BSC 2011 - EVIDENCE OF EVOLUTION LAB

Objectives:

1. Identify categories of fossils and describe how they formed.
2. Explain how fossil evidence supports the idea that organisms change over time.
3. After comparing vertebrate embryos, explain how embryology offers proof of evolution.
4. Provide several examples of ways biochemistry offers proof of evolution.
5. Explain how the field of comparative anatomy supports the theory of evolution. Compare skull features of primate skulls, dentition formulas and jaw structures between humans and possible hominid ancestors.

Exercise I - FOSSIL CHART

BACKGROUND INFORMATION:

Fossils can be grouped into categories based on their formation. Several groups of fossil evidence exist.

Remains refer to the actual remains of organisms that once lived on earth. They can be:

Petrified - the organism's living material has been replaced by mineral matter that crystallizes into rock-like material.

Preserved - the actual remains of the plant or animal have not decayed or been replaced, rather kept in tact as they once were many years ago. Organisms found in amber, tar, peat bogs, mud flats, sand bars, permafrost, or embalmed in some way fit in this category.

Casts and molds - The organism or a part of the organism decomposes leaving an indentation or mold that fills with minerals that harden into a cast of the organism. Imprints and footprints are examples.

Tracings - the organism is no longer there but its molecular decay left a mark on or in the rock. A fern frond decays and leaves a carbon stain on the rock it is buried in.

PROCEDURE: After viewing the fossils on display, complete the fossil matrix chart given. Include a sketch and description of how the fossil probably formed. Indicate the Era of origin and if the organism is extinct or extant today.

QUESTIONS:

1. Why is the fossil record biased toward aquatic organisms and against organisms of tropical rainforests?

2. Why is the fossil record biased toward organisms with hard parts and against soft-bodied organisms?

3. Provide several examples of organisms most likely to fossilize.

FOSSIL CHART

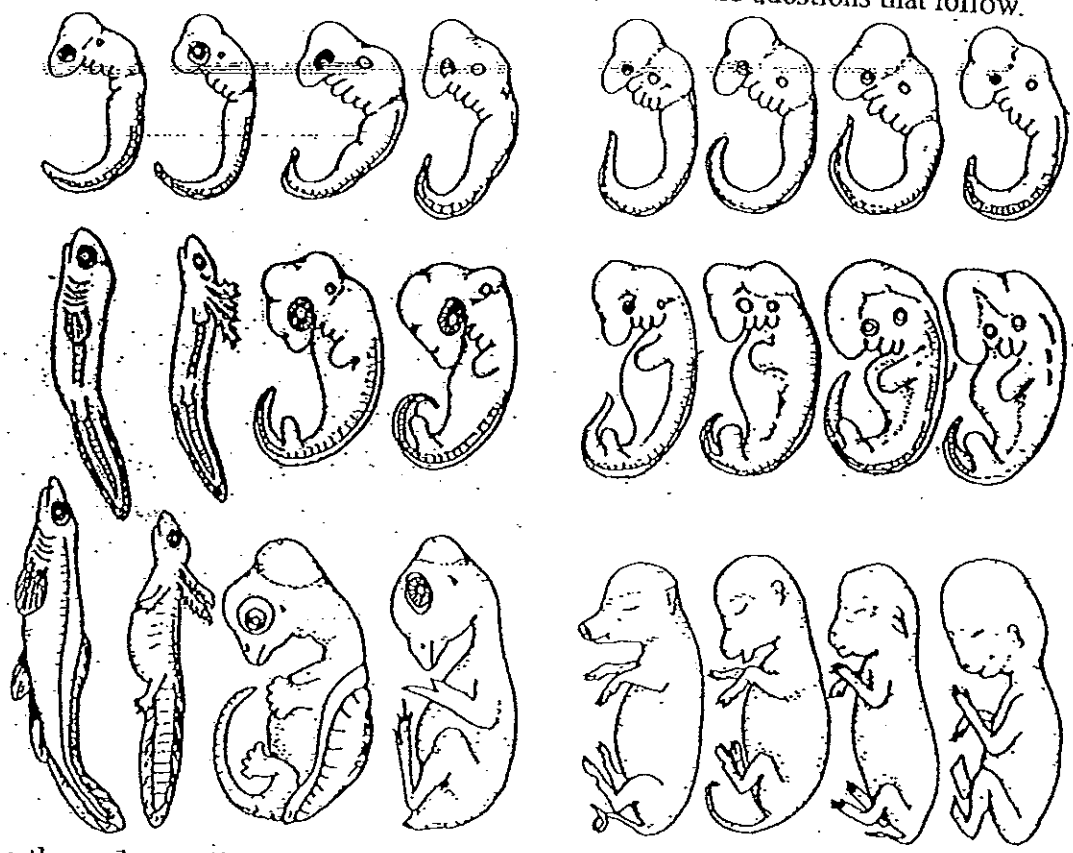
NAME/ DESCRIPTION	SKETCH	FOSSIL TYPE/ CATEGORY

Exercise II - COMPARISON OF EMBRYOS

BACKGROUND INFORMATION:

Early embryological development may provide evidence of the homology among structures that are very different in the adult form. As embryos mature, early similarities are lost and traits more typical of the adult species are produced. It seems likely that similarities in their early structures reflect retention of genetic material from an ancestral line of descent. The amazing similarities of the early embryos provide evidence of a close relationship in the past or rather a common ancestry.

PROCEDURE: After comparing the vertebrate embryos given, answer the questions that follow.



QUESTIONS:

1. After observing the embryos, list as many similarities among them as you can. (Minimum of 5)

2. Why do you think vertebrate embryos experience similar developmental stages?

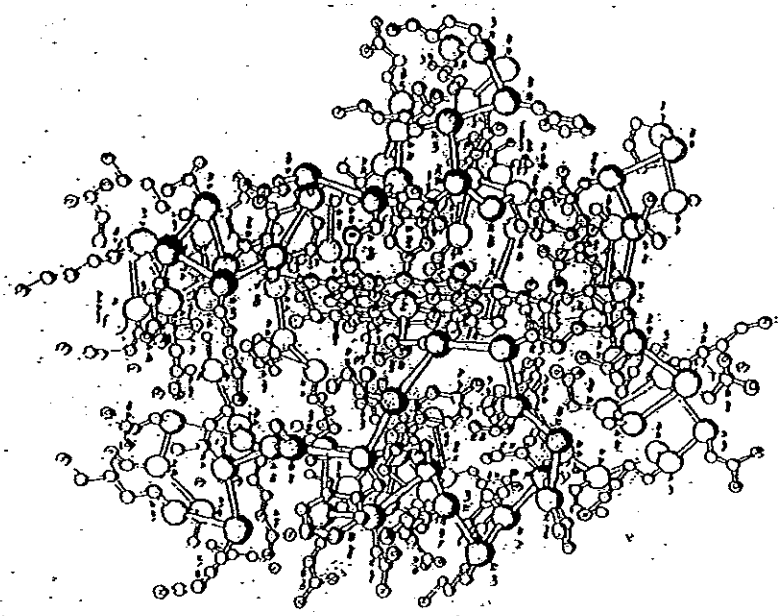
EXERCISE III - BIOCHEMICAL EVIDENCE

BACKGROUND INFORMATION:

Cytochrome c is a respiratory protein found in all aerobic species as unrelated as mushrooms, algae, butterflies and worms. Cytochrome C structure and function remain the same with some variations occurring in the amino acid's sequences. **It can be concluded that the greater the protein similarities or biochemical similarities, the closer the evolutionary relationship of any two organisms.**

Biological relationships based on amino acid analysis of cytochrome C.

(Structure of cytochrome C)



PROCEDURE:

Review the data in the table below and answer the questions following it.

Comparison of Cytochrome C from Different Organisms

SPECIES COMPARED	AMINO ACID DIFFERENCES
Human - Monkey	1
Human - Horse	12
Human - Dog	10
Horse - Cow	3
Mammals - Chicken	10 - 15
Mammals - Tuna	17 - 21

QUESTIONS:

1. What evolutionary relationships, if any can be suggested for the above species based on their cytochrome c differences?

2. Label the diagram below.

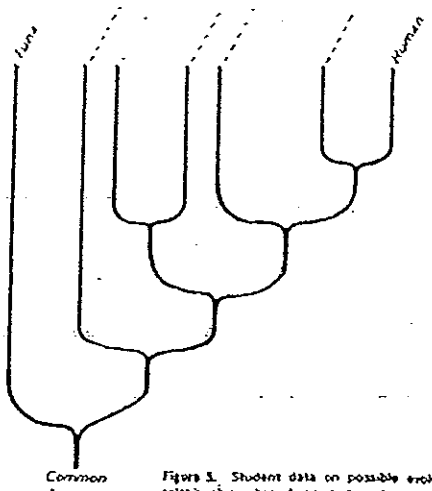


Figure 5. Student data on possible evolutionary relationships based on a comparison of cytochrome c amino acid sequences.

EXERCISE IV - COMPARATIVE ANATOMY AND HUMAN ORIGINS:

BACKGROUND INFORMATION:

Notice the evolutionary trend in the canines of these representative primates. Canines are used as tools to get food such as peeling nuts and fruit and used as defensive weapons or to establish dominance. Notice a space between the canines and incisors that lets the lower jaw canine fit in so the jaw can close. This space is the simian gap or diastema. The rows of teeth in humans form a rounded semicircle angling away from each other. In apes the rows of teeth are more parallel to each other.

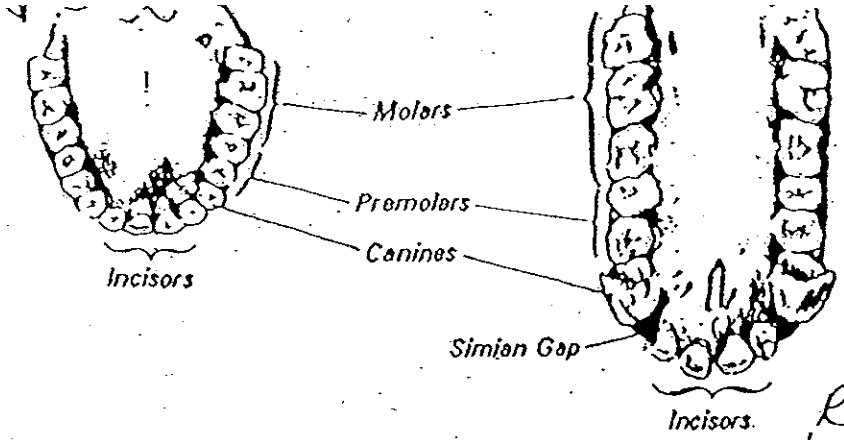
1. Dentition formula refers to the number of each type of tooth in one quadrant of the jaw. (incisors, canines, premolars, and molars)
2. Diastema is a simian gap or space between teeth.
3. Are the rows of teeth angled or parallel?

PROCEDURE:

Examine the skulls on display. Look carefully at the teeth. Note their size of their teeth, their shapes, and how they are arranged. Please handle with extreme care. Complete the chart below for the following characteristics.

	Chimpanzee	Gorilla	Australopithecus Or Ramepithecus	Human
Dentition Formula				
Diastema present/absent				
Teeth - angled or parallel				

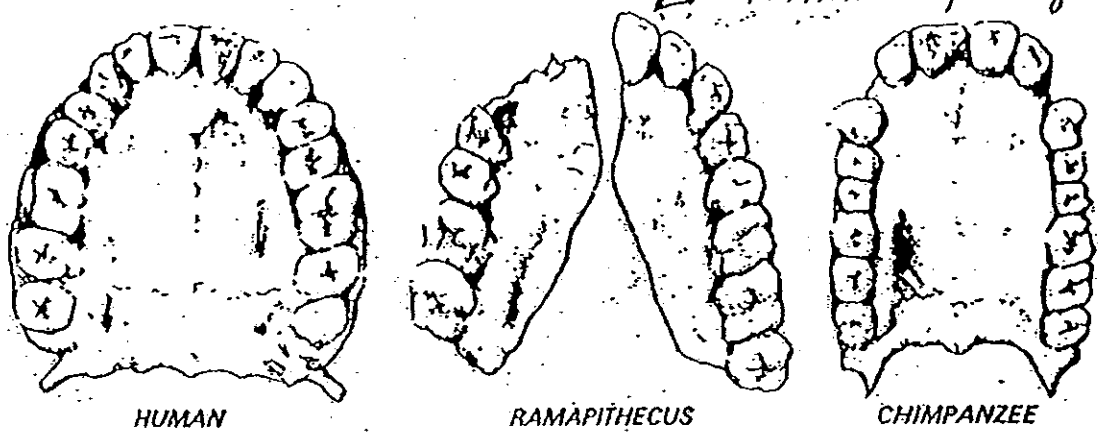
note rows of teeth are angled.



note: rows of teeth are parallel to each other.

Figure 12. Dental arches of human and gorilla.

Ramapithecus was 1st fossil with human characteristics... lived 14 million yrs. ago.



QUESTIONS:

1. Observe yourself chewing in the mirror. Note how your teeth and jaws move. Did you notice you could move your jaw freely from side-to-side? Can a chimpanzee do this?

2. What is the advantage of your arched palate?

3. How do the canines of hominids compare to the canines of pongids, the apes, gorillas, and chimps?

4. What factor do you think was responsible for the evolution of smaller canines?

EXERCISE V - TRENDS IN PRIMATE EVOLUTION

BACKGROUND INFORMATION:

1. Trends show changes in overall skeletal structure in primate evolution as the mode of locomotion evolved. Many changes occurred in the shoulder bones, vertebral column, pelvic girdle, as well as foot bones and leg bones of primates over time. For example, quadraped monkeys leaped from limb to limb, crouched apes climbed and swung through trees, and bipedal primates were capable of walking upright.

2. Trends in primate evolution show increased manipulative skills. The evolution of the hand allowed for the ability to spread fingers, cup the hand, wrap fingers around objects and use an opposable thumb. Primates could sit up, stand, reach for and hold things such as infants and branches.

3. A trend in primate evolution indicates a decreased reliance on smell and greater reliance on vision. Eyes moved forward providing greater depth perception and visual field.

4. Trend in primate evolution resulted in a change in dentition with fewer, smaller, and less specialized teeth.

5. A trend in primate evolution led to an expansion in brain capacity. As cranial capacity of the ancestors of humans crossed over the $750cm^3$ mark, they were classified as fully human. As brain size grew larger the face size became smaller.

6. Behavioral trends in primate evolution included increased life spans, single births, longer time of infant dependency and cultural evolution.

PROCEDURE:

Compare the position of the foramen magnum located on the underside of the skull. This is the passage for the spinal cord through the brain case. Its location is a clue to an organism's stance. Was it biped or quadraped? Note its location at the back of the skull in the chimp. All quadraped animals such as dogs and cats have the foramen magnum located at the back of the skull. Note the overall size of the skull.

QUESTIONS:

1. Where is the foramen magnum located in man? Explain why?

2. What part of the skull shows an increase in size? What organ is located in this part of the skull? What result did its evolution have?

3. Using cranial capacity as a criterion, construct a family tree graph for the hominids. The independent variable for the graph is time in millions of years and the dependent variable is brain volume in cc's. Use your text, lab handouts, or the Internet as a source of data. Consider *Australopithecus africanus, Australopithecus afarensis, and Australopithecus robustus and Australopithecus boisei, Homo habilis, Homo erectus, and Homo sapiens.*

Opposable thumbs allowed for grasping which is something necessary to an arboreal existence. This tree-dwelling niche developed the forelimbs and led to an increased cranial capacity. The larger brains correlate with bipedalism.

It seems man's upward stance freed his forelimbs for other uses such as tool manipulation and construction. These "correlations between brain size, bipedalism, tool manipulation, and associated features suggest that the characteristics evolved more or less as a unit... with brain size increase following the development of the others." (Savage)

Those individuals with the greatest manipulative ability of the hands were the most adept toolmakers and thus had an advantage in the competition for survival. Using the hands required manipulative ability and intelligence. It appears that as the brain evolved, it also increased in size.

PROCEDURE:

Begin this exercise by taping down one student's thumbs. This student should perform the following tasks without the use of his/her thumbs and then remove the tape and try the tasks again.

Activity	**Without thumbs (time/sec)**	**With thumbs (time/sec)**
Tighten the screw in the board		
	Without thumbs (appearance)	**With thumbs (appearance)**
Write your name		

4. What role do you think this adaptation (opposable thumb) played in human evolution?

5. Which came first increased cranial capacity or bipedalism? Explain your answer. Discuss with your group before answering.

19

Human Evolution
Skull Examination

Objectives

By the end of this exercise you should be able to:

1. Describe the parts of a modern human skull.
2. Distinguish between skulls of males and females.
3. Distinguish between skulls of apes and modern humans.

Throughout time, no issue has interested humans more than learning about our origins. Where did we come from? What did our ancestors look like? Where did they live? Today, we are beginning to understand those questions, thanks to evidence provided by biologists and anthropologists. Nevertheless, the topic remains controversial and often elicits strong responses from people.

In this exercise you will examine some of the information underlying recent ideas about human evolution by examining the skulls of human and humanlike organisms. Specifically, you will examine skulls of

Gorilla gorilla, the modern gorilla. Gorillas and humans share a common ancestor.

Australopithecus (fig. 19.1), a relatively small, humanlike organism that had small, pointed canine teeth, an elongate face, and was adapted for bipedalism and an upright stance. The most famous australopithicine was "Lucy," discovered in 1974 in Ethiopia. *Australopithecus*, the best known of the early humanlike organisms, lived 3.5–2.5 million years ago.

Homo erectus, a human ancestor characterized by an upright posture, a sloping forehead, a large brow ridge, a thick skull, and a larger braincase (900 cm^3) than earlier humanlike organisms. *H. erectus* lived 1,800,000–27,000 years ago.

Homo sapiens, or modern humans, are characterized by a vertical forehead, small brow ridge, thin skulls, and a larger braincase (1400 cm^3) than earlier humanlike organisms. *H. sapiens* appeared 200,000 years ago.

As you examine these skulls, think of how their traits link modern humans with other primates. Also know that anthropologists are constantly making new discoveries of early human fossils and that the specimens you will analyze represent a small subset of these species.

Figure 19.1
Australopithecus africanus was the first australopithecine to be discovered. It was unearthed in southern Africa by Raymond Dart in the 1920s.

THE MODERN HUMAN SKULL

The human skull (fig. 19.2), including the lower jaw, consists of 22 bones, 8 of which are paired. All of the bones fit together at joints called sutures, which appear as wavy lines. Projections and raised lines are sites of muscle attachment.

Although skulls from males and females share many features, they usually can be distinguished. However, such a diagnosis—even when done by experts—is only about 90% reliable (80% if the lower jaw is missing).

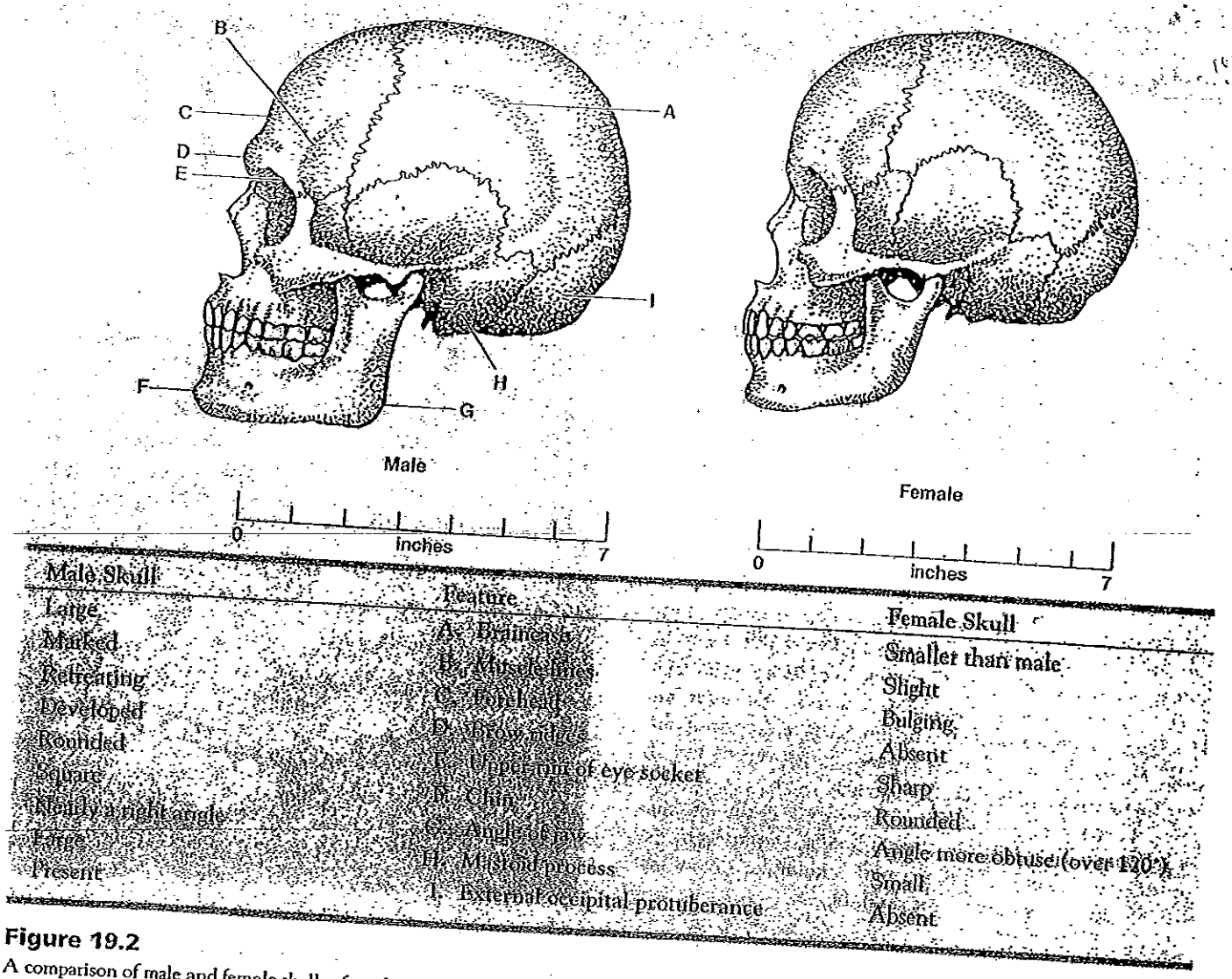


Figure 19.2
A comparison of male and female skulls of modern *Homo sapiens*.

Procedure 19.1

Examine skulls of modern humans

1. Examine the skulls of modern humans available in the lab to familiarize yourself with their structure and geometry. Be sure to examine skulls of males and females.
2. Compare these skulls with those shown in figure 19.2. The letters beside each feature in the table correspond to those shown in the diagrams.

Question 1

a. How do skulls of females differ from those of males?

b. What is the biological significance of these differences?

Procedure 19.2

Examine the skulls of apes

Use figure 19.3 and the specimens in the lab to study the following features of ape and human skulls.

Face

Prognathism is the extent to which the face and jaws protrude forward when viewed from the side. Their larger teeth and jaws cause apes to exhibit more prognathism than do humans.

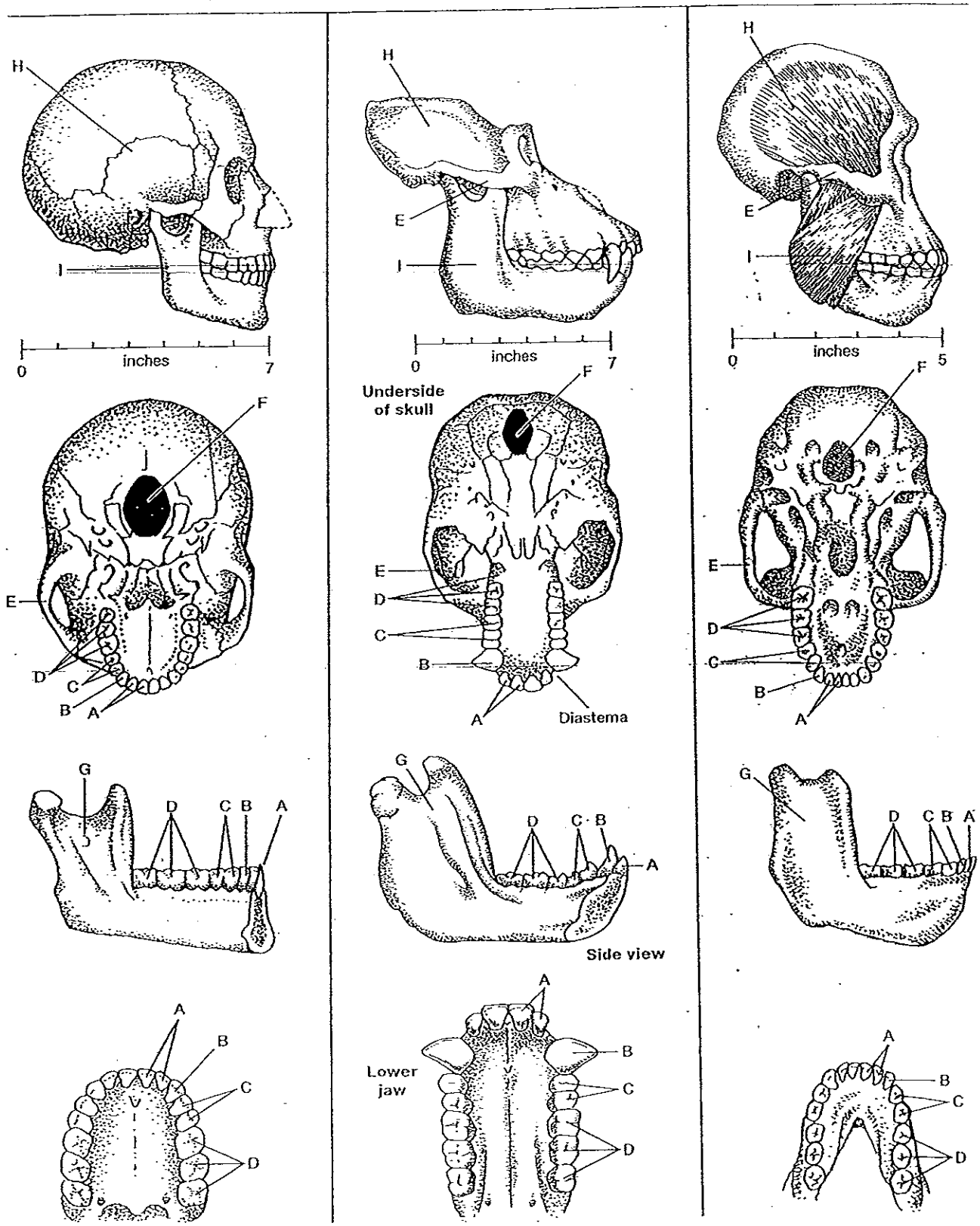


Figure 19.3

Comparison of skull features of modern *Homo sapiens*, gorilla, and *Australopithecus* skull and jaws:

A. Incisors
B. Canines
C. Premolars
D. Molars
E. Zygomatic arch
F. Foramen magnum
G. Vertical ramus for muscle attachment
H. Skull surface for muscle attachment
I. Jaw surface for muscle attachment

Feature	Apes	Humans
Sagittal crest		
Brow ridge		
Foramen magnum		
Prognathism		
Canines		
Canine diastema		
Incisors		
Chin		
Arrangement of teeth		

Braincase

The brow ridge, the mass of bone over the eye sockets, supports the upper facial skeleton against forces produced by chewing. The brow ridge in apes is prominent. In humans, the brow ridge of modern humans is largely internalized because our frontal bone has expanded outward to a more vertical angle.

The sagittal crest is a thin ridge of bone atop and down the middle of the braincase. The sagittal crest is associated with having a small braincase and powerful jaws. In apes, the sagittal crest is an attachment site for the large temporalis muscle used for chewing.

The foramen magnum is the large opening in the base of the skull through which the spinal cord passes. The position of the foramen magnum reflects the posture of the body (and, indirectly, the pattern of movement) of hominoids. Humans stand erect and walk with the head directly over the vertical spinal column. Conversely, the knuckle-walking apes hold their heads forward, with the foramen magnum toward the rear. Thus, the foramen magnum is located in a more rear position in apes than in humans.

Teeth and Jaws

Adult apes and humans have the same number and types of teeth: 4 canines, 8 premolars, 12 molars, and 8 incisors. Identify these bones on the skulls and diagrams. In apes the canine teeth are longer and more pointed than others. In humans, the canine teeth seldom project above the others.

In humans, the four front teeth (incisors) are smaller, more vertical, and flatter than in apes. In nonhuman primates, the canine diastema is the gap in the teeth corresponding to the canines of the opposite jaw.

Question 2

a. Between which teeth does the gap occur? Why are these gaps essential in nonhuman primates?

b. Why are they usually absent in humans?

Humans have an outward projection on the lower part of their lower jaw (i.e., chin). Apes lack this feature; instead, they have a smooth, even slant to the front part of their jaw. In humans, teeth are arranged in a relatively continuous curve from the third molar around to the other third molar. The arrangement of teeth in apes is straighter, with a slight curve in front. This is primarily because of the larger size of the incisors and canines.

To summarize the differences between skulls of modern humans and apes, complete table 19.1.

Procedure 19.3

Study the skulls of fossil primates

Use the information and diagrams in figures 19.4–19.7 to learn about skulls of humans and ancient primates.

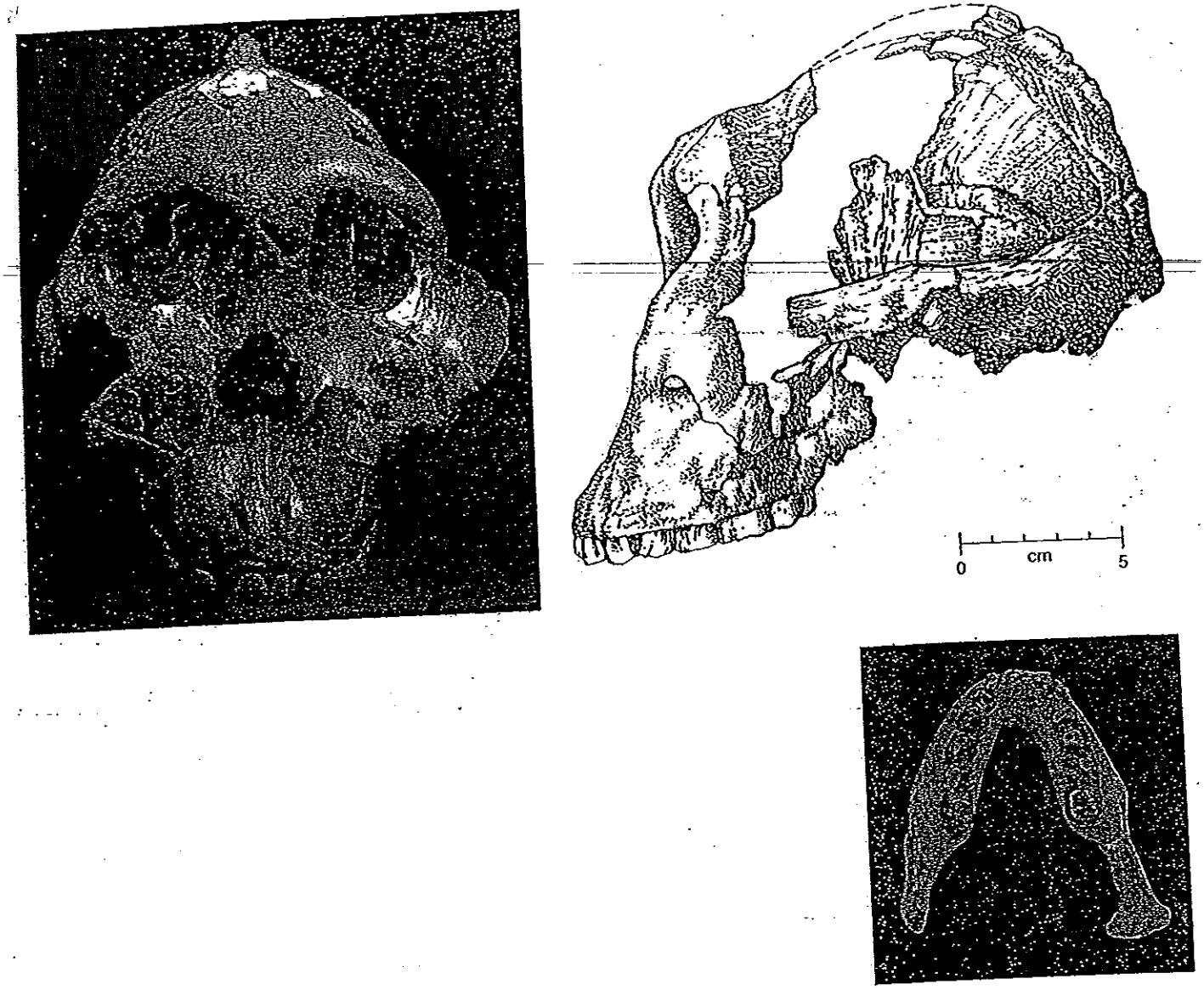


Figure 19.4
Views of the skull and teeth of *Australopithecus boisei*. Age: 1.8 million years. This skull includes massive molar and premolar teeth (similar in size to those of gorillas), and is nearly complete except for the lower jaw. It is commonly known as "Zinj," an abbreviation of the original genus name *Zinjanthropus*. Zinj and the remains of many smaller hominids (humanlike organisms) were discovered in the Olduvai Gorge in Tanzania by Mary and Louis Leakey in 1959.

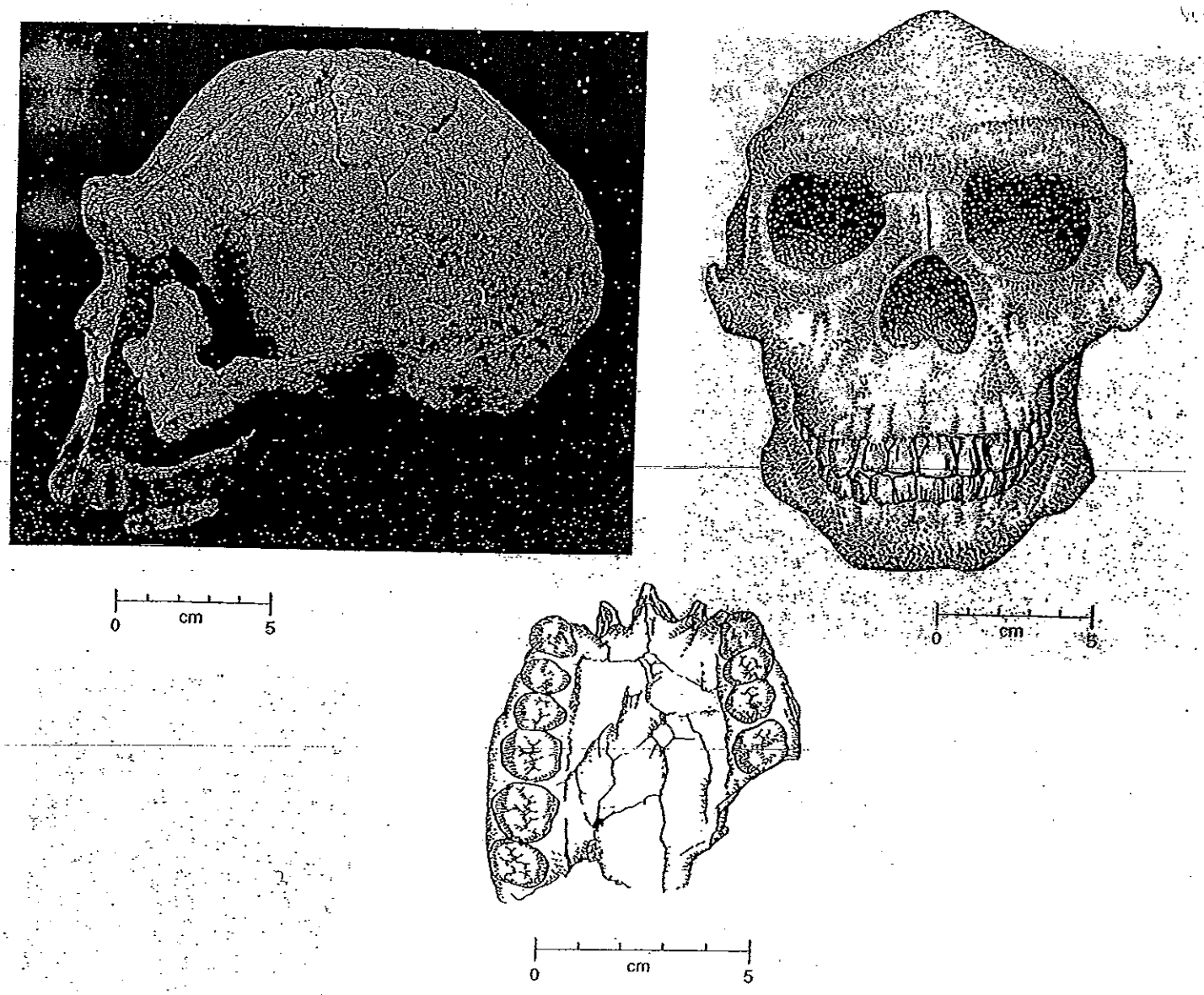


Figure 19.5

Views of the skull and teeth of *Homo erectus*. Age: Less than 1 million years. This diagram shows a reconstruction that includes parts of skulls discovered in 1937 and 1939 in Java (Sangiran). The skull of *Homo erectus* differs from modern human skulls in that it is low vaulted and has a relatively small volume; *H. erectus* skulls have volumes of 900–1100 cm^3, whereas skulls of modern humans have volumes of approximately 1400 cm^3. Skulls of *H. erectus* also have small mastoid processes behind the ear openings, large jaws, and small chins, and large molar teeth.

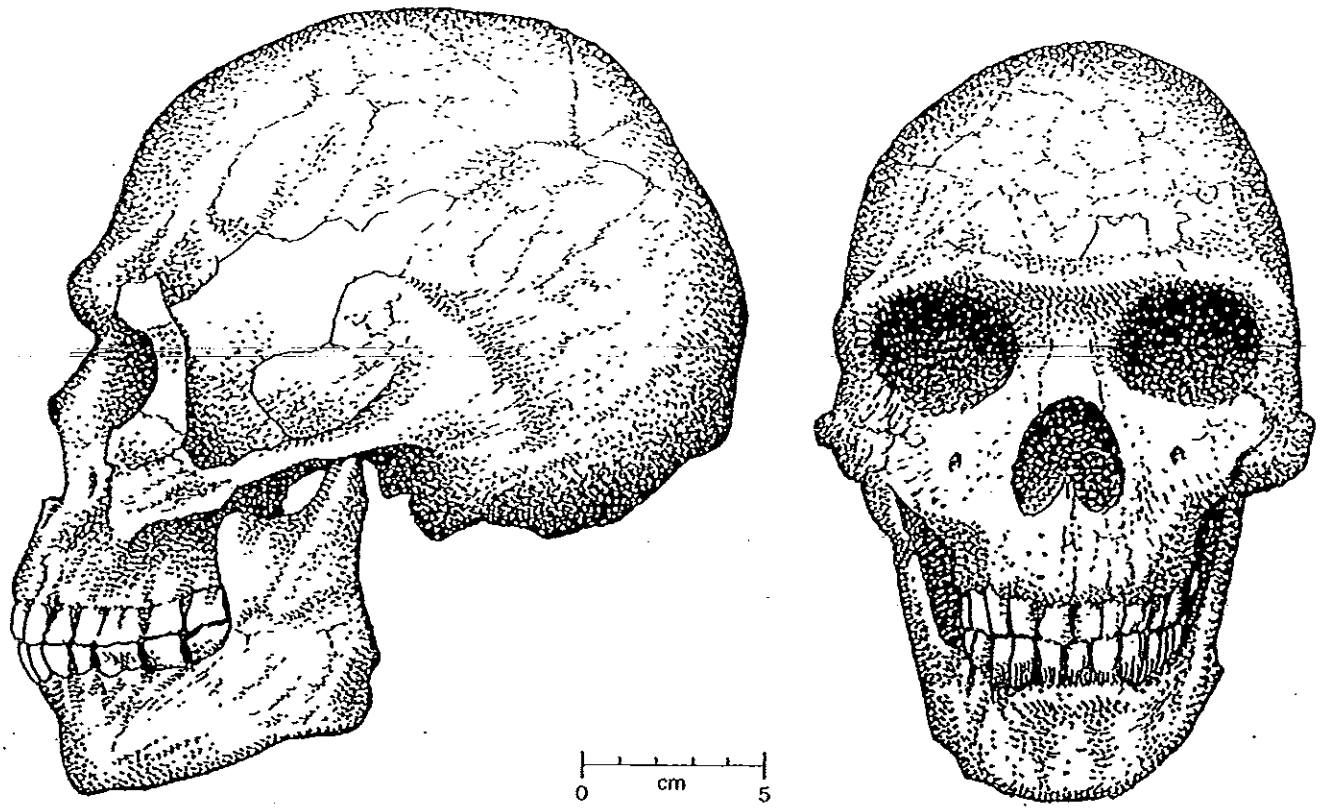


Figure 19.6

Views of the skull and teeth of *Homo sapiens*. Age: About 32,000 years. Also known as Neanderthal Man, this type was recovered in 1932 from Mugharet-es-Skhull, Wadi el-Mughara, Israel. The skull is nearly complete.

Homo sapiens (modern)

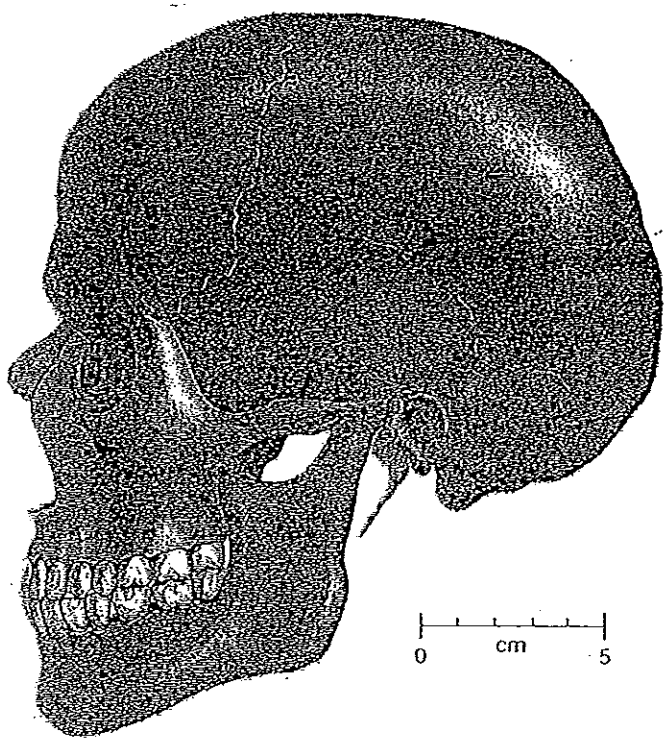


Figure 19.7

Skull of modern *Homo sapiens*. Age: About 10,000 years. This skull is from one of at least 50 skeletons recovered at Oued Agrious, Algeria, during the late 1920s.