative to modern *Homo sapiens?* Use the data to explain your answer.

2. Using your data collected above, which hominid is the oldest? Explain your answer.

3. What other information or data might be useful in comparing these hominids? Describe at least two things.

4. One of the things you looked at and measured was the upper right canine tooth of each skull. What do you notice about these teeth and what does this tell you about the hominids they came from?

5. Paleontologists often look to a single skull as the defining fossil for an entire species. Are there any problems with this? Explain.

Name:_____ **Period:**_____
Partner(s):_____ **Date:**_____

Apes Through The Ages

Congratulations! You have received an offer from the American Museum of Natural History to join the Human Evolution Research Unit! As part of this group, you will be responsible for comparing and contrasting different hominid relatives throughout Earth's recent history. A *hominid* is a member of the group of organisms known as "Great Apes." The Great Apes include modern animals like chimpanzees, gorillas, and orangutans, as well as modern humans and all of the extinct ancestors of humans. Today you will be measuring important characteristics of different hominid skulls. Skulls are incredibly useful fossils to scientists; we can use skulls to learn about an animal's diet, whether it walked upright or on all four legs, and how big its brain was among many other things.

Comparing Hominid Skulls

You will have ten minutes to complete your drawings and measurements at each skull. Try to include as much detail as you can in your drawing and do your best! Start by measuring each skull with your partner(s) to make sure you have plenty of time to collect your data. Use the following figure in determining where to measure:

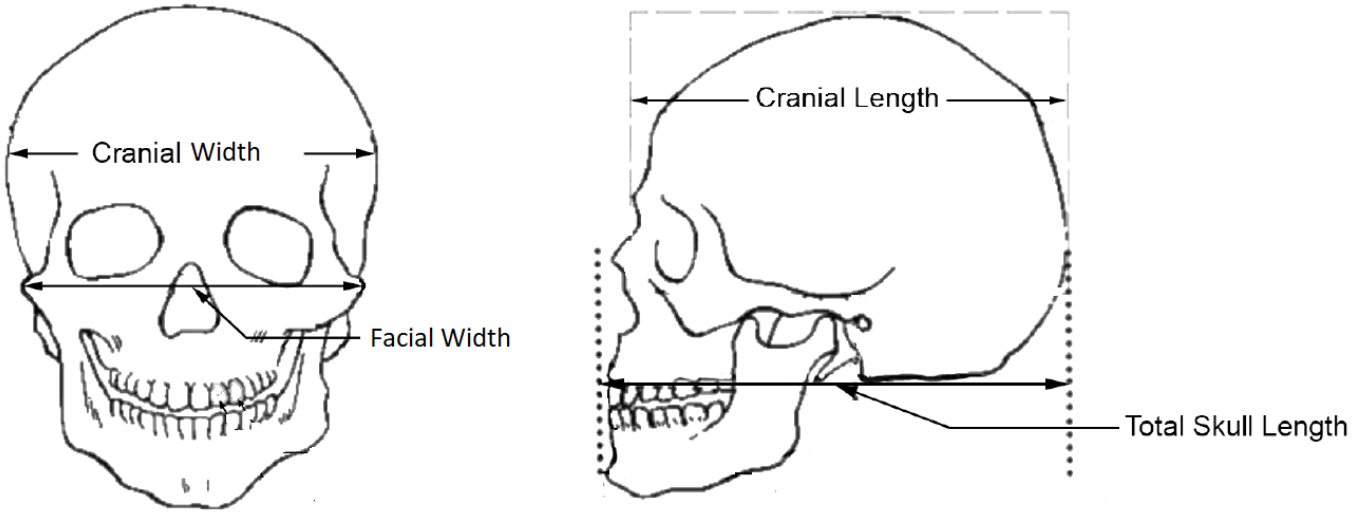


Figure 1

As you work through the stations, you will be taking the following measurements for each skull:

- Cranial Width: The widest part of the top of the skull (Fig. 1)
- Facial Width: The distance across the face as measured from cheekbone to cheekbone (Fig. 1)
- Cranial Length: The length of the top of the skull from front to back midline (Fig. 1)
- Total Skull Length: The distance from the front of the upper jaw to the back of the skull (Fig. 1)
- Length of upper right canine tooth: If you are looking at the front of the skull, this tooth is on the upper jaw and to the right of the incisors
- Cranial Height: Measure from the top of the left earhole to the top of the skull (Fig. 2)

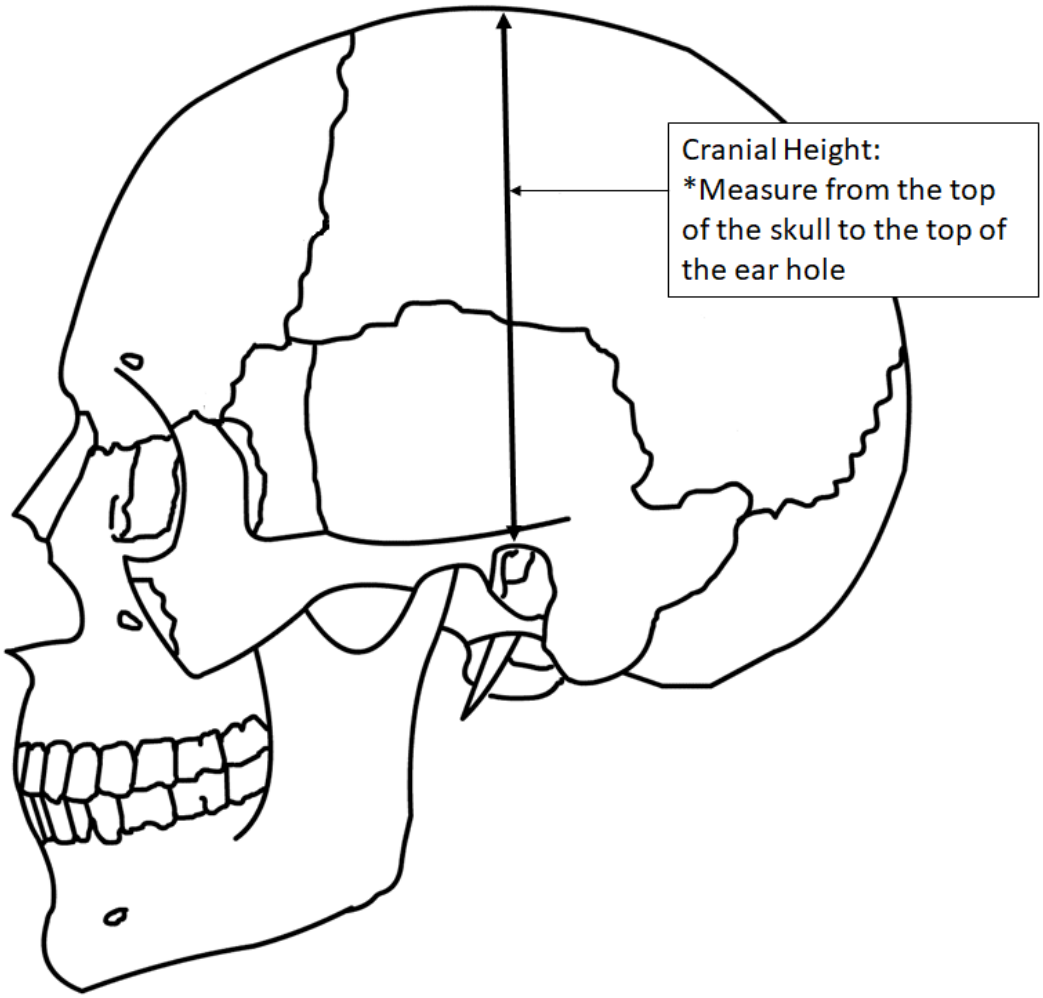


Figure 2

Please be careful not to overtighten any of the digital calipers! Please ask your teacher for help if you need any assistance!

Station 1: *Australopithecus africanus*

	Measurement (mm)
Cranial width	
Cranial length	
Total skull length	
Facial length	
Length of upper right canine tooth	
Cranial height	

Drawing of canine tooth:

Station 2: *Homo erectus*

	Measurement (mm)
Cranial width	
Cranial length	
Total skull length	
Facial length	
Length of upper right canine tooth	
Cranial height	

Drawing of canine tooth:

Station 3: *Homo sapiens*

	Measurement (mm)
Cranial width	
Cranial length	
Total skull length	
Facial length	
Length of upper right canine tooth	
Cranial height	

Drawing of canine tooth:

Station 4: *Pan troglodytes*

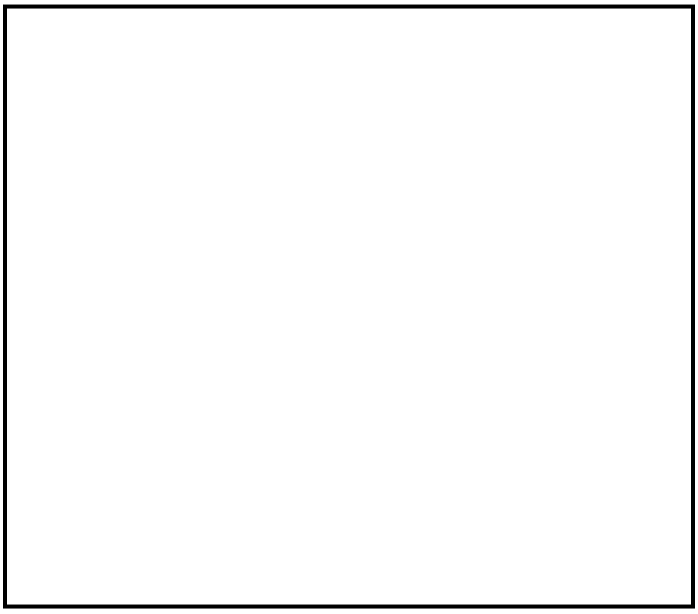
	Measurement (mm)
Cranial width	
Cranial length	
Total skull length	
Facial length	
Length of upper right canine tooth	
Cranial height	

Drawing of canine tooth:

Station 5: *Paranthropus boisei*

	Measurement (mm)
Cranial width	
Cranial length	
Total skull length	
Facial length	
Length of upper right canine tooth	
Cranial height	

Drawing of canine tooth:



Questions:

1. Which of the skulls looks the most like the *Homo sapiens* skull? What does this tell you about that skull?

2. Describe at least two anatomical features that differ significantly between the *Homo sapiens* and chimpanzee skulls. How might these differences affect function in the wild?

3. What additional measurements of the skull might be helpful in describing and comparing the different hominid species? Describe.

4. What assumptions are you making in measuring these skulls as representative individuals of their given species?

Calculations:
You are now going to calculate the "Cranial Index" of each skull. The Cranial Index can tell us if the hominid's skull was more rounded or more elongated. In primates, rounded skulls like those found in humans are more evolved characteristics. Complete the table below using the following formula:

Cranial index = (Cranial width/Cranial Length)

Species	Cranial Width (CW)	Cranial Length (CL)	Cranial Index (CW/CLx100)
Australopithecus africanus			
Homo erectus			
Homo sapiens			
Pan troglodytes			
Paranthropus boisei			

You are now going to calculate the "Skull Proportion Index" of each skull. The Skull Proportion Index tells us how much of the skull is cranium as compared to how much of the skull is face and jaws. The larger this index is, the greater the cranial size of the skull. Complete the table below using the following formula:

Skull Proportion Index = (Cranial Width/Facial width)

Species	Cranial Width (CW)	Facial Width (FW)	Skull Proportion Index (CW/FWx100)
Australopithecus africanus			
Homo erectus			
Homo sapiens			
Pan troglodytes			
Paranthropus boisei			

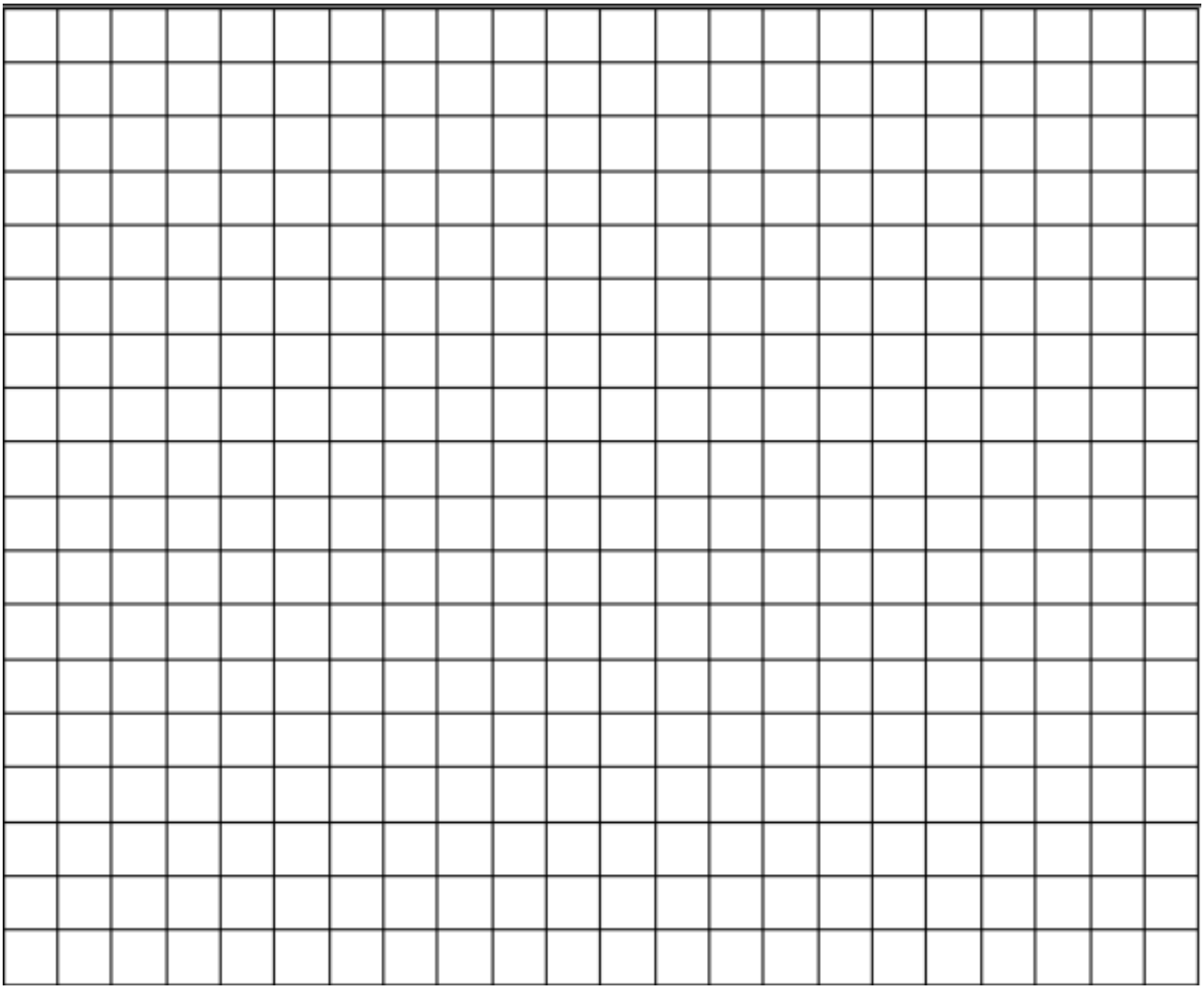
You are now going to calculate the "Cranial Volume" of each skull. The cranial volume tells us how much space is inside of the skull. Because of this, the larger the cranial volume, the larger the primate's brain was. Complete the table below using the following formula:

Cranial Volume = Cranial Width (CW) x Cranial Length (CL) x Cranial Height (CH)

Species	Cranial Width (CW) (mm)	Cranial Length (CL) (mm)	Cranial Height (CH) (mm)	Cranial Volume = CW x CL x CH (mm^3)
Australopithecus africanus				
Homo erectus				
Homo sapiens				
Pan troglodytes				
Paranthropus boisei				

Graphing:
Using the following information, graph the cranial capacity and cranial index of each species as a double line graph. Be sure to label your graph and its axes with units! Include a clear and appropriate scale for each axis. You do not need to draw a line of best fit until **after** you have completed number 7 of your final conclusion questions.

Species	Age
Australopithecus africanus	3.3-2.5 mya
Homo erectus	1.89mya – 143,000 ya
Homo sapiens	200,000 ya - Present
Pan troglodytes	~400,000 ya - Present
Paranthropus boisei	2.3-1.3 mya



Questions:

1. Using your data collected above, which hominid do you think is the closest relative to modern *Homo sapiens?* Use the data and information provided to explain your answer.

2. One of the things you looked at and measured was the upper right canine tooth of each skull. What do you notice about these teeth and what does this tell you about the hominids they came from?

3. Paleontologists often look to a single skull as the defining fossil for an entire species. Are there any problems with this? Explain.

4. What does the change in cranial index over time tell us about hominid evolution?

5. How would changing cranial capacity affect a hominid's ability to compete in a natural environment? Explain.

6. The skull proportion index tells us what proportion of the skull is cranium and what proportion of the skull is face. How does this relationship change over time and what does this tell us?

7. Using the information below, design a phylogenetic tree that incorporates the five species you examined in lab, as well as the new five species for which data is presented. Hint: you may need to reference your textbook section on phylogenetics in completing this portion of the assignment. Go back and add these values for these species to the graph you completed earlier in this lab.

Species	Cranial Index	Cranial Volume (cm^3)	Age
Australopithecus afarensis	0.74	445.8	3.8-2.95 mya
Homo habilis	0.69	610.3	2.4-1.4 mya
Homo heidelbergensis	0.61	1262.8	700,000-200,000 ya
Homo neanderthalensis	0.64	1500-1750	400,00-40,000 ya
Gorilla gorilla	0.59	340-752	Modern