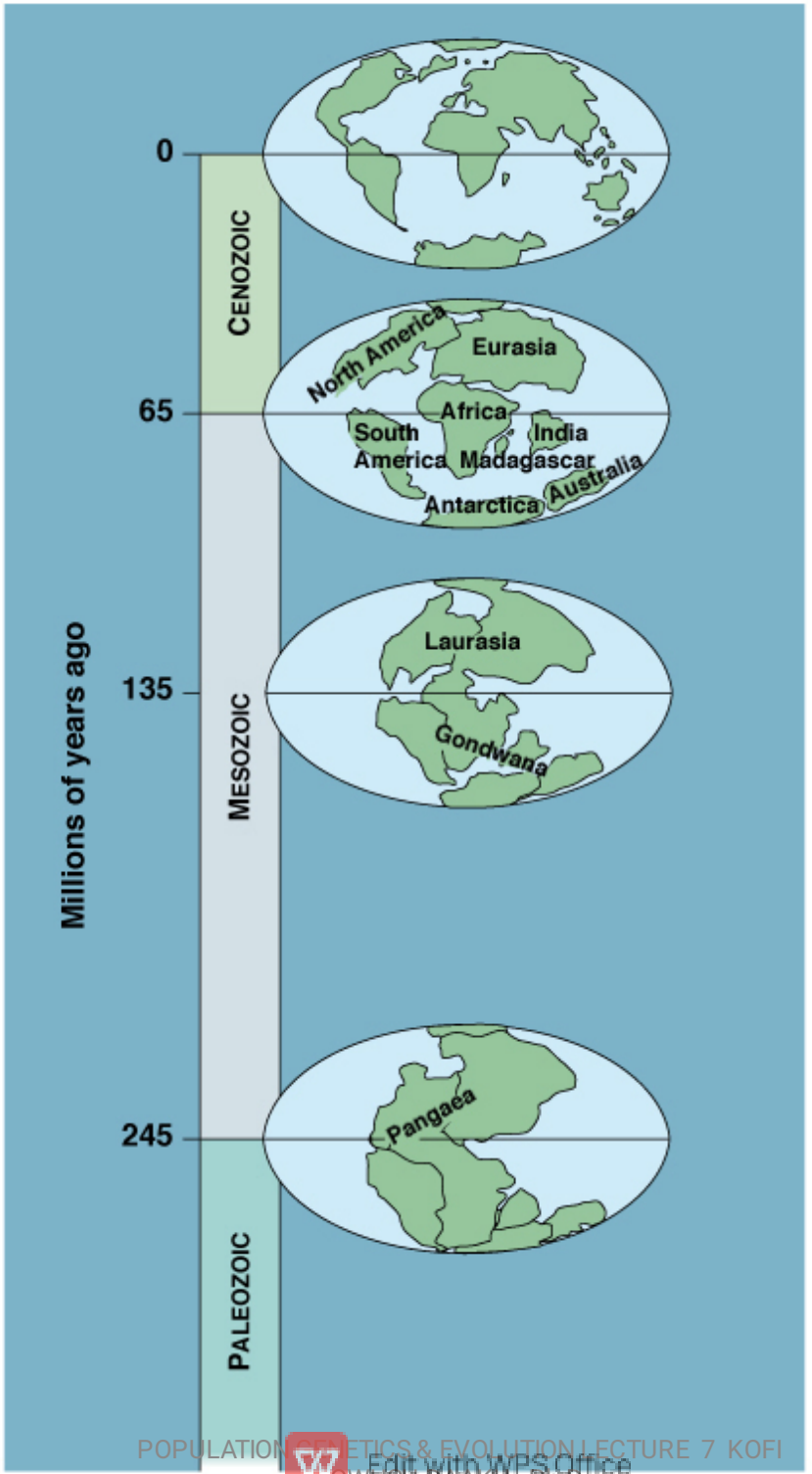
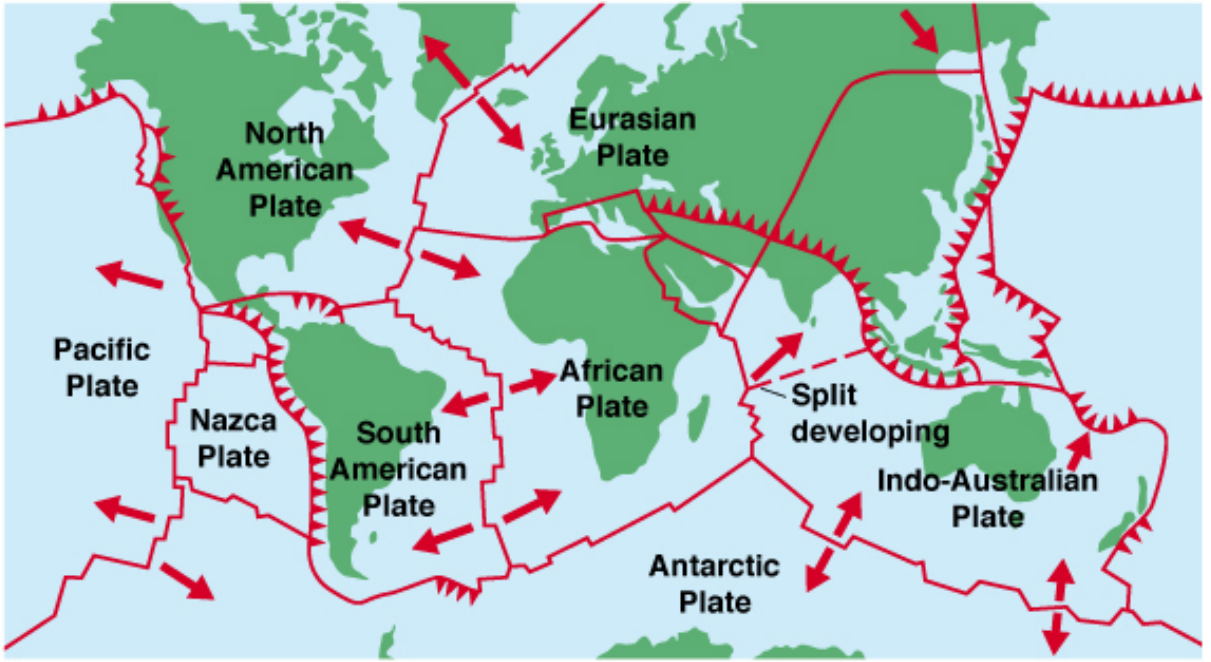
Geological time scale

DR. KOFI OWUSU-DAAKU

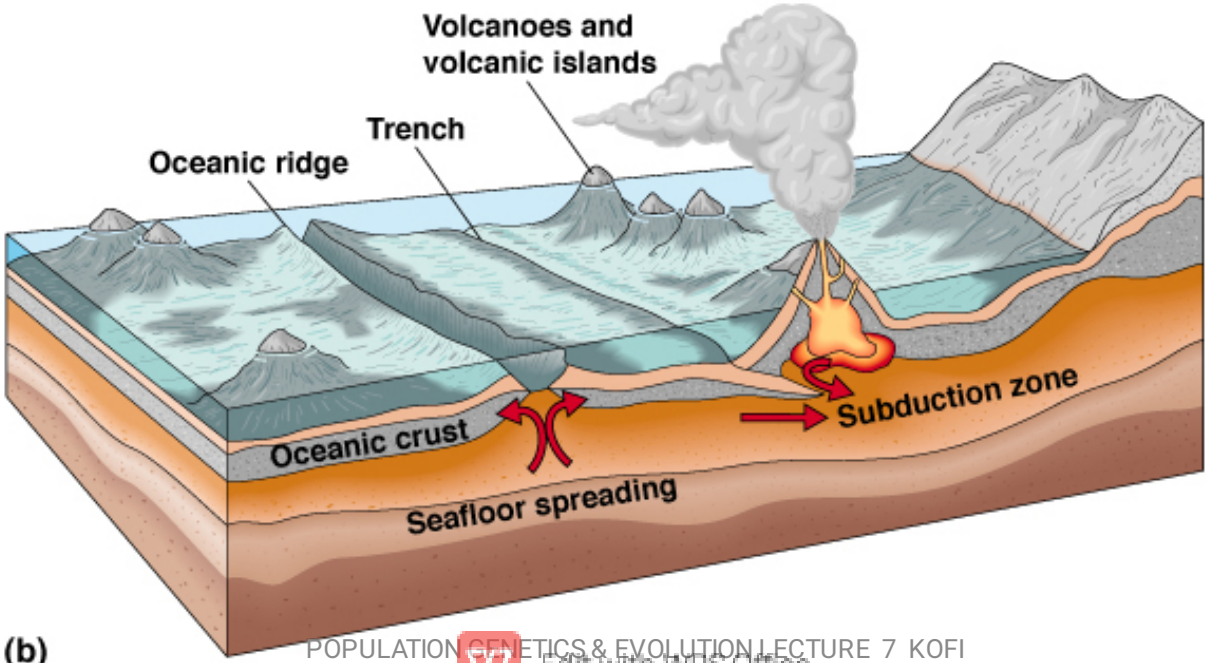
POPULATION GENETICS AND EVOLUTION

LECTURE 8





(a)



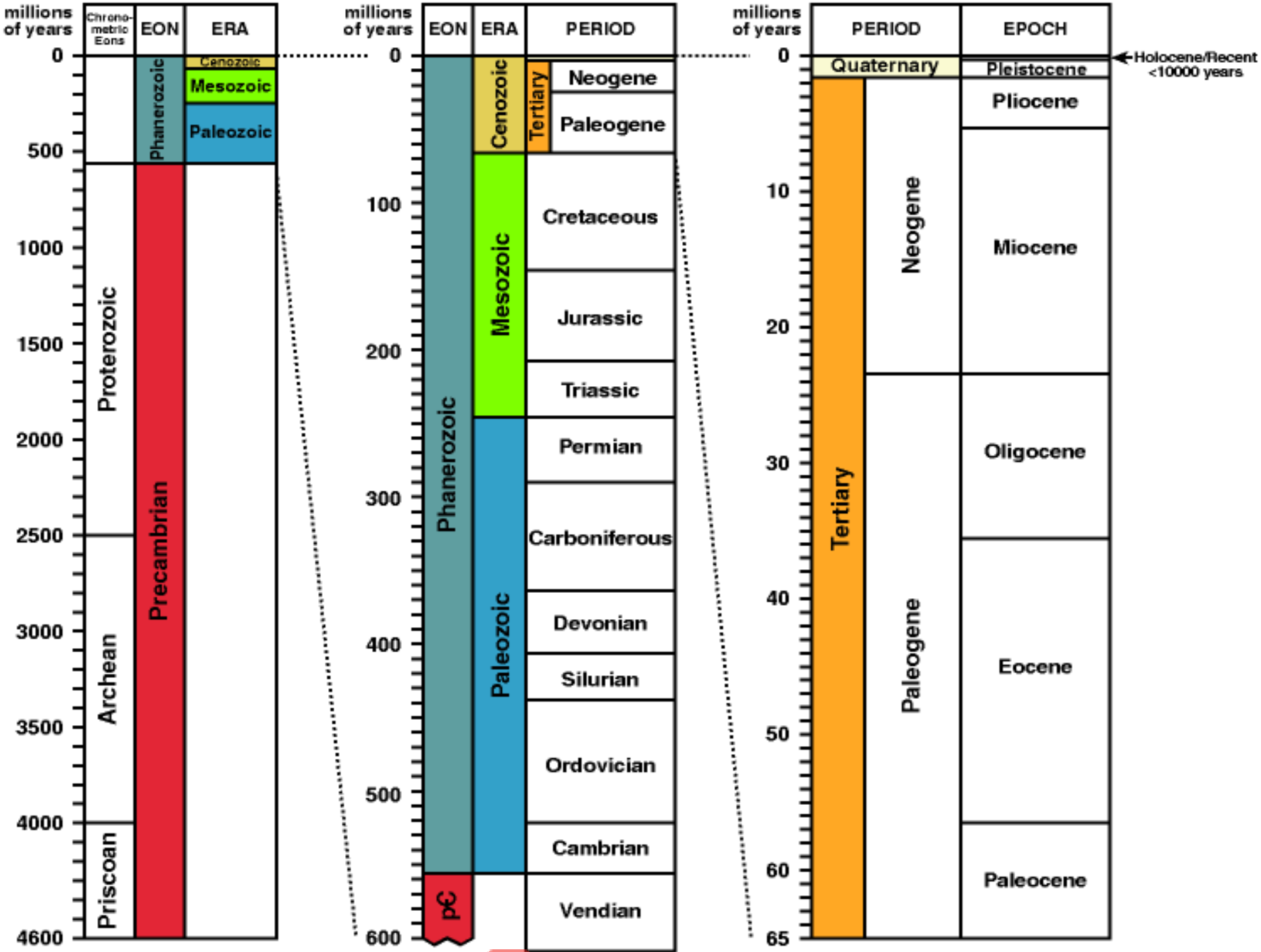
(b)

Extinctions

- Background extinction is the rather inevitable loss of species as local conditions change over periods (usually long) of time.
- Mass extinctions are abrupt disappearances due to catastrophic, global events.

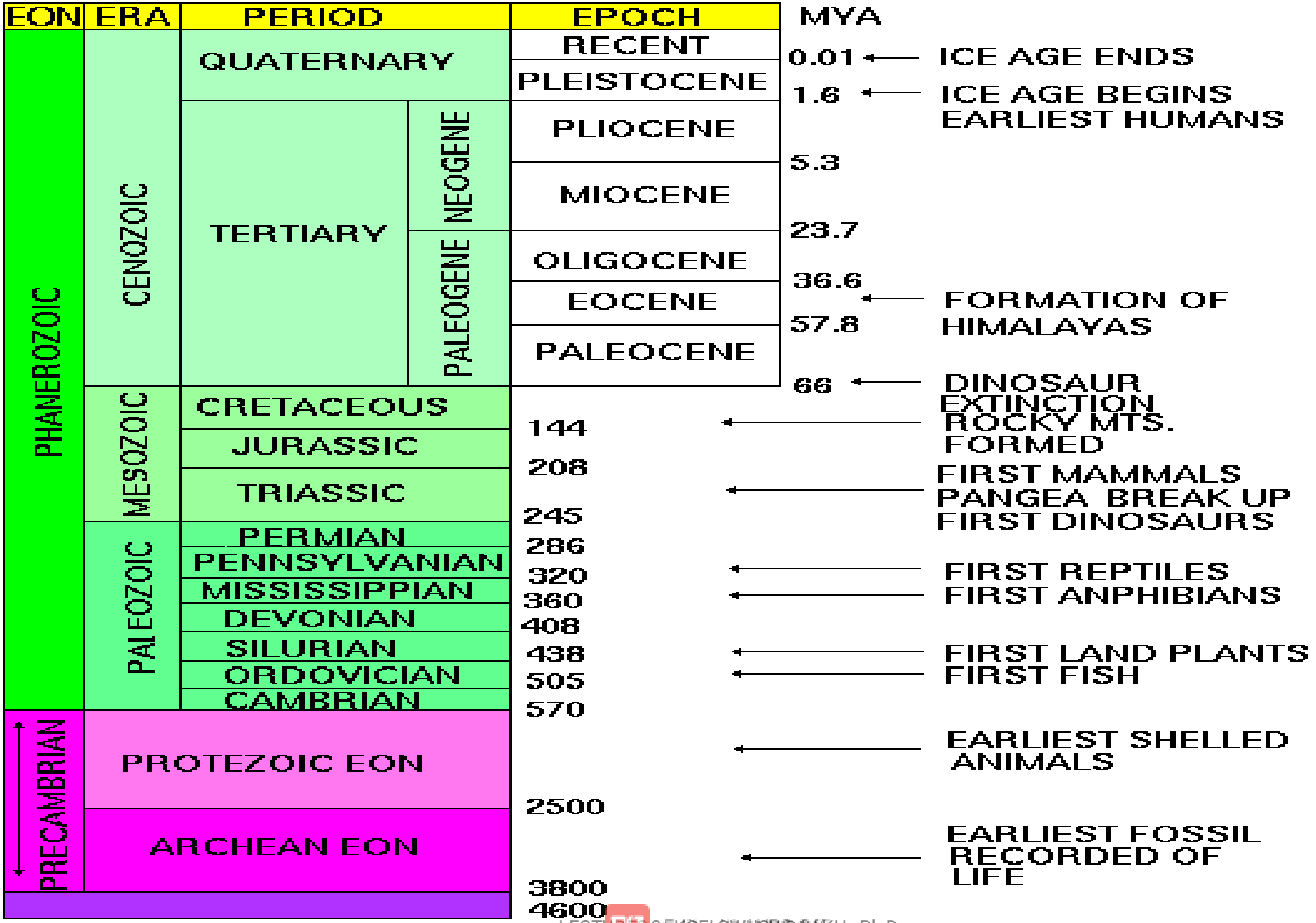
TIME LINE IN EVOLUTION – THE GEOLOGICAL TIME SCALE

Re


millions of years
Chrono-metric Eons
EON
ERA
0
500
1000
1500
2000
2500
3000
3500
4000
4600
Phanerozoic
Precambrian
Cenozoic
Mesozoic
Paleozoic
Proterozoic
Archean
Priscoan
millions of years
EON
ERA
PERIOD
0
100
200
300
400
500
600
Phanerozoic
pЄ
Cenozoic
Mesozoic
Paleozoic
Tertiary
Neogene
Paleogene
Cretaceous
Jurassic
Triassic
Permian
Carboniferous
Devonian
Silurian
Ordovician
Cambrian
Vendian
millions of years
PERIOD
EPOCH
0
10
20
30
40
50
60
65
Quaternary
Tertiary
Neogene
Paleogene
Pleistocene
Pliocene
Miocene
Oligocene
Eocene
Paleocene
Holocene/Recent
<10000 years

CENOZOIC ERA (Age of Recent Life)	Quaternary Period	The several geologic eras were originally named Primary, Secondary, Tertiary, and Quaternary. The first two names are no longer used. Tertiary and Quaternary have been retained but used as period designations.
	Tertiary Period	
MESOZOIC ERA (Age of Medieval Life)	Cretaceous Period	Derived from Latin word for chalk (creta) and first applied to extensive deposits that form white cliffs along the English Channel.
	Jurassic Period	Named for the Jura Mountains, located between France and Switzerland, where rocks of this age were first studied.
	Triassic Period	Taken from the word "trias" in recognition of the threefold character of these rocks in Europe.
PALEOZOIC ERA (Age of Ancient Life)	Permian Period	Named after the province of Perm, U.S.S.R., where these rocks were first studied.
	Pennsylvanian Period	Named for the State of Pennsylvania where these rocks have poduced much coal.
	Mississippian Period	Named for the Mississippi River Valley where these rocks are well exposed.
	Devonian Period	Named after Devonshire, England, where these rocks were first studied.
	Silurian Period	Named after Celtic tribes, the Silures and the Ordovices, that lived in Wales during the Roman Conquest.
	Ordovician Period	
	Cambrian Period	Taken from the Roman name for Wales (Cambria) where rocks containing the earliest evidence of complex forms of life were first studied.
PRECAMBRIAN		The time between the birth of the planet and the appearance of complex forms of life. More than 80 percent of the Earth's estimated 4-1/2 billion years falls within this era.


MESOZOIC ERA
200 MILLION YEARS AGO
251 MILLION YEARS AGO
TRIASSIC PERIOD
JURASSIC PERIOD
CRETACEOUS PERIOD
65 MILLION YEARS AGO
PALEOZOIC ERA
542 M.Y. AGO
CAMBRIAN PERIOD
ORDOVICIAN PERIOD
SILURIAN PERIOD
PERMIAN PERIOD
PENNSYLVANIAN PERIOD
MISSISSIPPIAN PERIOD
DEVONIAN PERIOD
PRECAMBRIAN ERA
1 B.Y. AGO
2 B.Y. AGO
3 B.Y. AGO–EARLIEST ORGANIC STRUCTURES
4.5 BILLION YR. AGO
CENOZOIC ERA
TERTIARY PERIOD
Paleocene Epoch
Eocene Epoch
Oligocene Epoch
Miocene Epoch
Pliocene Epoch
QUATERNARY PERIOD
Pleistocene Epoch
Holocene Epoch
11,500 YR. AGO


EON
ERA
PERIOD
EPOCH
MYA
PHANEROZOIC
CENOZOIC
QUATERNARY
RECENT
PLEISTOCENE
0.01
ICE AGE ENDS
1.6
ICE AGE BEGINS
EARLIEST HUMANS
TERTIARY
NEOGENE
PLIOCENE
5.3
MIOCENE
23.7
PALEOGENE
OLIGOCENE
36.6
EOCENE
FORMATION OF HIMALAYAS
57.8
PALEOCENE
66
DINOSAUR EXTINCTION
MESOZOIC
CRETACEOUS
144
ROCKY MTS. FORMED
JURASSIC
208
FIRST MAMMALS
TRIASSIC
PANGEA BREAK UP
245
FIRST DINOSAURS
PALEOZOIC
PERMIAN
286
PENNSYLVANIAN
320
FIRST REPTILES
MISSISSIPPIAN
360
FIRST ANPHIBIANS
DEVONIAN
408
SILURIAN
438
FIRST LAND PLANTS
ORDOVICIAN
505
FIRST FISH
CAMBRIAN
570
PRECAMBRIAN
PROTEZOIC EON
EARLIEST SHELLED ANIMALS
2500
ARCHEAN EON
EARLIEST FOSSIL RECORDED OF LIFE
3800
4600

GEOLOGICAL TIME SCALE

- Geological time scale refers to the various stages in the history of life on the earth.
- On the basis of fossils found in rocks, the geological time scale has been divided by scientists into different intervals that are characterised by the most significant changes that occurred in the organisation of organisms.

- The largest defined unit is the Eon. An Eon is divided into Eras and Eras are, in turn, divided into Period and Epochs.
- Nicholas Steno in the late 17th century laid down the principle underlying the geological time scale.
- The geological time scale has been divided into six major divisions called Eras, which are as follows:

I. Azoic Era

(a) Earliest time in the history of the earth.

(b) Complete absence of living organisms.

(c) The earth was formed during this period.

II. Archaeozoic Era

(a) Age of invisible life.

(b) Prokaryotes and eukaryotes originated.

(c) Oxygen begins to accumulate in the atmosphere.

(d) Age of primitive marine invertebrates.

III. Proterozoic Era

(a) Extended from 1,600 to 6 million years ago.

(b) Age of primitive marine invertebrates.

(c) The Archaeozoic and Proterozoic eras are together designated as the Cryptozoic era or 'Precambrian time'.

IV. Palaeozoic Era

(a) Popularly known as the 'cradle of ancient life'.

(b) Duration of about 370 million years, beginning about 600 million years ago and ending by about 230 million years ago.

(c) At the beginning of Palaeozoic era, life existed only in or near the oceans.

(d) It was also characterised by mass extinction of many life forms.

(e) Fossils of first vertebrates appeared.

The Palaezoic era has been divided into the following six periods:

1. The Cambrian Period

- Age: 600 to 500 million years ago.
- Age of trilobites

2. Ordovician Period

- Age: 438 to 505 million years ago.
- The first vertebrate appeared.

3. Silurian Period

- Age: 405 to 425 million years ago.
- The first jaw vertebrate appeared.

4. Devonian Period

- Age: 360- 408 million years ago.
- Age of fishes.

5. Carboniferous Period

- Age: 285 to 320 million years ago.
- Formation of coral beds.
- Origin of reptiles.

6. Permian Period

- Age: 245 to 285 million years ago.
- Trilobites disappear completely.
- Crinoids became rare.
- Appearance of first reptiles, cotylosaurs.

V. Mesozoic Era

- It is one of the three eras of the Phanerozoic era.
- The Mesozoic era lasted about 180 million years from about 245 million years to about 65 million years ago.
- It is called the age of dinosaurs.

- At the beginning of Mesozoic era, all of the world's continents were joined into the super-continent of Pangea.
- By the end of this era, most continents had separated into their present forms.

1. Triassic Period

The Mesozoic era is divided into three periods:

- Age: 208 to 225 million years.
- Egg-laying mammals made their first appearance.
- The first dinosaurs appeared.
- Primitive amphibians had disappeared

2. Jurassic Period

- Age: 144 to 188 million years ago.
- Dinosaurs were dominant.
- Marsupial mammals originated.
- At the end of this period, the *Archaeopteryx* (primitive bird) had originated.

3. Cretaceous Period

- Age: 63 to 133 million years ago.
- Giant reptiles became extinct.
- Eutherian mammals made their appearance.

VI. Cenozoic Era

- It is the last major division of the geologic time scale.
- It is the present age (65 million years ago to the present).
- It is the age of mammals.
- It is divided into the following two periods:

1. Tertiary Period

- Duration: 1 to 63 million years ago.
- More than 95 percent of the Cenozoic era belongs to the Tertiary period.
- Modern orders of class mammalians originated.

(a) **Paleocene Epoch**

The Tertiary period is divided into following five epochs:

- Age: 58 to 63 million years ago.
- Primitive primates appeared.

(b) **Eocene Epoch**

- Age: 37 to 58 million years ago.
- The horse originated

(c) **Oligocene Epoch**

- Age: 24 to 37 million years ago.
- Odd-toed ungulates were widespread.
- Even-toed ungulates began to radiate.
- Human-like primates appeared.

(d) **Miocene Epoch**

- Age: 6 to 24 million years ago.
- Human-like apes appeared.
- The *Merychippus* evolved.
- Modern dogs, elephants and cats appeared.

(e) **Pliocene Epoch**

- Age: 2 to 6 million years ago.
- Hominids, i.e., human-like forms evolved.

2. Quaternary Period

- The Quaternary period includes only the last 1.8 million years.
- It is divided into the following two epochs:

a) The Pleistocene Epoch

- Age: 0.6 to 2 million years ago.
- Humans and the modern horse *Equus* evolved in this period.
- Hunting by humans, along with climatic change, served to kill off most of the planet's mega fauna.

b) The Holocene Epoch

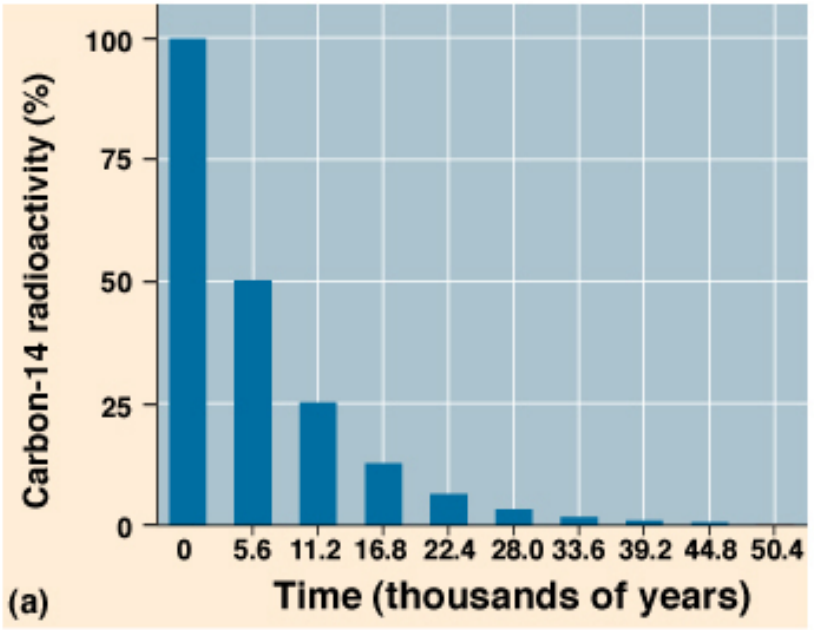
- It began 0.6 million years ago.
- The age of humans.

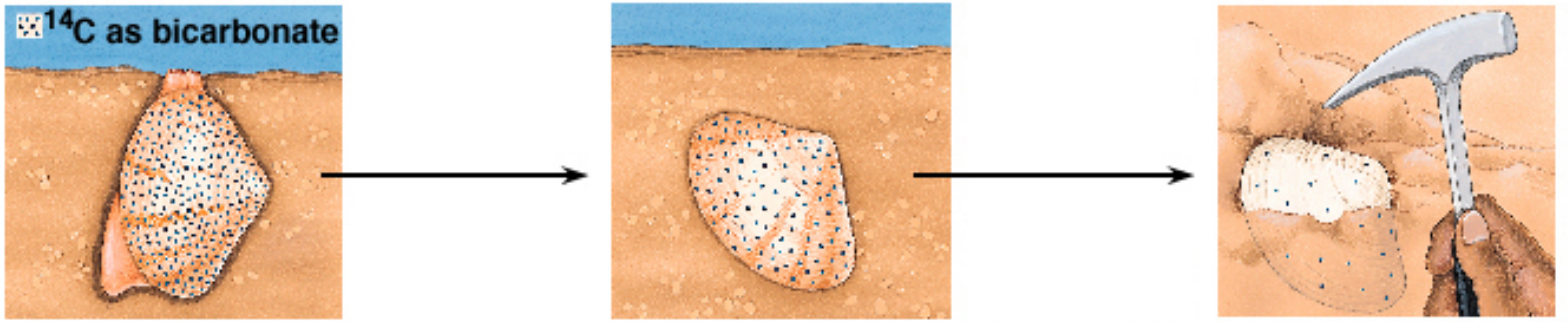
Floods and Fossils

- Traditional explanations of rock formations and fossils relied on effects of the Great Deluge.
- Modern geologists view the same evidence as showing changes in geology and living organisms through time.
- ***Macroevolution refers to the large-scale patterns, trends, and rates of change among highertaxa groupings of species.***
- Evolution proceeds by modifications of organisms that already exist.
- "New"" species emerge as mutation, natural selection, and genetic drift change allele frequencies in reproductively isolated populations.

Fossilization

- Fossils are recognizable, physical evidence of organisms that lived long ago-skeletons, shells, leaves, seeds, imprints of leaves and tracks (trace fossils),and even fossilized feces (coprolites)
- For fossilization, body parts or impressions must be buried in rock before decomposition.
- Over time, chemical changes and pressure transform living structures into stony hardness.
- Preservation is favored when organisms are buried rapidly in the absence of oxygen and the burial site is left undisturbed.





(b)

❶ While an organism, in this case a clam, is alive, it assimilates the different isotopes of each element in proportions determined by their relative abundances in the environment. Carbon-14 is taken up in trace quantities, along with much larger quantities of the more common carbon-12.

❷ After the clam dies, it is covered with sediment, and its shell eventually becomes consolidated into a layer of rock as the sediment is compressed. From the time the clam dies and ceases to assimilate carbon, the amount of carbon-14 relative to carbon-12 in the fossil declines due to radioactive decay.

❸ After the clam fossil is found, its age can be determined by measuring the ratio of the two isotopes to learn how many half-life reductions have occurred since it died. For example, if the ratio of carbon-14 to carbon-12 in this fossil clam was found to be one-fourth that of a living organism, this fossil would be about 11,200 years old.

Interpreting the Geologic Tombs

- Stratification, the layering of sedimentary deposits bearing fossils, is quite similar from continent to continent.
- Deepest rock strata are assumed to be the oldest, surface layers the youngest.
- Abrupt changes in the fossils in the layers were the basis for dividing earth history into great eras, which formed a geologic time scale (Proterozoic, Paleozoic, Mesozoic, and Cenozoic) to which actualdates were added later.

Interpreting the Fossil Records

- The fossil record is far from complete, but some lineages are extensive.
- Fossil records vary according to type of organism (hard parts preserve wet soft parts do not), stability of the geographical region (sea floor vs, eroding hill), and quality of the specimen.

A Skull of *Homo erectus*

B Petrified tree

C Ammonite casts

D Dinosaur tracks

E Fossilized organic matter of a leaf

F Insect in amber

G "Ice Man"

Meanwhile, geology was advancing

Fossil record – discovery of rocks that resemble animal parts

Are fossils remnants of living things or a bizarre mineral formation?

Robert Hooke (late 1600's) - microscopy studies showing that fossils closely resemble living forms

How did fossils get where they are?
Why do some fossils resemble no living species?

→ Could the earth be very old?
→ Can species go extinct?

Law of superposition (late 1600's) - geological layers correspond with age

- The fossil record
  - Reveals that organisms have evolved in a historical sequence

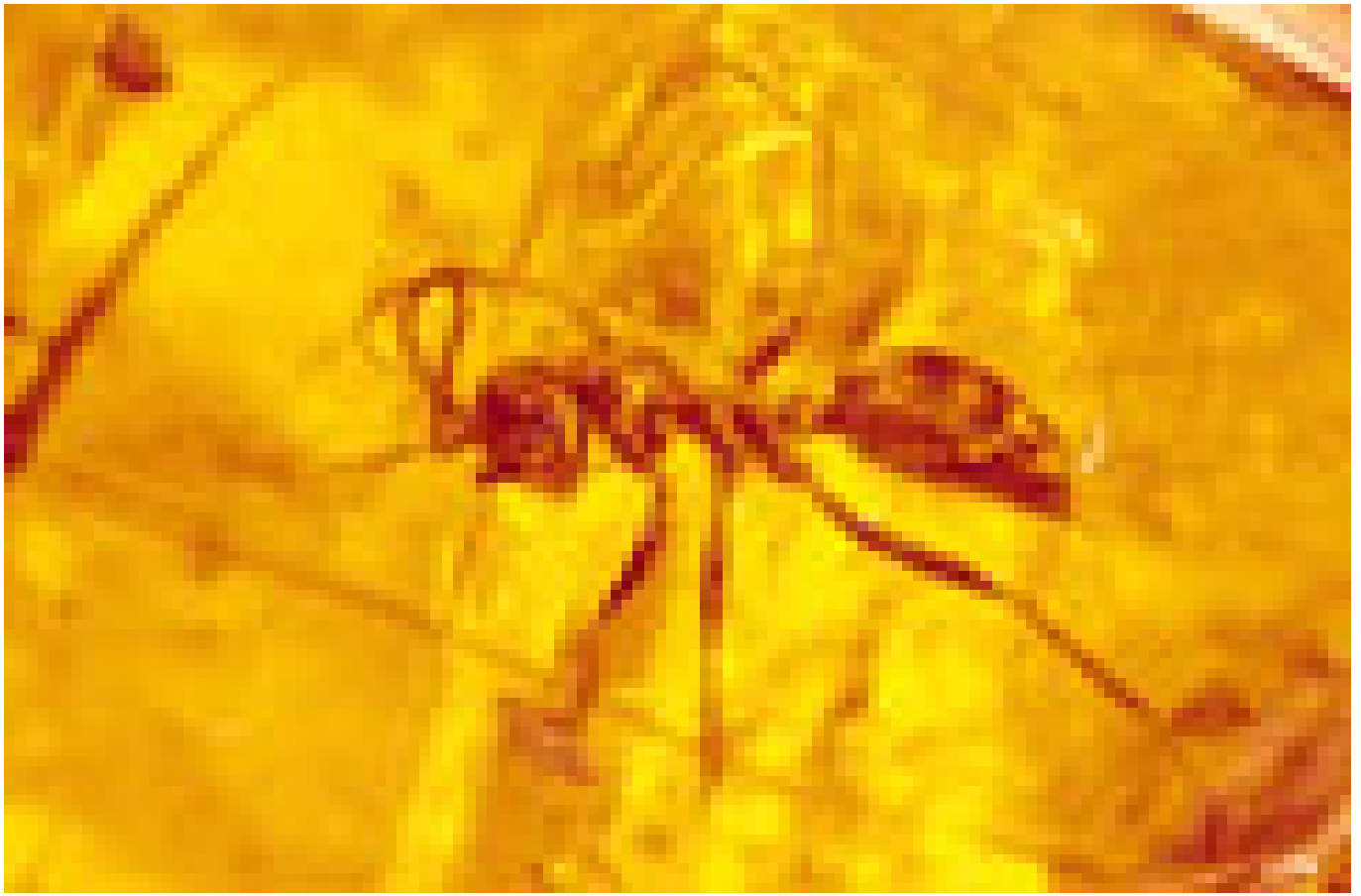
Strata

Figure 13.3H

Weathering has exposed layers of sedimentary rock near the Paria River in Utah.

Fossil trilobite

Fossils in Amber

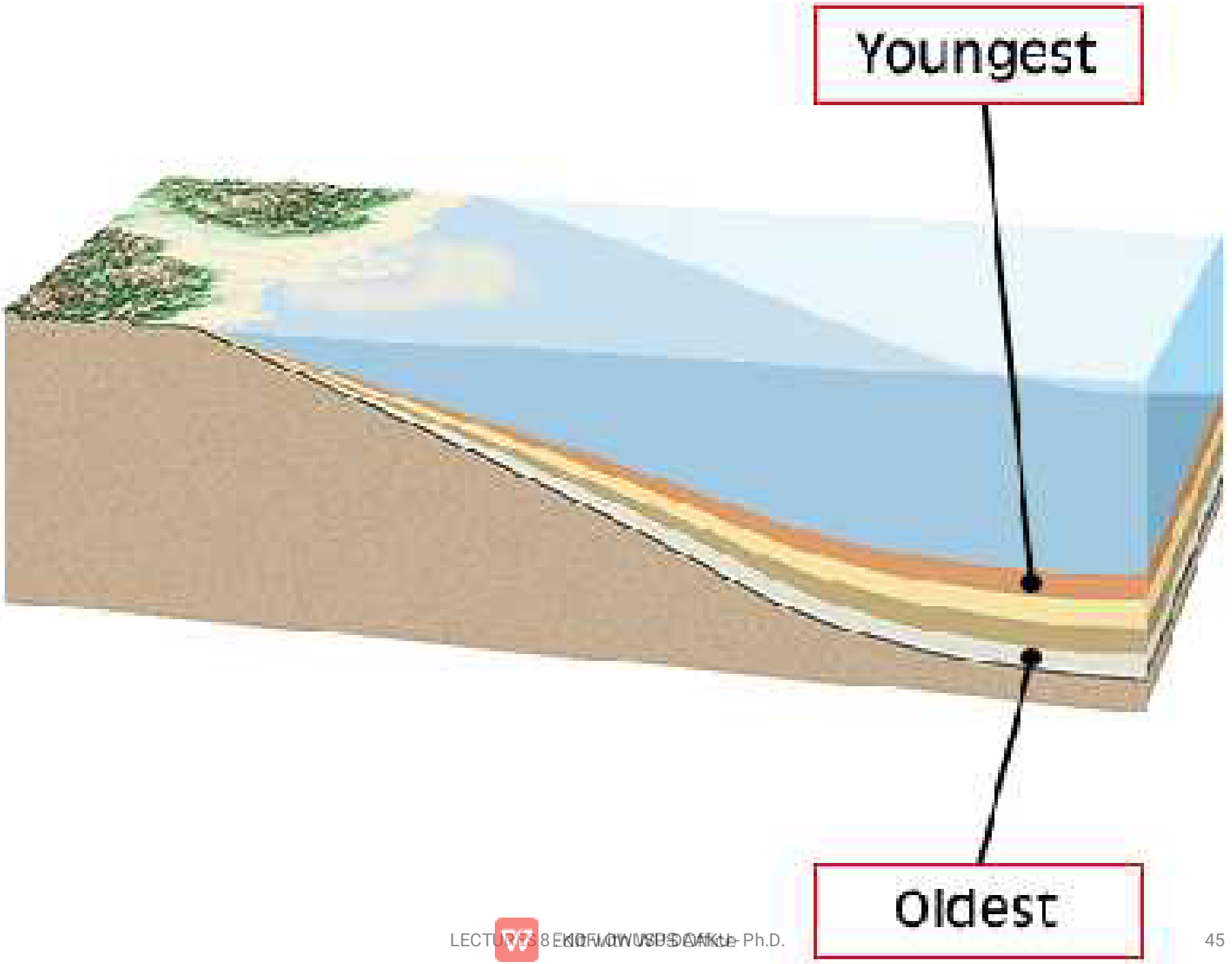


Fossil Jellyfish

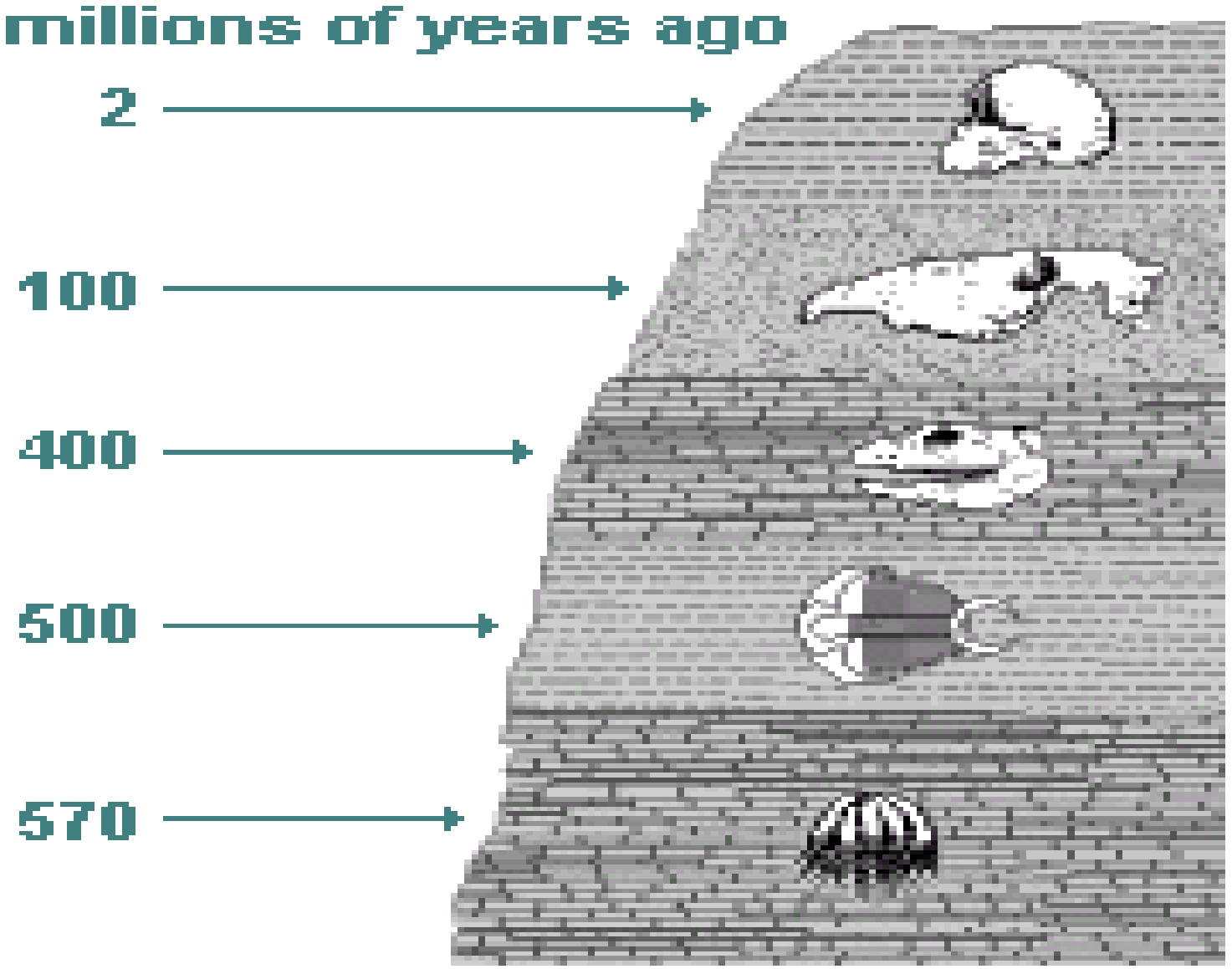
Relative Time

Steno's Laws

The **principle of original horizontality** states that strata are originally deposited in uniform horizontal sheets.


Youngest
Oldest

Strata layers in Rocks

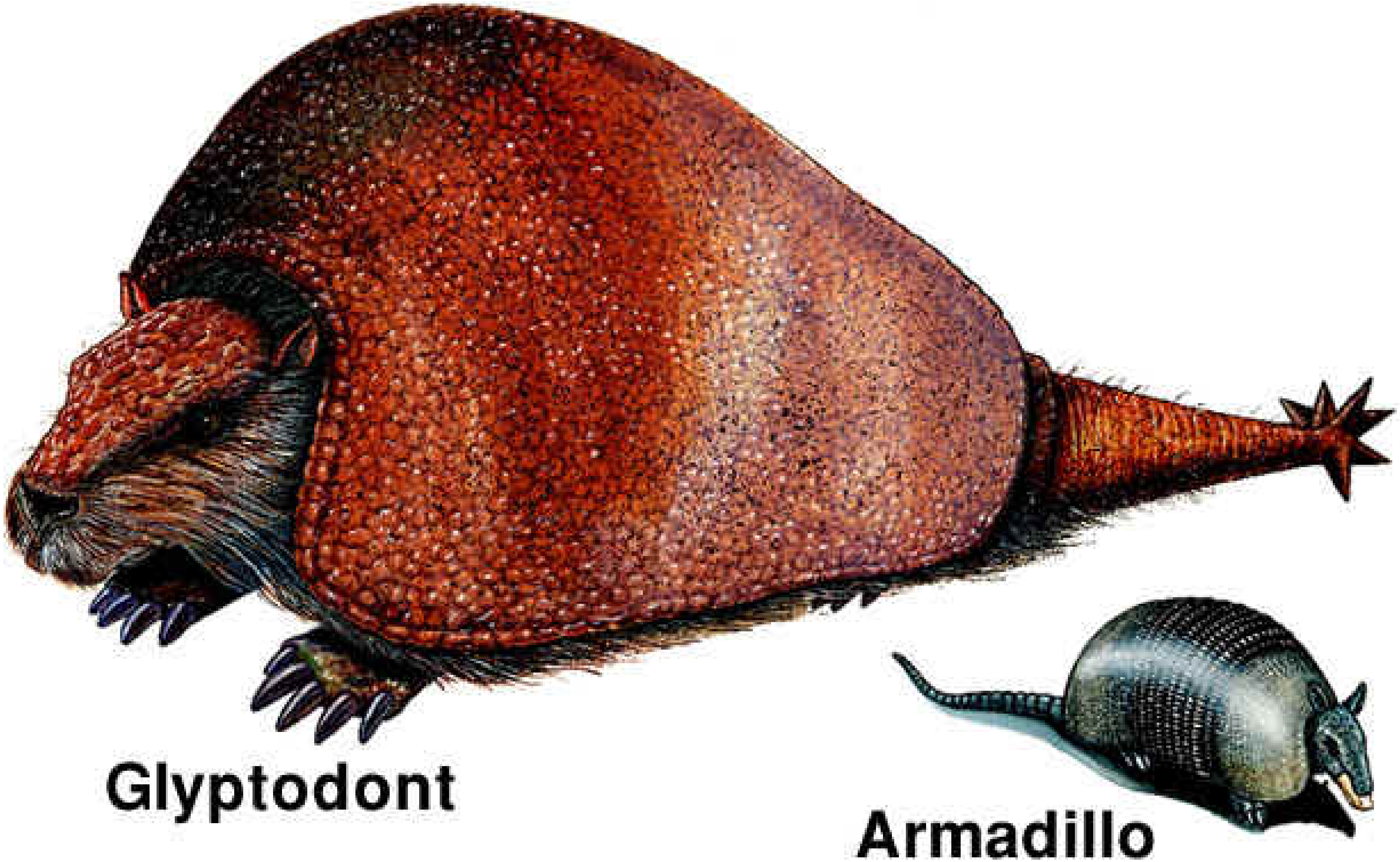


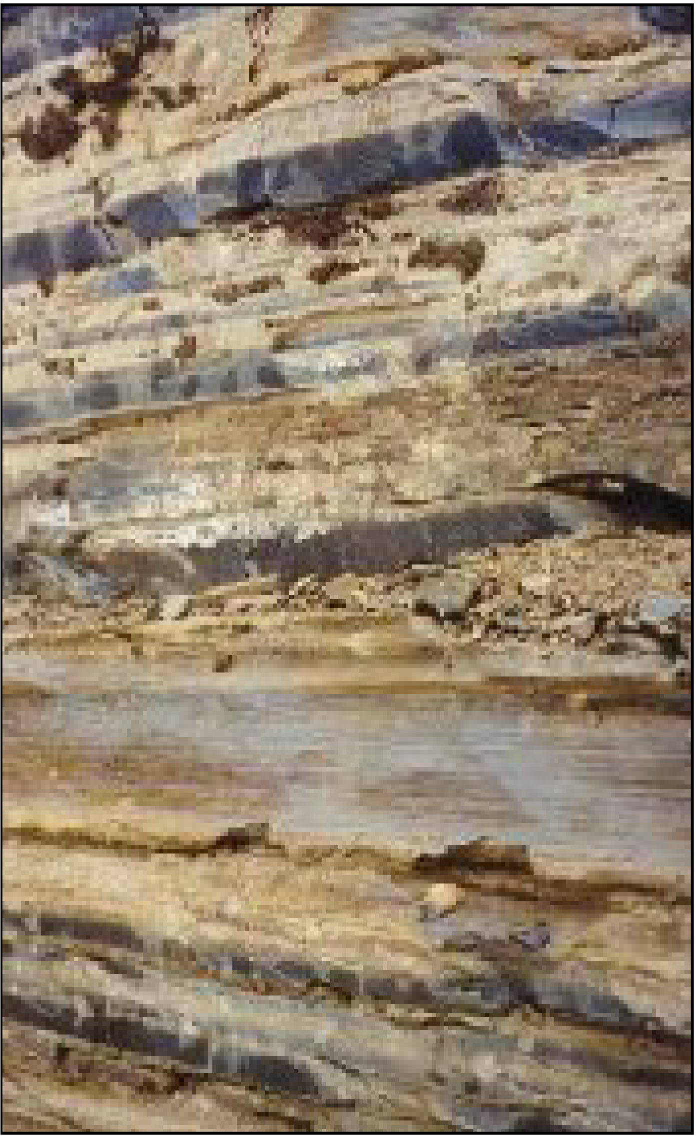
Fossilized remains of a bird like dinosaur *Archeopteryx*

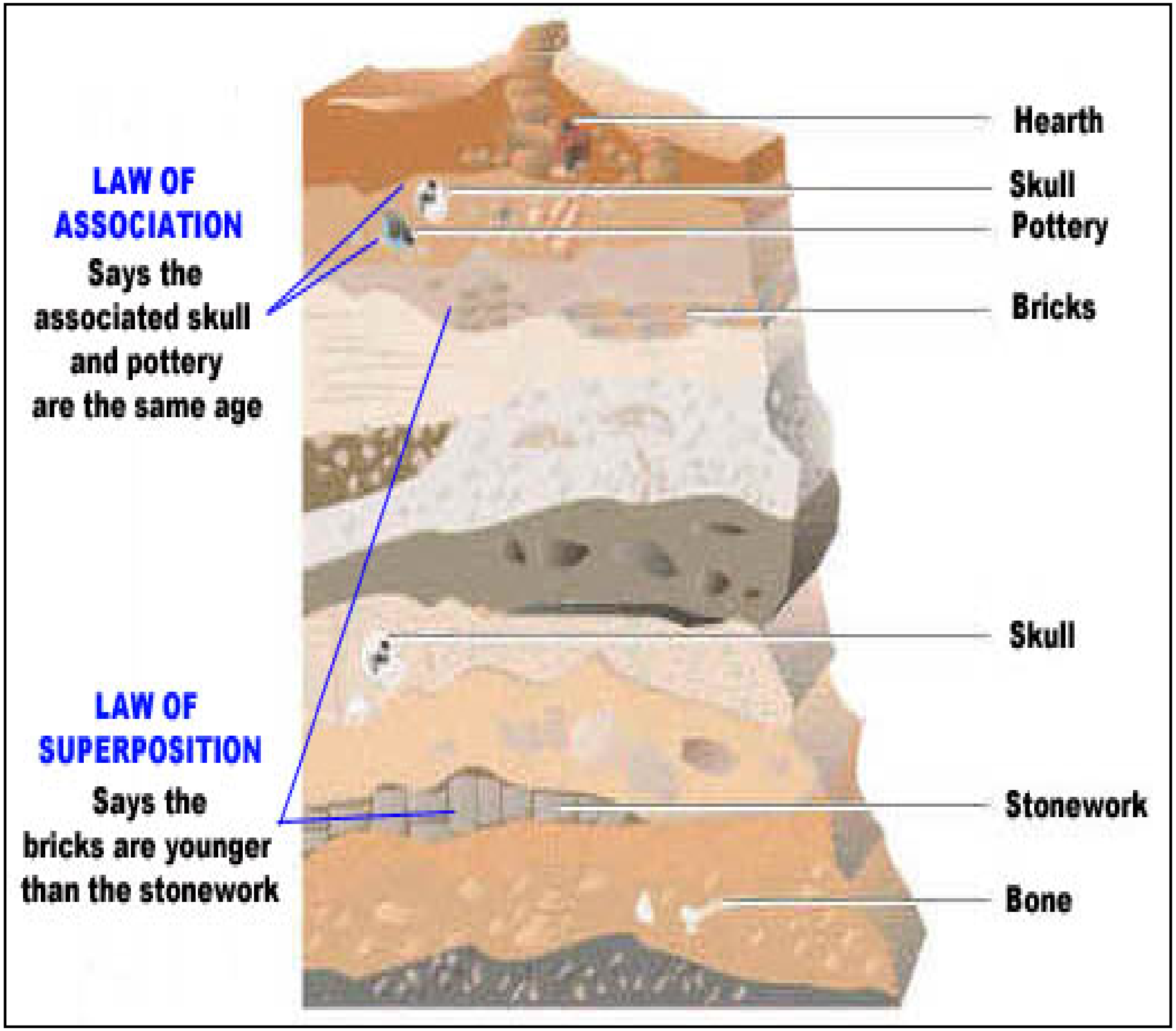
Fossil Evidence of Evolution

- Fossils distributed consistently throughout strata of same age
- Order of fossil appearance shows more complex forms appearing after simpler forms
- Recent fossils (new strata) most closely resemble modern organisms

Fossil Evidence of Evolution





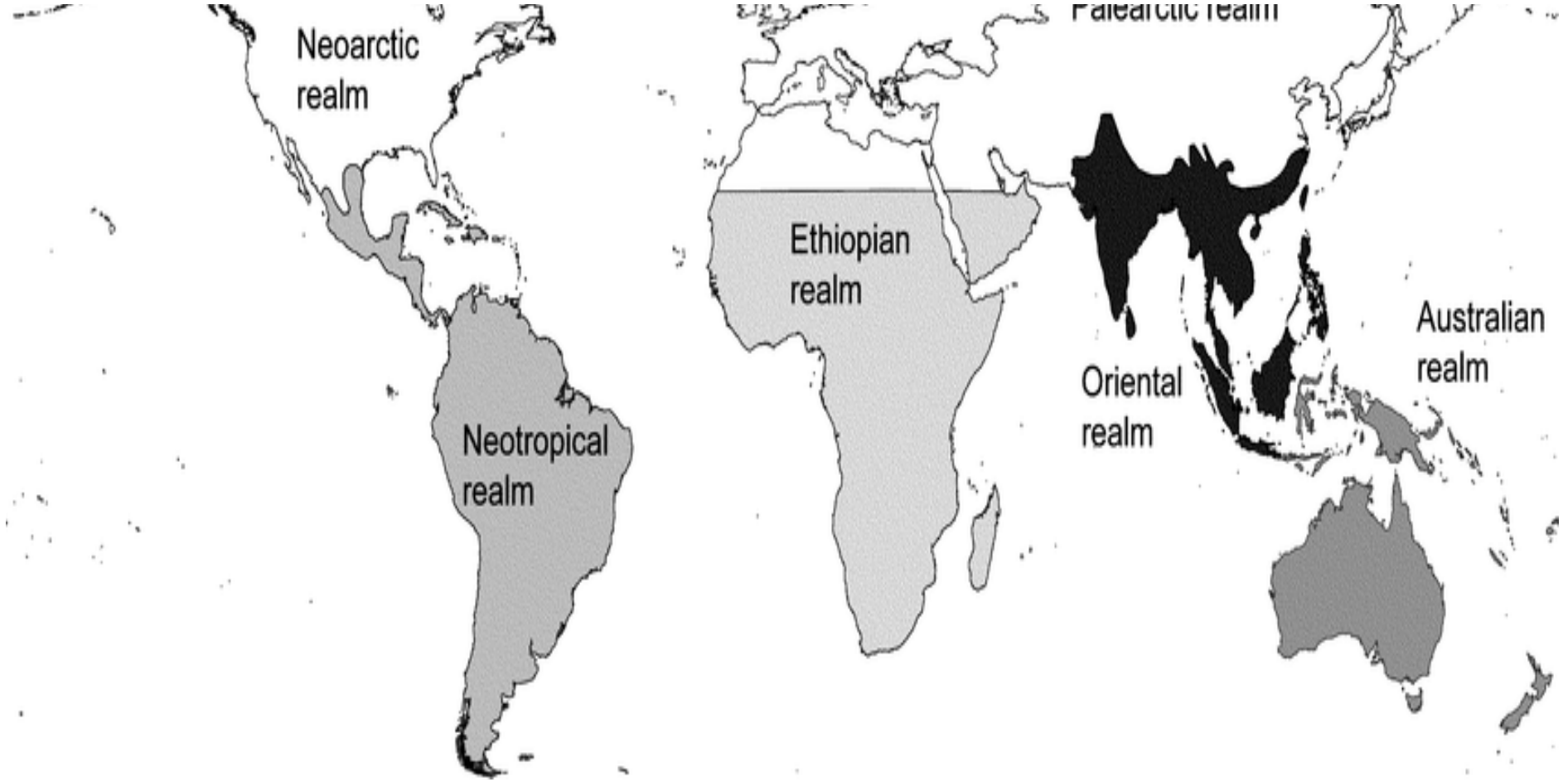

LAW OF ASSOCIATION
Says the associated skull and pottery are the same age
LAW OF SUPERPOSITION
Says the bricks are younger than the stonework
Hearth
Skull
Pottery
Bricks
Skull
Stonework
Bone

- Radiometric dating confirms that the earth is very old and allows scientists to determine the age of fossils. By analyzing fossil remains, biologist can reconstruct what organisms looked like long ago, learn how organisms were related to each other, and understand how groups of organisms evolved over time.

Zoogeography

- Zoogeography is the study of patterns of distribution of animals in nature.
- Wallace (1876) has divided the whole world into six regions known as zoogeographical regions or realms.
- These six regions are as follows:

Six zoogeographical regions by Wallace (1876).



I. Neotropical Region

- The Neotropical region is one of the six major zoogeographical regions of the world.
- This region includes South and Central America, the West Indies and the Southern Mexico.
- This is the most biologically diverse region on the earth.

- The region has tropical climate except the southern region, which has south temperate zones.
- There are many diverse habitats in this region that are tropical.
- It has been divided into the following subregions:

(a) Chileian subregion
(b) Brazilian subregion
(c) Mexican subregion
(d) Antillean subregion

- 43 families and subfamilies of fishes are endemic to this region. The gymnotiformes, loricarridae and characidae families of fishes are unique to this region. Family cyprinidae is completely absent.
- Amphibians are represented by both anura and urodela.

- The region is inhabited by 15 families of lizards. Agamidae are completely absent. The characteristic genera of snake are *Ungalia, Elaps, Dromicus, Epicrates,* etc. Crocodiles, alligators, turtles and tortoises are common

- 31 bird families are endemic to the Neotropical region. They include rhea, tinamous, curassows and toucans. Bird families originally unique to the Neotropical region include hummingbirds (family trochilidae) and wrens (family troglodytidae).

- The unique mammals of this region are American opossum, shrew opossum, anteaters, sloths, armadillos, new world monkeys, cavimorpha rodents, etc.

II. Palaearctic Region

- The Palearctic region occupies 39 percent of the mainland. It is the largest region.
- It is a modest zone as far as the number of kinds of animal is concerned.
- It has no tropical zone.
- It includes Europe and middle North Asia.

- It has been divided into the following subregions:

(a) European subregion

(b)Mediterranean subregion

(c) Siberian subregion

(d) Manchurian subregion

- This region includes 136 families of vertebrate animals, 100 genera of mammals and 174 genera of birds. There are 35 and 37 unique genera of mammals and birds.
- One bird family Pynellidae is endemic to this region. The Holoarctic has four other endemic bird families, viz., Tetraoninae, Alcidae, Gavidae and Bombycillidae. Parrots are absent in this region.

- The Palearctic region has no endemic mammals but several families are endemic, viz., Ailuridae, Calomyscidae, Prolagidae, etc. The camel family has discontinuous distribution.

III. Ethiopian Region

- The Ethiopian region includes Africa south of Sahara, Madagascar and South Arabia.
- This region has poor diversity of animals.
- It resembles the Neotropical and Oriental regions in its fish and amphibious fauna, while in bird fauna, it shows much similarity with the Oriental region.

- This region has the following four subregions:

(a) East African subregion
(b) West African subregion
(c) South African subregion
(d) Malagasy subregion

- This region represents 174 families of vertebrate animals, 140 genera of mammals and 294 gene of birds.
- The characteristic fauna of this region are *Protopterus,* secretary birds, giraffes, lions, zebras, baboons, gorillas, chimpanzees, hippopotamuses, etc.

- *Rana, Bufo* and tailed amphibians, iguanids, talpidae, ursidae, cervidae and wrens are absent.

IV. Australian Region

- The Australian region includes Australia, New Zealand, New Guinea, Tasmania and the Ocean Islands of the Pacific.
- This region has no land connection with the rest of the regions,
- This region is characterised by both tropical and temperate climates.

- The flora and fauna of this region are peculiar due to their isolation from other regions of the world
- The Australian region has been divided into the following subregions:

(a) Austro-Malayan subregion

(b) Australian subregion

(c) Polynesian subregion

(d) New Zealand subregion

- This region includes 18 families of mammals, 71 of birds, 31 of reptiles, 11 of amphibians and 11 of freshwater fishes.
- The region is characterised by an abundance of endemic genera and families and a small number of placental mammals. Marsupials and monotremes are found only in this region.

- Out of 670 species of birds inhabiting the Australian region, about 450 are endemic.
- The diagnostic fauna are *Echidna,* duck-billed platypus, kangaroo, marsupial moles, honey eaters, kiwi, cassowaries, paradise birds, crowned pigeons, *Sphenodon, Lioplema,* narrow mouthed toads, *Neoceratodus,* etc.
- The crotalidae and viperidae (reptiles) as well as tailed amphibians are totally absent.

V. Oriental Region

- The Oriental region includes the whole of India, Sri Lanka, Burma, South China, Thailand peninsula, Malaya and Malayan islands (Sumatra, Philippines, Java, Bali and Borneo).
- This entire region is located within the tropics and is covered by luxuriant tropical forests.
- This region is known for its varied physical features.

- This region is subdivided into the following sub-regions:

(a) Indian subregion

(b) Ceylonese subregion (Sri Lanka)

(c) Indo-Chinese subregion and

(d) Indo-Malayan subregion

- The Oriental region includes 164 families of all vertebrates, 118 genera of mammals and 340 genera of birds. There are 12 unique families of vertebrates, 55 unique genera of mammals and 165 unique genera of birds.
- Primitive fishes are absent in this region.

- Some important animals of this region are the Indian elephants, tigers, rhinoceroses, antelopes, gibbons, flying lemurs, sun birds, honeyguids, woodpeckers, peacocks, broadbill birds, geckos, iguanas, *gavialis,* etc.

VI. Nearctic Region

- It consists of the geographical territories of North America and Greenland.
- The Neotropical region has a mixture of fauna of the Palaearctic and Neotropical regions.
- It has varied types of climates as well as an extensive mountain range.

- This region is subdivided into the following subregions:

(a) Californian subregion
(b) Rocky mountain subregion
(c) Alleghany subregion and
(d) Canadian subregion

- This region has 24 genera of mammals, 50 genera of birds, 21 of reptiles, 15 of amphibians and 29 of freshwater fishes.
- The characteristic fauna of this region are *Amia calva, Necturus,* axolotl, rattlesnakes, *Heloderma, Phrynosoma,* blue jay turkeys, raccoons, opossums, etc.

Wallace Line

- The Wallace Line is an imaginary line that separates the zoogeographical region of Asia and Australasia.
  It is so named after the name of its originator Alfred Russel Wallace.
- It runs through the Malaya Archipelago, between Borneo and the Celebes and Bali and Lombok.

- To the west of line are found organisms related to Asiatic species, while to its east are found organisms related to Australian species.

Evolution of horse and man

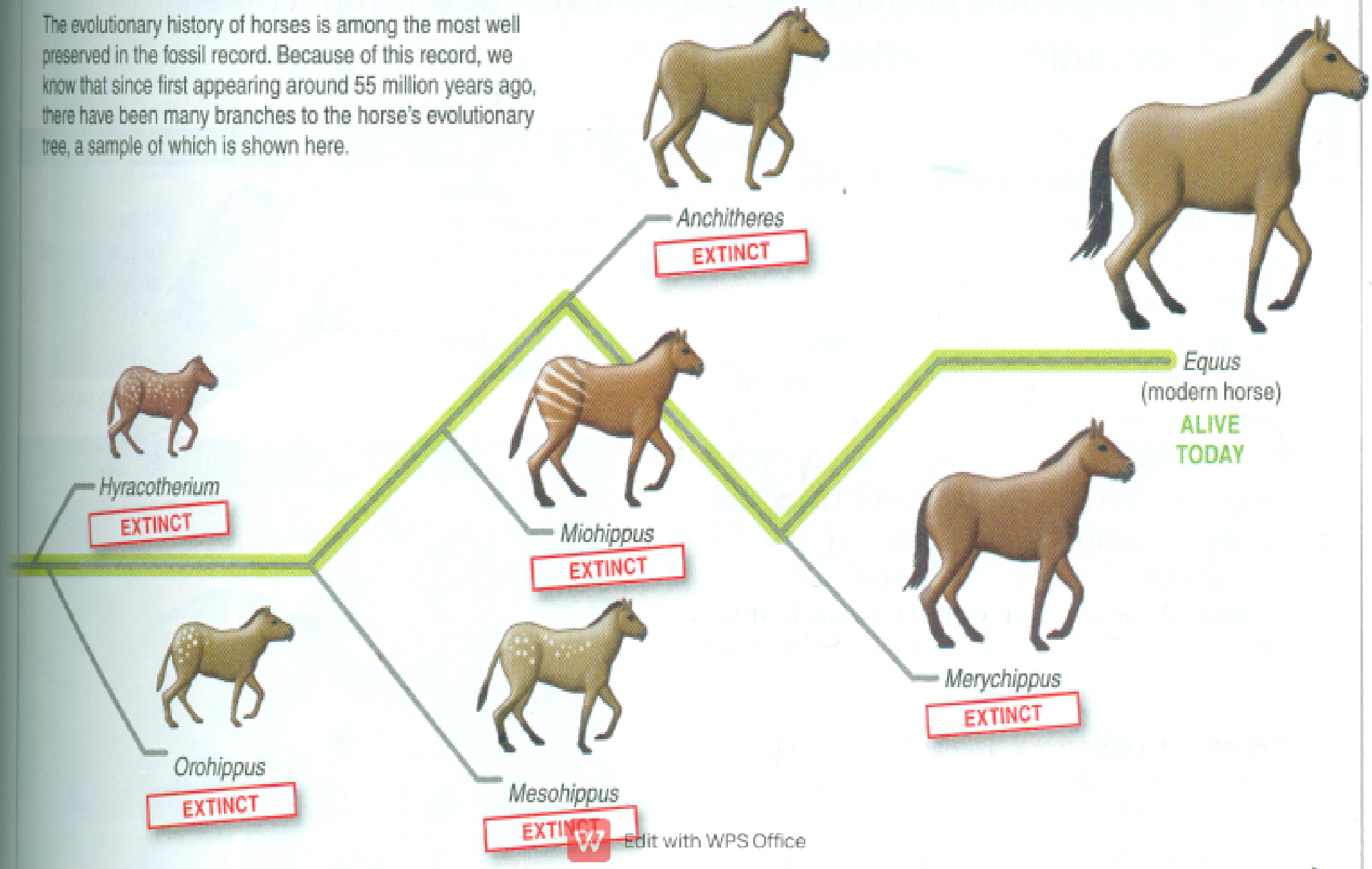
KOFI OWUSU-DAAKU

POPULATION GENETICS AND EVOLUTION

LECTURE VI

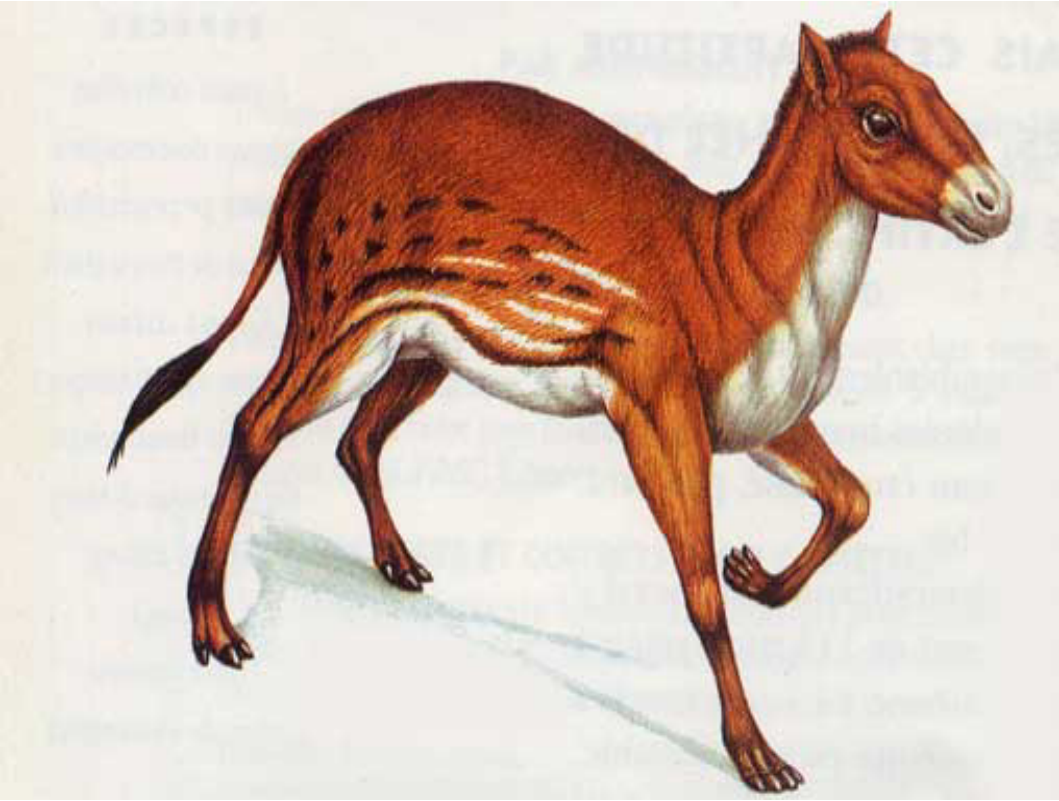
EVOLUTIONARY HISTORY OF HORSES

The evolutionary history of horses is among the most well preserved in the fossil record. Because of this record, we know that since first appearing around 55 million years ago, there have been many branches to the horse's evolutionary tree, a sample of which is shown here.



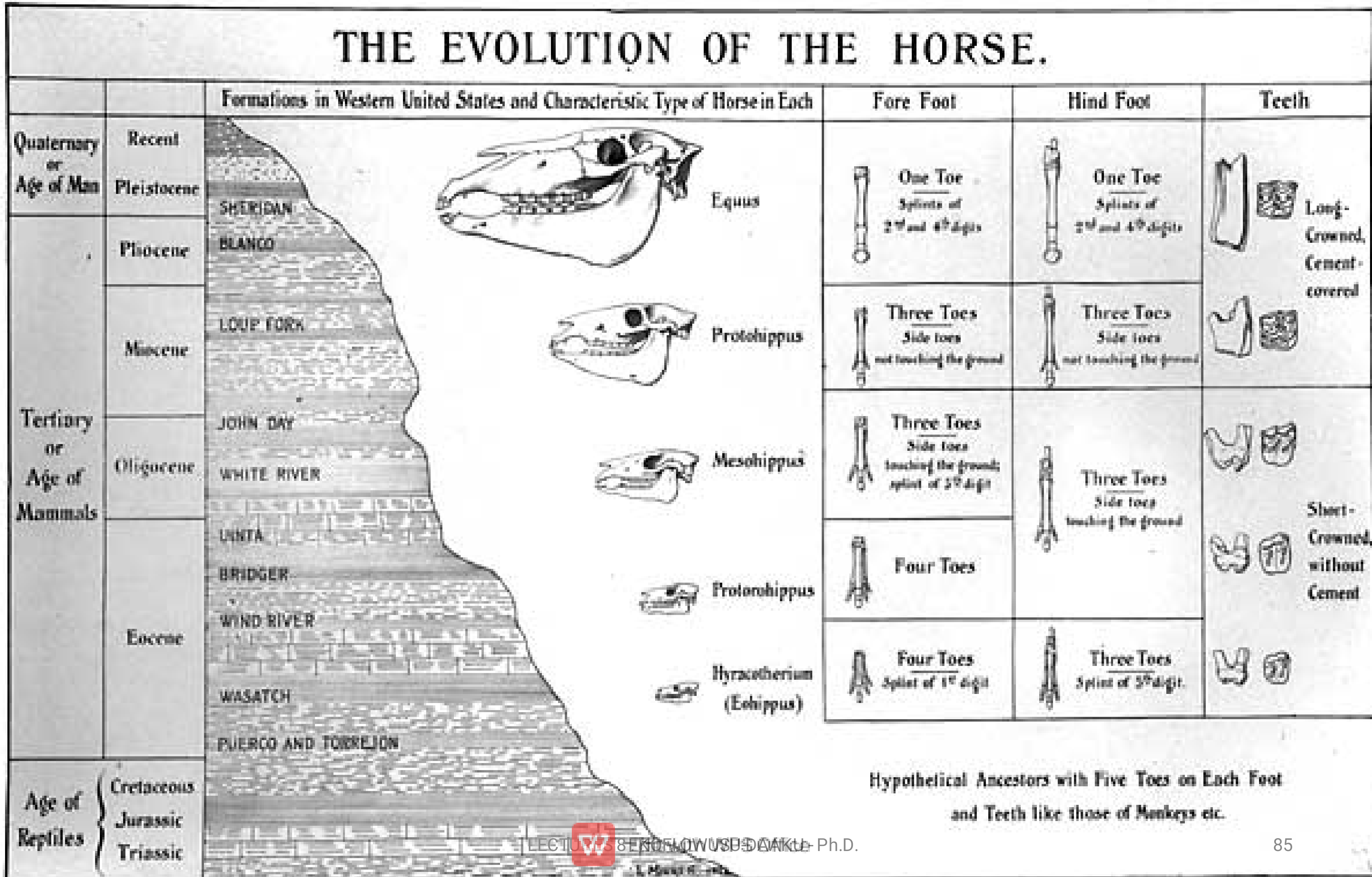
Common Theory

- Horses have evolved from a small dog like creature with many toes to a single hoofed animal
- They grew from the size of a dog to the modern horse on average 160cm

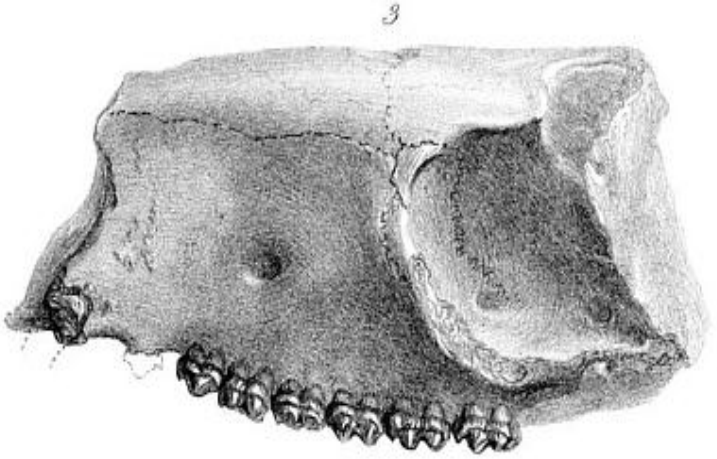


Hyracotherium or Eohippus

- The most famous evolutionary diagram showing the gradual growth and changes of the horse

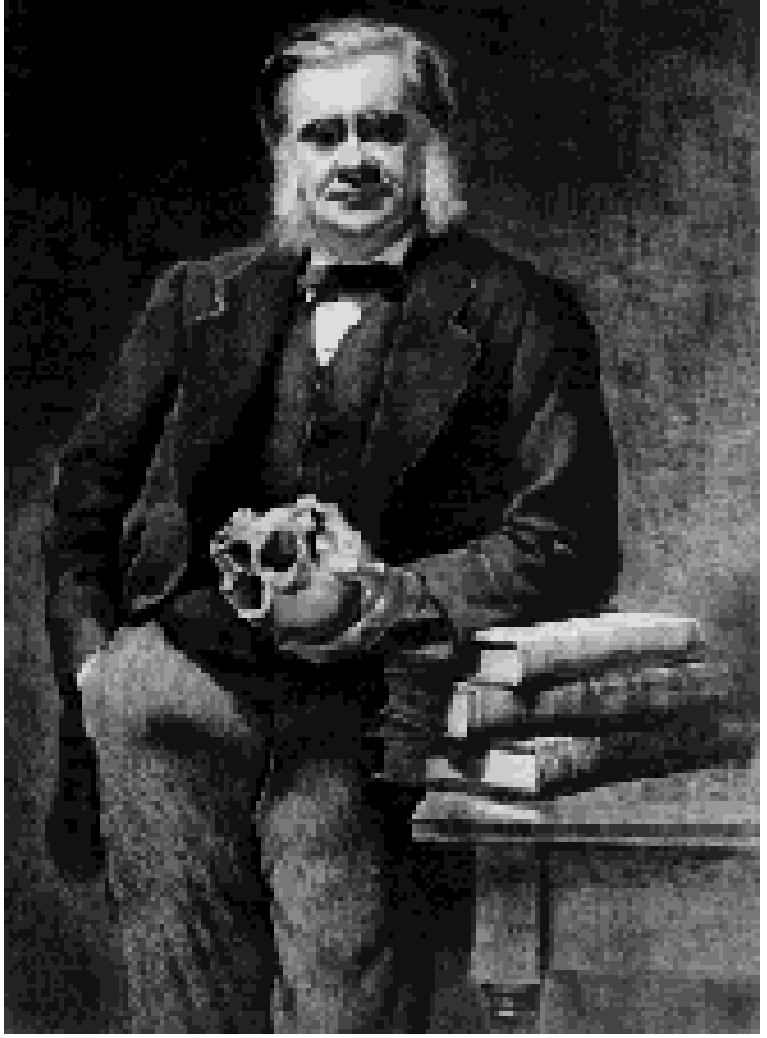


History of Horse



- First fossil found in 1841 in London
- Found by Richard Owen
- It was a small fox like animal skull he called *Hyracotherium*
- No apparent link between this primitive animal and the horse
- Kovalevsky then linked it to the modern horse

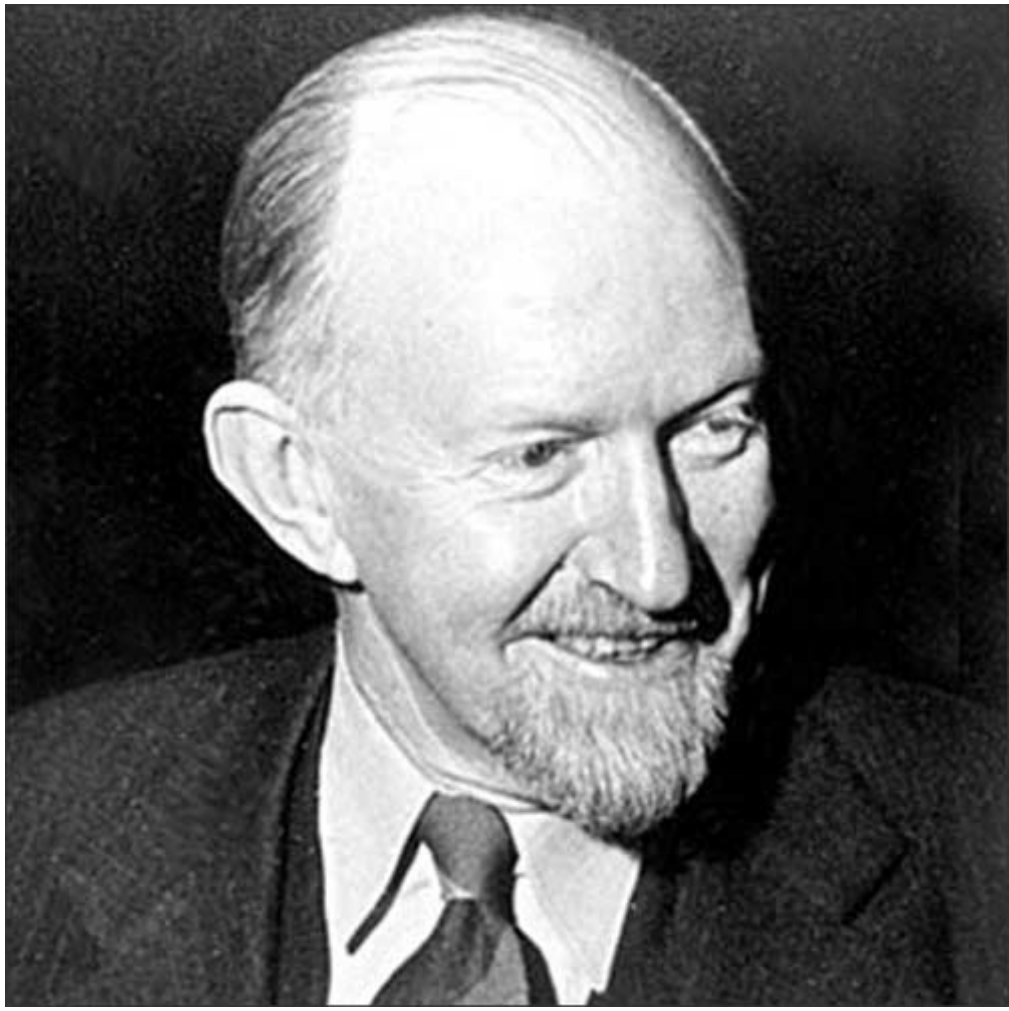
- Henry Huxley was a famous palaeontologist
- He was a big fan of *Darwin's Origin of Species* 1859
- He went to America to give a lecture in New York to the *Zoological Society* in 1880
- He met up with O.C. Marsh and they collaborated to form a genealogic diagram of the evolutionary line of the horse for his presentation
- This was then published in the *American Journal of Science* in 1879 - 80



- Marsh used the limited number of fossils he had, which was the most extensive at the time, to form this simple diagram which seemed to be the most correct sequence
- This is now the famous straight evolutionary line of Hyracotherium to Equus (*anagenisis*)
- This is the sequence that non-evolutionists use to discredit evolution
- In reality the graph is much more “bushy”,with complex branching, that waxes and wanes its way through history (*cladogenisis*)

- Dr. Niles Eldr[illegible]n Natural History Museum, commented on the exhibition there
- *"There have been an awful lot of stories, some more imaginative than others, about what the nature of that history [of life] really is. The most famous example, still on exhibit downstairs, is the exhibit on horse evolution prepared perhaps 50 years ago. That has been presented as the literal truth in textbook after textbook. Now I think that is lamentable, particularly when the people who propose those kinds of stories may themselves be aware of the speculative nature of some of that stuff."*

- Other evolutionists have disagreed with the straight line illustration also, such as George Gaylord Simpson [1921-1970] who proposed the cladogenisis model
- The general idea of Huxley and Marsh in a sense is right because the modern horse came from the *Hyracotherium,*
- It is easier for the less scientific audience to understand as the real sequence is complicated and branched



EVOLUTION OF HORSE cont`d

- The evolutionary history of the horse gives a very clear picture of gradual progressive evolution.
- In the entire evolutionary history of animals, none is so beautifully arranged as the horse.
- The record of the evolutionary line of the horse is almost complete.

Evolution Of Horse Cont`d

- The primary centre of the evolution of the horse was in North America, especially in the region of the Great Plains.
- The history of the horse family equidae began during the Eocene Epoch.
- The evolution of the horse provides a good example of Cope's law (the trend of evolution to lead to larger animals).

Evolution Of Horse Cont`d

- The fossil lineage of the horse provides a remarkable demonstration of directional succession.
- Horses share a common ancestry with tapirs and rhinoceroses.
- Fossils of *Equuus* are found in every continent except Australia and Antarctica.
- *Equuus* is the only surviving genus in the once diverse family of horses.

Evolution Of Horse Cont`d

- The horse belongs to:

(a) Phylum Chordata
(b) Subphylum Vertebrata
(c) Class Mammalia
(d) Sub class Eutheria
(e) Order Perissodactyla
(0 Sub order Hippomorpha
(g) Family Equidae
(h) Genus Equus

Evolutionary Trends

(a) An increase in body size.

(b) An increase in the size and complexity of teeth.

(c) An increase in the size of the head.

(d) Reduction in the number of toes on the front foot from four to one.

(e) Change of foot posture from semiplantigrade to unguligrade.

(f) Perfection of the hoof.

The recorded fossil history of the horse is as follows:

1. Eohippus

(a)It was of lower Eocene and four-toed form.

(b) It had low crowned teeth.

(c) It was a forest-dwelling animal that browsed on foliage.

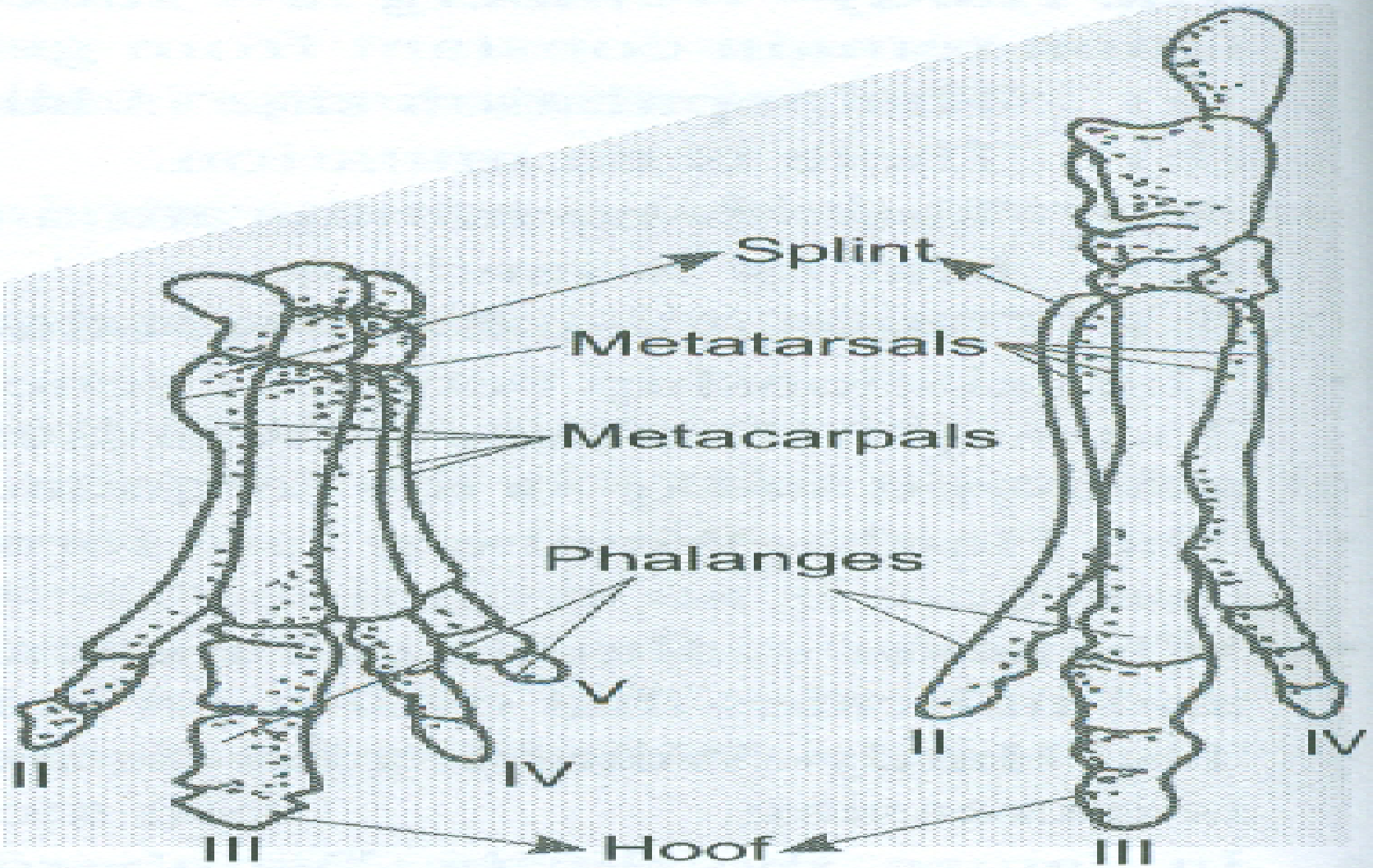


Fig. 4 Bones of forelimb and hindlimb of *Eohippus*

2. Orohippus

(a) It was of middle Eocene form.

(b) The forelimbs had four toes while the hind limbs had three toes.

(c) The middle digits in both the limbs were dominant.

(d) It was a browser.

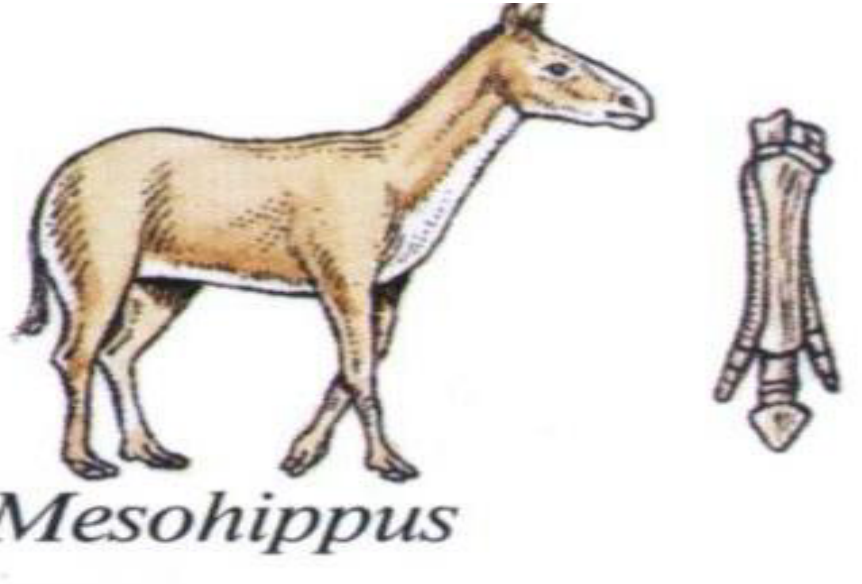
3. Epihippus

(a) It was of upper Eocene form.

(b) The forelimbs had four digits and the hindlimbs had three digits.

(c) It was a browser.

(d) They became extinct by the end of Eocene and were replaced by *Mesohippus.*



4. Mesohippus

(a) It was of sheep-s form.

(b) It had only three toes on the forefoot.

(c) The teeth were low crowned

(d) It became extinct by the end of middle Oligocene epoch.

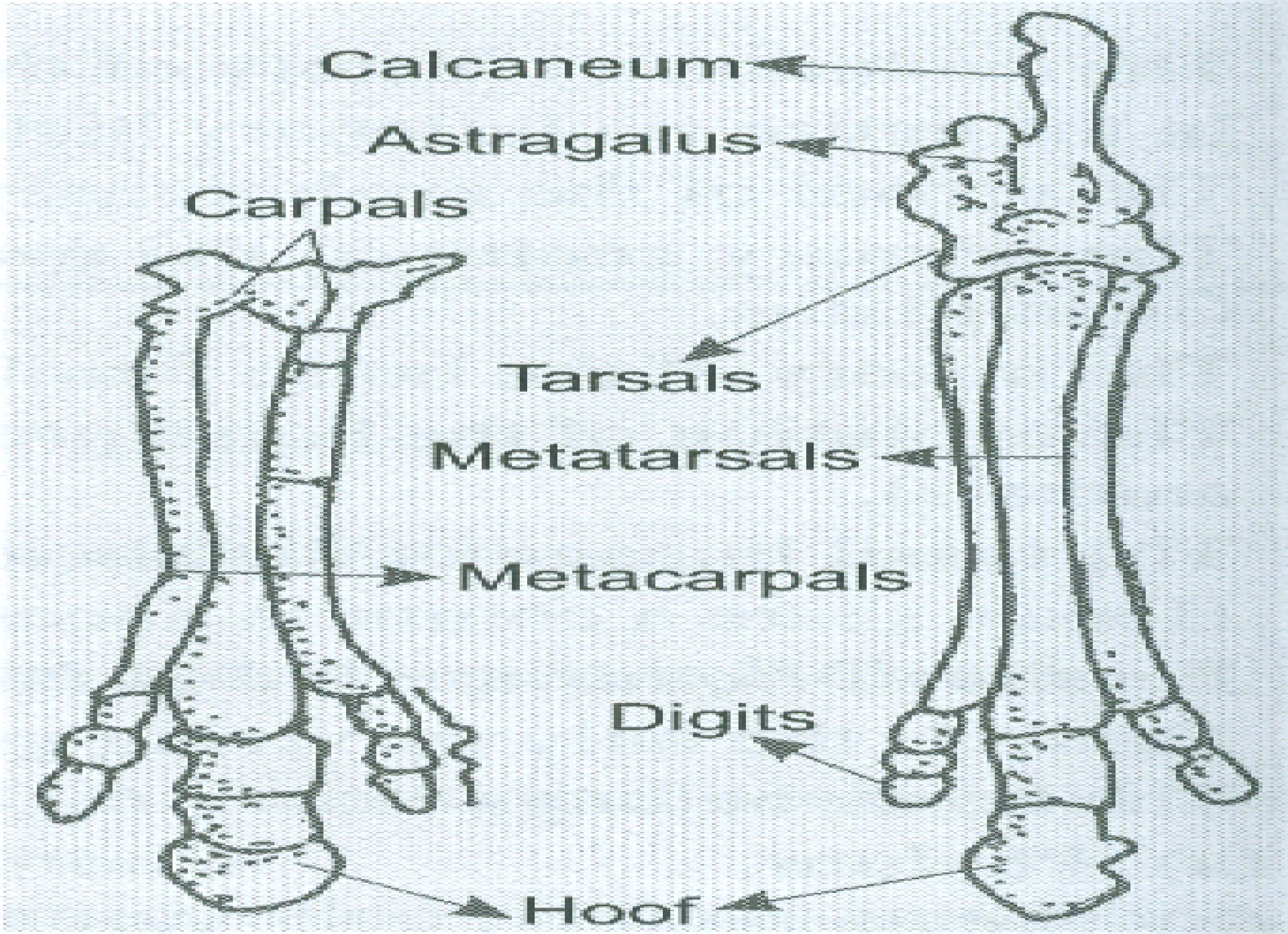


Fig. 5 Bones of forelimb and hindlimb of *Mesohippus*

Miohippus

- It was of upper Oligocene form.
- The forelimbs and hindlimbs were three toes.
- Toes were broad and spreading.
- The teeth were low crowned and it was a browser.
- It was a forest-dweller.
- *Miohippus* is the ancestor of many equine forms.

Parahippus

- It was of lower Miocene form.
- It was in the direct line of equine evolution.
- The third digit in the forelimbs and hindlimbs was more prominent.
- Only the median digit was effective in locomotion.
- The side toes were slender.
- The dentition was of a hyposodont

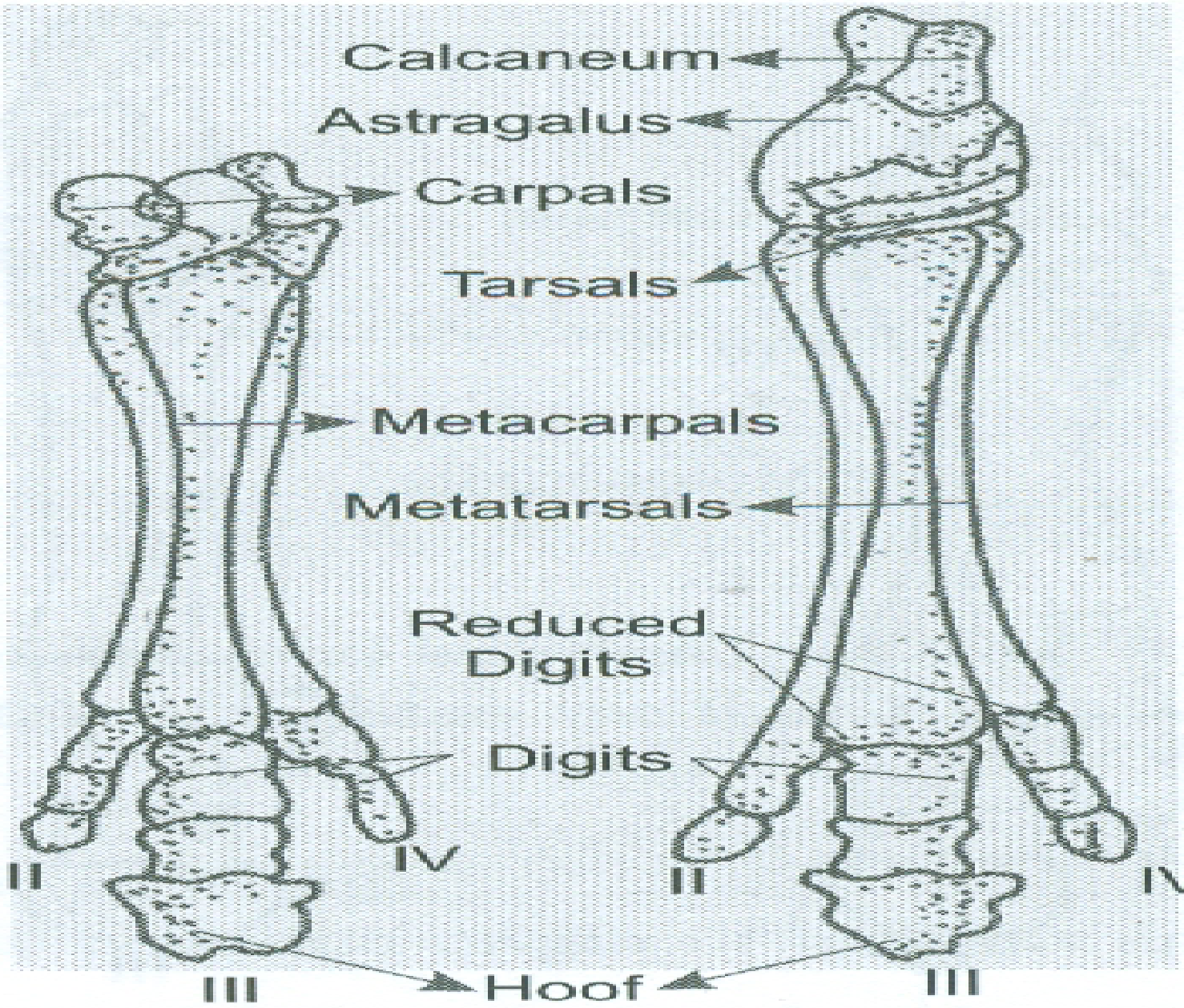


Fig. 6 Bones of forelimb and hindlimb of *Parahippus*

Merychippus

a) Merychippus represents a milestone in the evolution of horses
b) It had a long face.
c) Its long legs allowed it to escape from predators and migrate over long distances to feed.
d) It was three-toed but the central one bore the most body weight.

Merychippus cont`d

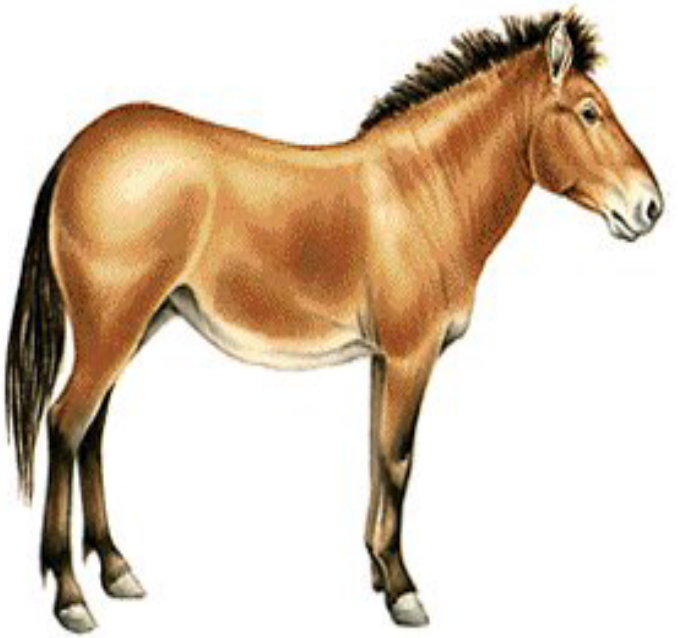
e) The teeth were highly crowned, coated in cement and had a more complex chewing surface.

f) The ligaments of muscles were highly developed.

g) The footpad was lacking

h) It was the first of three-toed grazers

Pliohippus



- It was of late Miocene to P
  form.
- The side toes became vestigial, although some species are known to have had three toes.
- It was the first single-toed horse.
- It was well adapted for treeless plains.
- It is believed that *Pliohippus* have given rise to *Hippidion* and *Onohippidon* genera and *Dinohippus*.

Plessippus

- It was of upper Pliocene form.
- It was one-toed.
- The teeth were like those of the modern horse.

£quus (Modern horse)

a) It originated in the upper Pliocene epoch.
b) Some side branches are seen which became extinct in the Pleistocene epoch.
c) The height is about 60".
d) There is only one toe in each foot

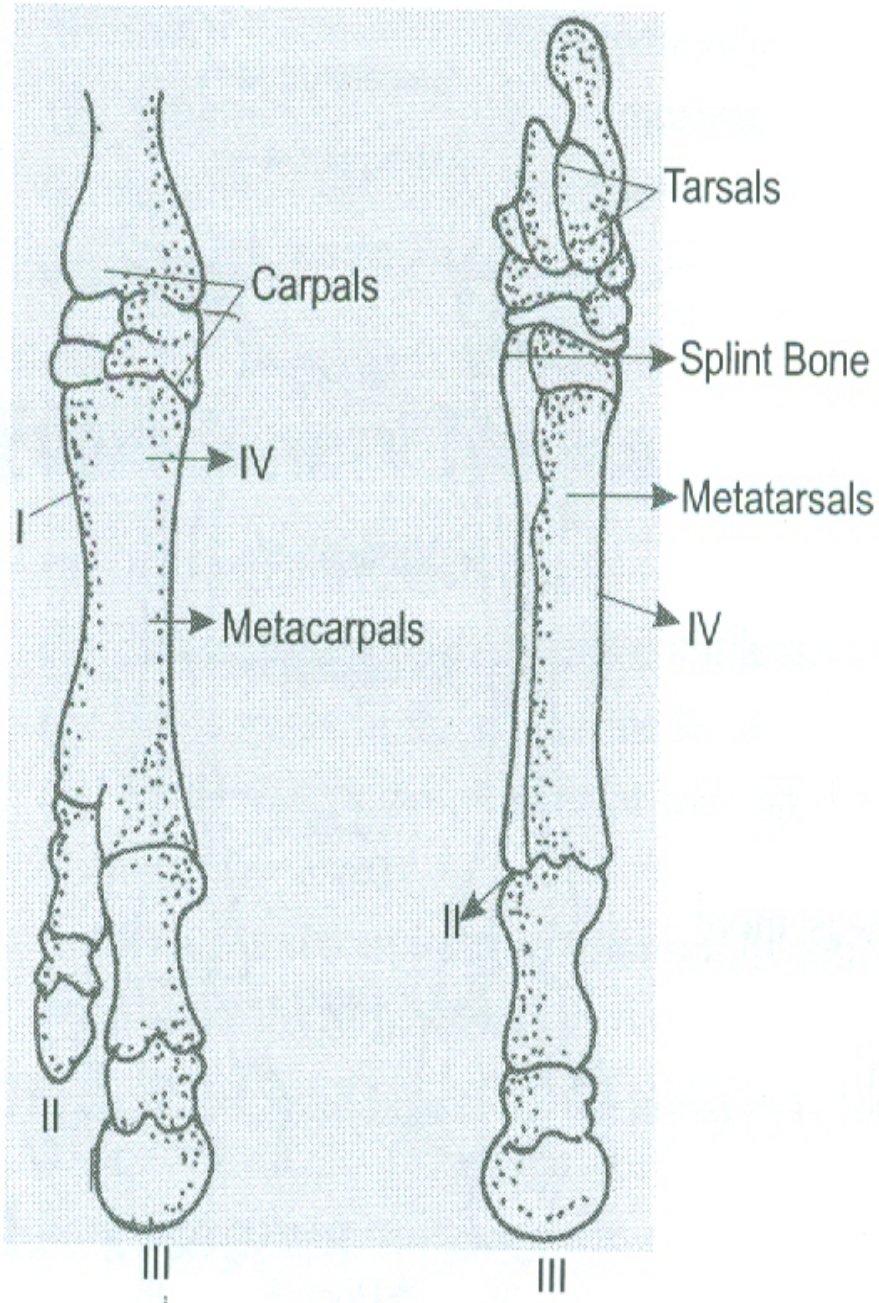


Fig. 7. Bones of forelimb and hindlimb of *Pliohippus*

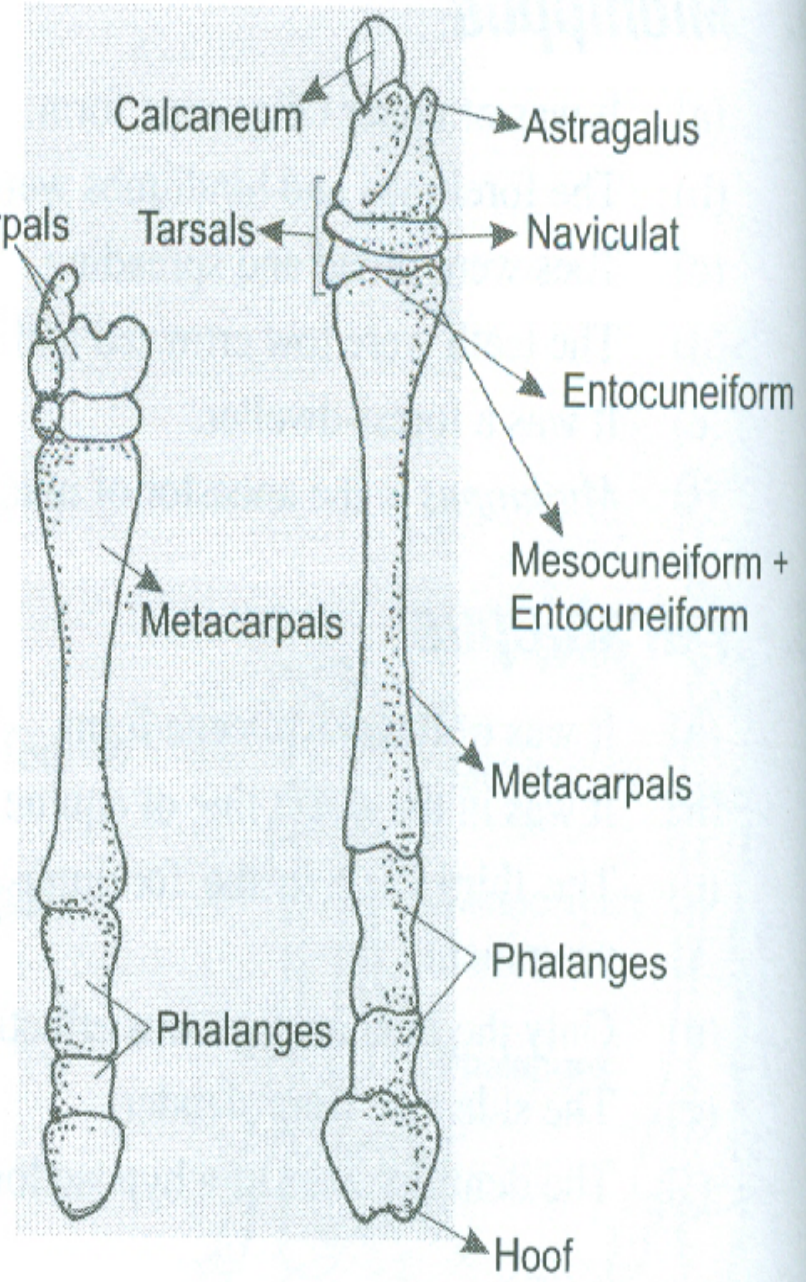


Fig. 8 Bones of forelimb and hindlimb *Equus*

e) A well-developed hoof is present.

f) The molars have a very long crown.

g) It has a large brain with grooved cerebral hemispheres.

There is a huge variety in modern horses but most of this is due to selective breeding rather than evolution

The evolution of the horse involves changes in height, toes and teeth as well as it becoming a grazer from a browser. Species of *Equus* lived from 5 million years ago until the present times. The horse was domesticated about 3,000 years ago and had profound impact on human history.

EVOLUTION OF MAN & CULTURE

Where have we come from ?

- The Cave at Lascaux and the Hands of Gargas
- Ancient humans left images painted on cave walls about 20, 000 years ago.
- Humans are the product of evolution that began with primates (60 million years ago) and mammals (250 million years ago).

Human's shared Mammalian Heritage

- Like all vertebrates, mammals have a nerve cord within a vertebral column and a skull containing a " three-part" brain.
- Mammals have several distinctive features:
- Mammals have hair.
- There is an extended period of infant dependency (mammary glands for nutrition) and learning.
- There is flexibility in their responses, because the mammalian brain has a large capacity for memory and learning.
- Dentition, which is number, type, and size of teeth, is indicative of what an mammal eats and hence also of its life style.

Primates

- **Primates** include prosimians, tarsoids, and anthropoids, including monkeys, apes, and humans.
- **Hominoids:** apes and humans,
- **Hominids:** human lineages only.
- 2. Most primates live in forests, woodlands, or savannas and are tree dwellers.

Primate to Human: Key Evolutionary Trends-1

Upright Walking

- Bipedalism is the habitual two-legged gait characteristic of humans.
- Compared with monkeys and apes, humans have a shorter, S-shaped, somewhat flexible backbone which works with shoulder blades and pelvic girdle to allow bipedalism.

Precision Grip and Power Grip

- Prehensile movements allowed fingers to wrap around objects in a grasp.
- Opposable thumb and fingers allowed more refined use of the hand.
- The precision and power grip movements of the human hand allowed for tool making.

Primate to Human: Key Evolutionary Trends- 2

Enhanced Daytime Vision: resulted from forward directed eyes (depth perception) with their increased ability to discern shape, movement, color, and light intensity.

Changes in Dentition: resulted in humans having smaller teeth of more uniform length; generally the jaws and teeth became less specialized.

Changes in the Brain and Behavior

- The brain increased in size and complexity, resulting in new behaviors.
- **Evolution of Language** Allowed culture to evolved as the behavior patterns passed between generations by learning and symbolism .

Primate Origins

- The first primates (>60 million years ago) resembled tree shrews; they were night time 0mnivores.
- Some evolved into tree-living forms (54-38 million years ago, Eocene) with increased brain size, a shorter snout, enhanced daytime vision, and refined grasping movements ..
- Anthropoids, the ancestors of monkeys, apes, and humans evolved by 36 million years ago (Oligocene); they were distinctive tree dwellers.
- Hominoids appeared during the Miocene (23-5 million years ago) as major land masses moved and the climate became cooler and drier.
- By 13 million years ago, adaptive radiation produced the hominoids that branched into gorillas, chimpanzees, and eventually humans.

The First Hominids

- The first hominids evolved about 5-10 million years ago.
- Cooler and drier weather encouraged the transition of hominids to mixed woodlands and grasslands.
- The plasticity of early hominids was the result of the capacity to learn to adapt.

The First Hominids

- Australopiths are a group of several hominids.
- The oldest is *Australopithecus anamensis;* Gracile (slightly built) forms have been designated *A. afarensis* and *A. africanus;* robust (muscular) forms are *A. boisei* and *A. robustus.*
- They shared three characteristics:
- They walked upright with hands free for new functions.
- Their jaws and large, thickly enameled teeth accommodated a variety of foods.
- Cranial capacity was about 400 cc.

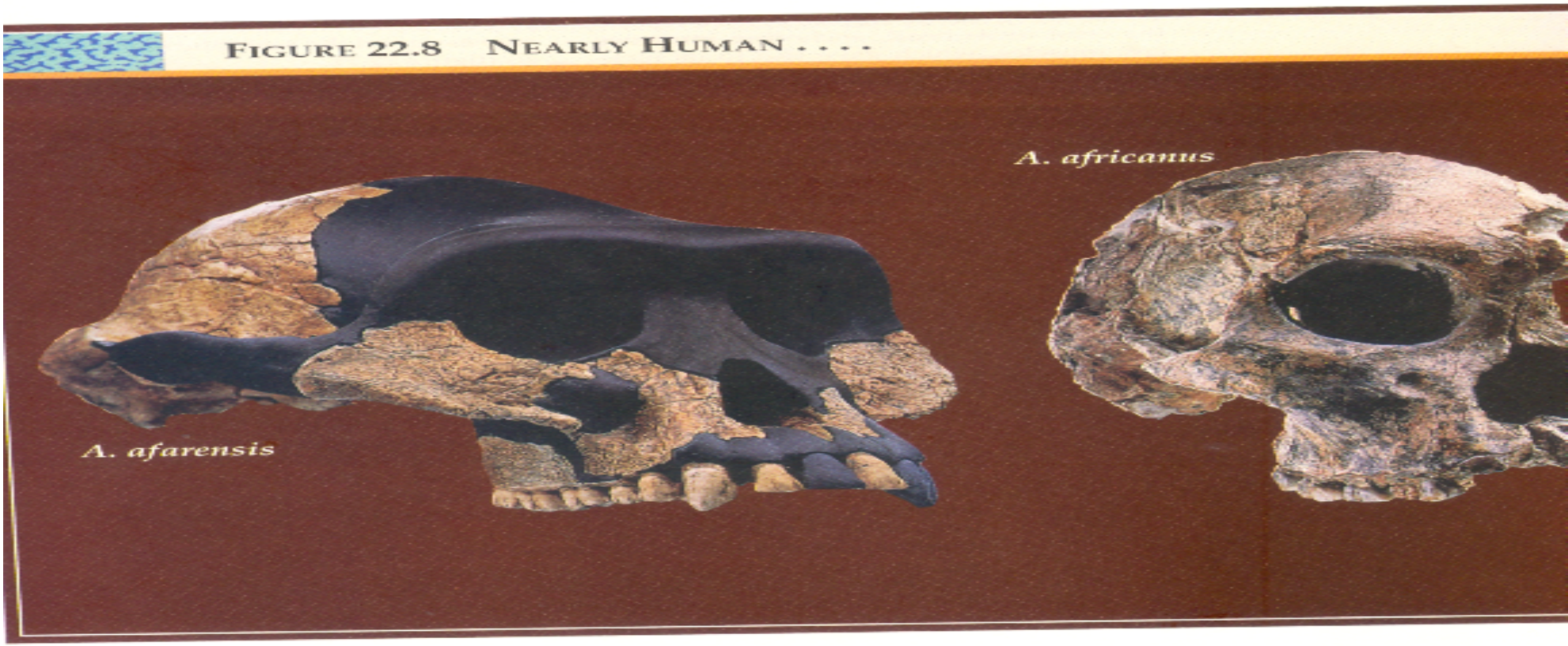
Emergence of Early Humans

- Defining "Human"
- Early humans had a smaller face, more generalized teeth, and a larger brain (with more developed cerebral cortex) than australopiths.
- Nevertheless, it is difficult to define strict criteria for the emerging human species.

Homo habilis and Homo erectus

- *Homo habilis* and the First Stone Tools
- Between 2.5 and 1.6 million year ago, H. *habilis* lived in the savannas of Africa.
- *Homo habilis* shared its habitat with large animals from which food was obtained by using stone tools to get marrow out of, and to scrape flesh from, bones.
- From *Homo erectus* to H. *sapiens*
- *Homo erectus* made advanced stone tools and used fire as they migrated out of Africa into Asia and Europe.

FIGURE 22.8 NEARLY HUMAN . . . .



objectives

THE FIRST HUMANS

1. **Compare and contrast *Homo habilis* and *Homo erectus*.**
2. **List the distinctive characteristics of Java man and Peking man.**
3. **Explain the success o *Homo erectus*.**

You are a member of the third and only surviving species of humans, *Homo sapiens*. Our two ancestors, *Homo habilis* and *Homo erectus* have long since gone extinct. The first humans evolved from australopithecine ancestors about two million years ago, only to be replaced later by a second, "improved" version of human that moved out of Africa and spread across the earth (figure 22.9).

African Origin: *Homo habilis*

In the early 1960s more hominid were discovered close to the site *A. boisei* had been unearthed. Sca among these bones were stone tool though the fossils were badly cru painstaking reconstruction of the pieces suggested a skull with a brai ume of about 640 cc, much larger th australopithecine range of 400–5

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EVOLUTION OF MAN

The fossil records of primates are fragmentary.

- All primates, including humans, must have had a common ancestry.
- According to Pough *et al*. (1996) 'Man descended from arboreal ancestors that lived in early tertiary forests about 65 million years ago'.

- Arboreal, shrew-like insectivores show the first indications of the evolutionary line of primates.
- Ancestral lemurs and lorises showed some remarkable features of primate evolution.
- Tarsius was more advanced and showed characteristics intermediate between lemurs and anthropoids.

- Humans belong to:
  - (a) Phylum Chordata
  - (b) Subphylum Vertebrata
  - (c) Class Mammalia
  - (d) Subclass Eutheria
  - (e) Order Primates
  - (f) Sub-order Anthropoidea
  - (g) Family Hominidae
  - (h) Genus *Homo*
  - (i) Specie *sapiens*

The anthropoid ancestors of humans:

- The evolutionary line of the old world monkey led to the evolution of apes and humans.
- Four types of apes are found today, among which the gibbon and the orangutan are found in Asia while the gorilla and the chimpanzee are found in Africa.
- The gibbon is the smallest ape while the gorilla is the largest.

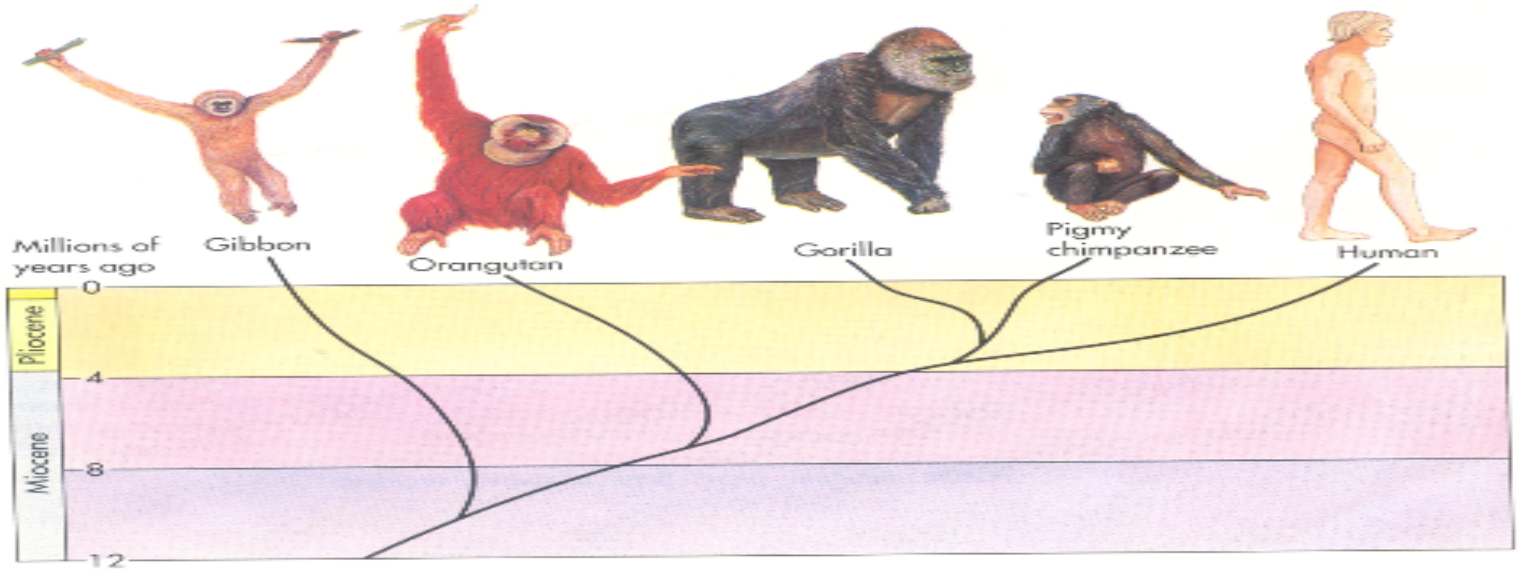
(b) (c)

(d)

2.4
apes. (*a*) Gorilla;
gibbon;
nzee;
an.

With the exception of the gibbon, which is small, all living apes are larger than monkeys. Apes exhibit the most adaptable behavior of any mammal except human beings. Once common, they are rare today. The living apes are confined to relatively small areas in Africa and Asia (figure 22.4). Apes never inhabited the North American continent. Apes and humans are collectively referred to as *hominoids*.

Studies of ape DNA have told us a great deal about how they evolved. The most primitive apes, the line leading to gibbons, diverged from other apes about 10 million years ago, while orangutans split off about eight million years ago. The key split between the *hominids* (lineage of humans) and the line leading to gorillas and chimpanzees occurred only about five million years ago (figure 22.5). Because the split was so recent, the genes of humans and chimpanzees have not had time to evolve many differences. Human and chimpanzee DNAs differ in less than 3% of their nucleotide sequences. Your hemoglobin molecule and that of a chimpanzee differ in only a single amino acid!



22.5
ution of living
ls—apes and

- The chimpanzee is considered to be the closet relative of modern human beings.
- Chromosome numbers and banding pattern studies have revealed the common origin of humans and chimpanzees.
- Central Africa is regarded as the centre of evolution of humans, as maximum number of fossils of primitive humans has been excavated

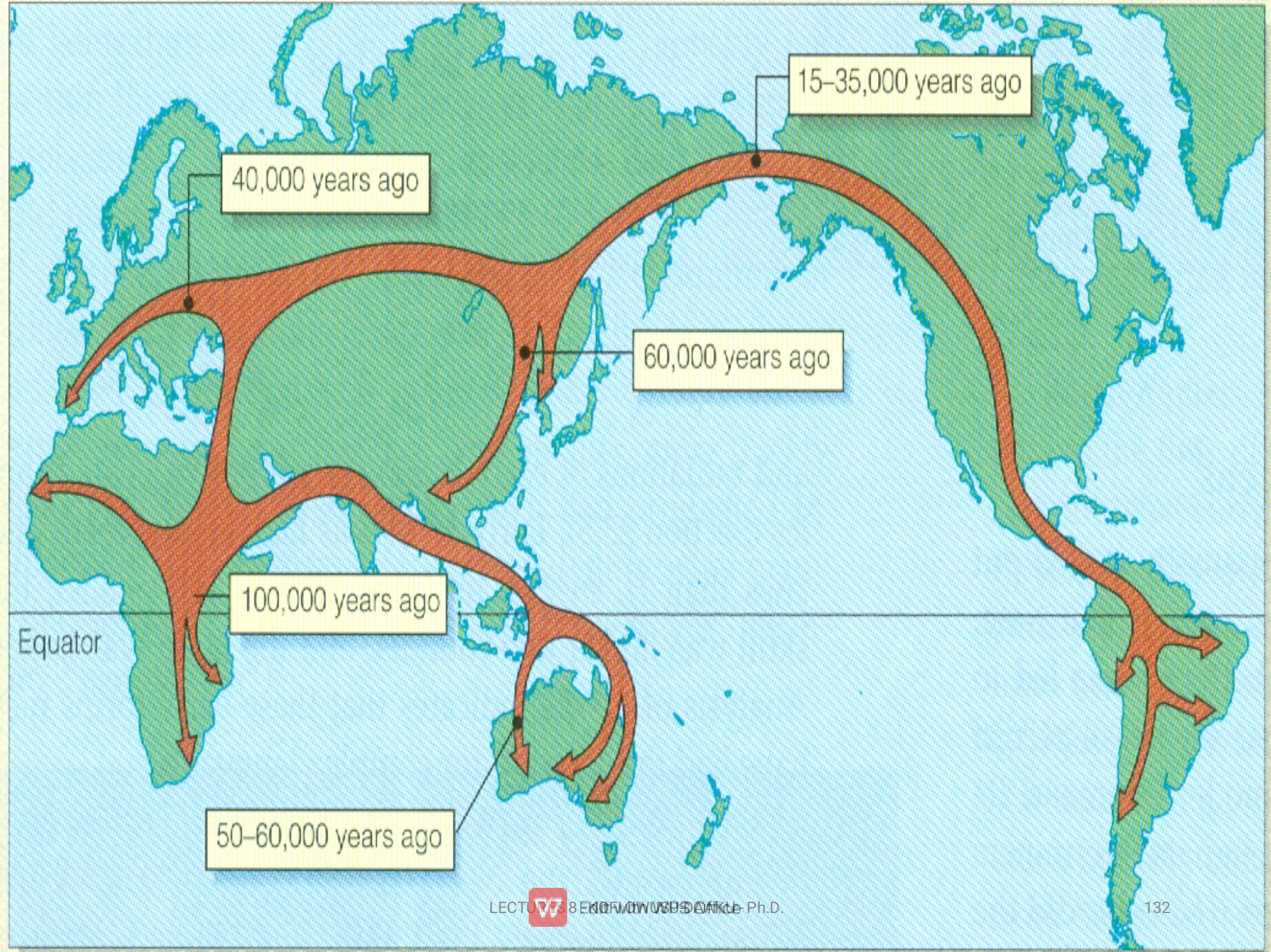
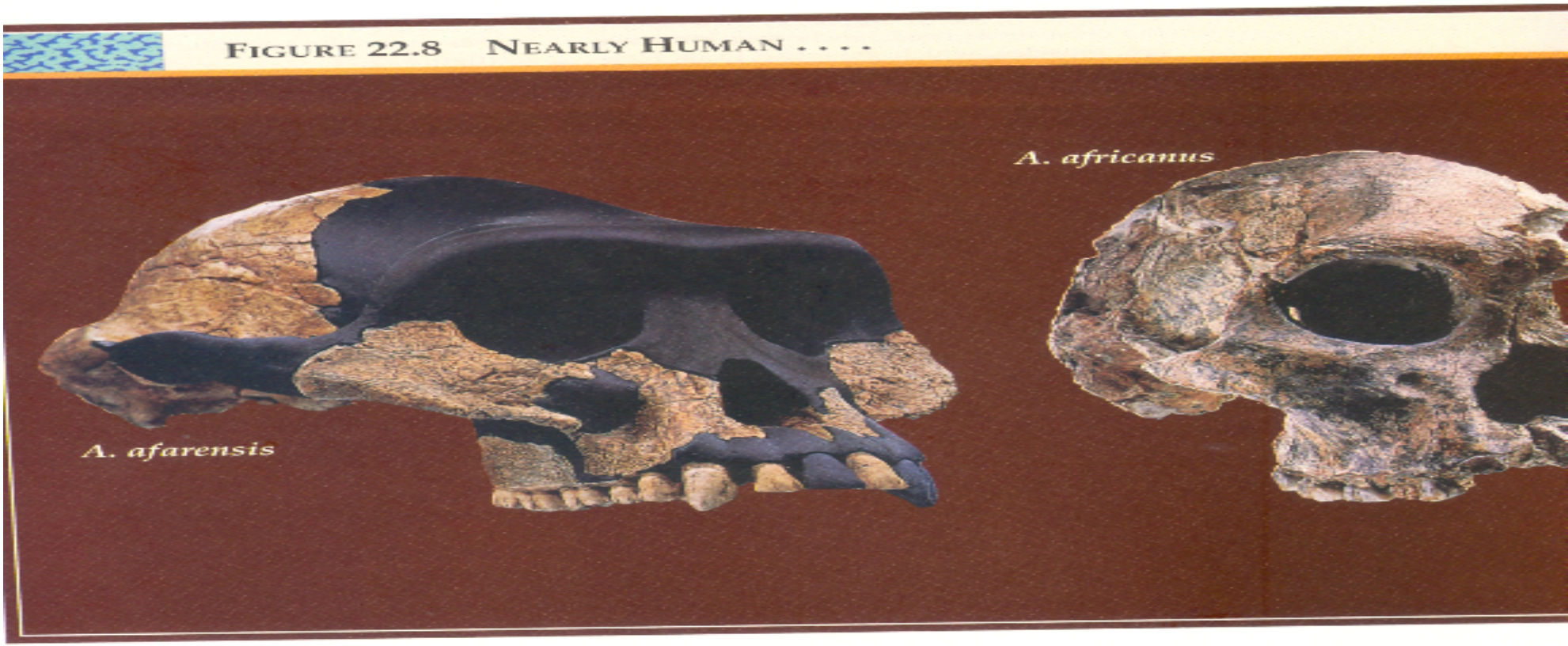

15–35,000 years ago
40,000 years ago
60,000 years ago
100,000 years ago
Equator
50–60,000 years ago

FIGURE 22.8 NEARLY HUMAN . . . .



THE FIRST HUMANS

o b j e c t i v e s

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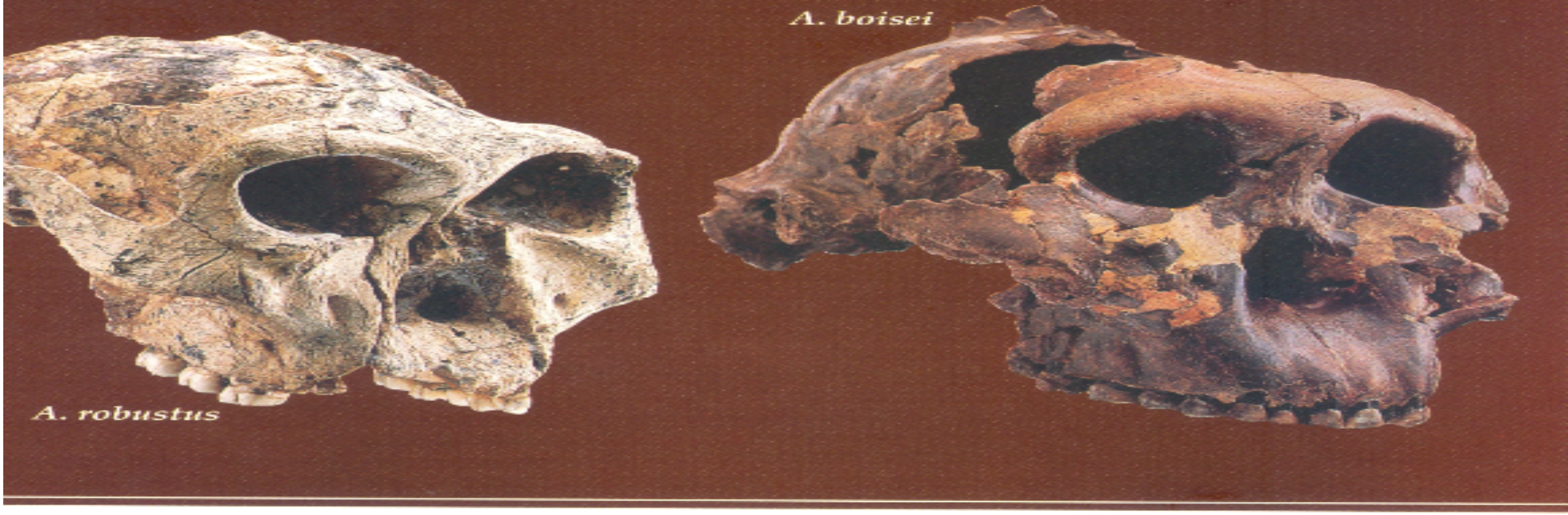


IGURE 22.9
path of human evolution
ws many early branches.
tralopithecus robustus and
oisei seem to represent
lutionary dead ends, with
iving descendants.
ether *A. africanus* was
estral to *Australopithecus*
sfus, as in (*a*), or to *Homo*
lis as well, as in (*b*), is
ently in dispute.

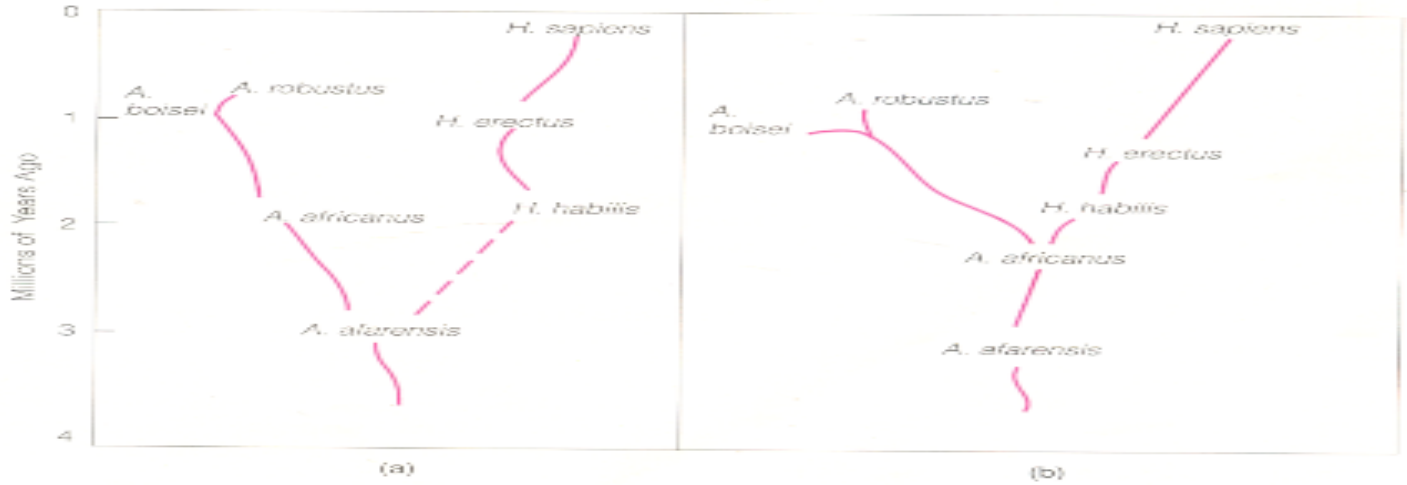
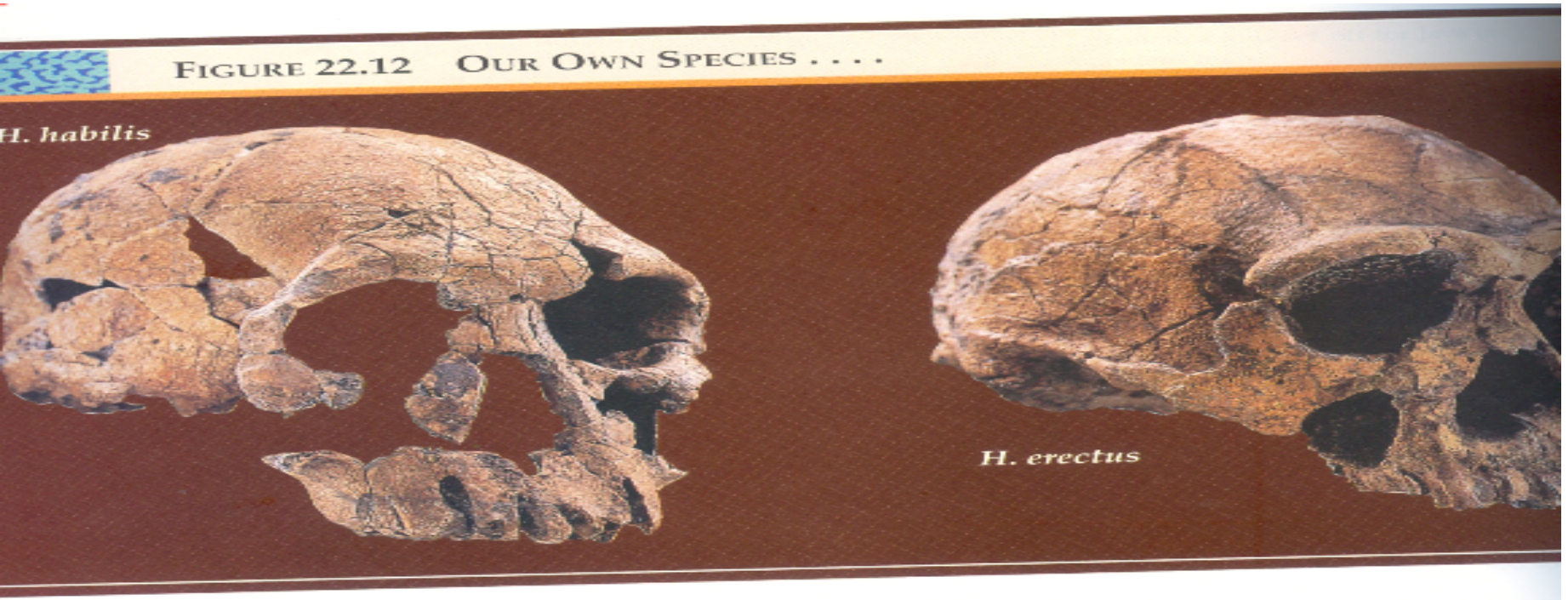


FIGURE 22.12 OUR OWN SPECIES . . . .



OUR OWN SPECIES

b j e c t i v e s

1. **Describe the evolutionary background of *Homo sapiens*.**
2. **Describe the evolutionary history of Neanderthal man.**
3. **Describe the evolutionary history of Cro-Magnon man.**

We come to the end of our evolutionary journey with the appearance about 500,000 years ago of *Homo sapiens* ("wise man"), our own species. Actually, we are newcomers to the human family, not having been around nearly as long as *H. erectus* was. Still, we have changed quite a bit since those first days.

Out of Africa Again: *Homo sapiens*

The origin of human races is a much-debated point among the scientists who study human evolution. Many have argued that the different races evolved from *H. erectus* independently, each adapted to a different place—Orientals in Asia, Ca casians in Europe, aborigines in Austral and so on. Others have felt it unlikely t the same species would evolve more th once, and argue that the races of huma appeared *after* our species evolved fr *H. erectus*. Recently, scientists studying DNA within human mitochondria h added fuel to the fire of this controve Examining mitochondrial DNA from ing humans all over the world, they ar that all the races of humans indeed c inated from one *H. sapiens* ance Where? You guessed it. Africa.

The reason these scientists looke mitochondrial DNA to study evoluti that the DNA within mitochondri transmitted only by females. (Humar

Evolutionary Trends

- Shifting from arboreal life to ground life
- Towards erect postures and freeing of hand
- Bipedal locomotion
- Increase in cranial capacity and complexity of brain
- Reduction in the size of canines and incisors

Evolutionary Trends

- Loss of jaw power
- Development of intelligence
- Forward shifting of the foramen magnum
- Orthognathous skull with high forehead without projecting eyebrow ridges
- Lack of simian gap and simian shelf

Early Evolution of Primates

- Evolution of human apes began in the Oligocene epoch and a common stock has been recognised, called *Propliopithecus.*
- In the Miocene epoch, a group of ape humans called *Dryopithecus* had evolved.

- Humans, gorillas and other apes originated diverging from *Dryopithecus*.
- *Dryopithecus* had broadened jaws, semi-erect gait, large canines and five-cusped molars.

Australopithecus

- Australopithecus was the immediate forerunner of the genus *Homo.*
- Its fossil was discovered by Dart (1924), who named it the 'southern ape'.
- It had a mosaic form of humans and apes, and can therefore be considered a connecting link between humans and apes.

1. Human Characteristics of *Australopithecus*

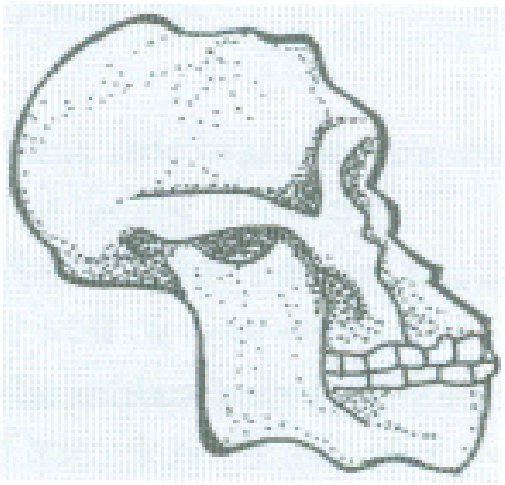
- Erect posture and bipedal locomotion.
- Dental arch with smoothly rounded parabola.
- Vertebral column with a distinct lumber curve.

- The simian gap was absent and canine teeth were not projecting over the head.
- Foramen magnum forward under the base of the skull.
- They used weapons made of bones.

2. Ape Characteristics of *Austra/opitheDUS*

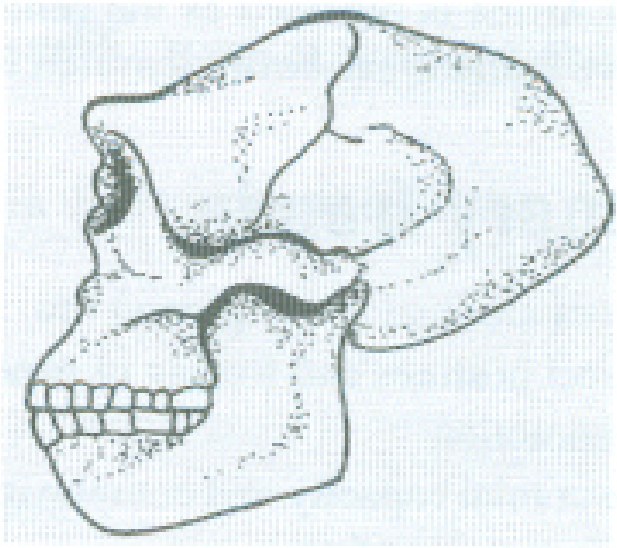
- The teeth were larger than modern humans.
- The face was prognathous.
- Eyebrow ridges projected over the eyes.
- Cranial capacity was 450 to 600 cc.

- There were several types of *Australopithecus,* like the gracile type *(A. africanus),* the robust type *(A. robust)* and the lucy *(A. afferensis).* The gracile type had a lightly body structure indicating an omnivorous form, but the robust type had strong cheek teeth, indicating an herbivorous diet.



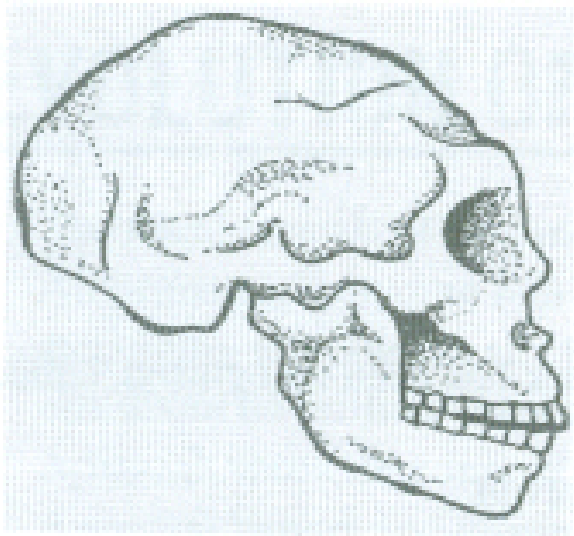
Australopithecus

Fig. 9 Skull of *Australopithecus*



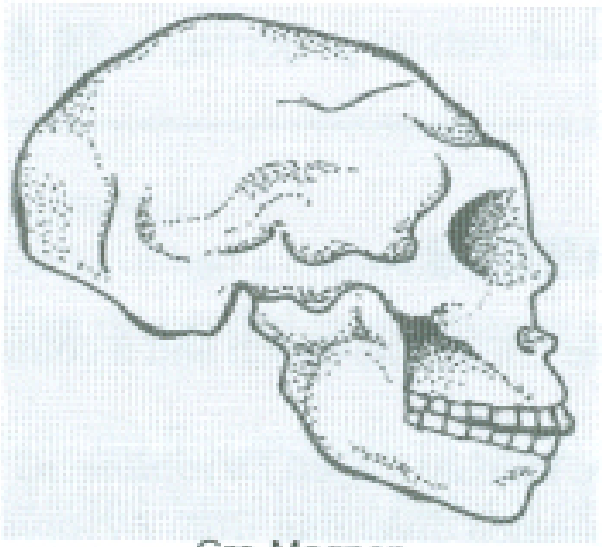
Pithecanthropus

Fig. 10 Skull of *Pithecanthropus*



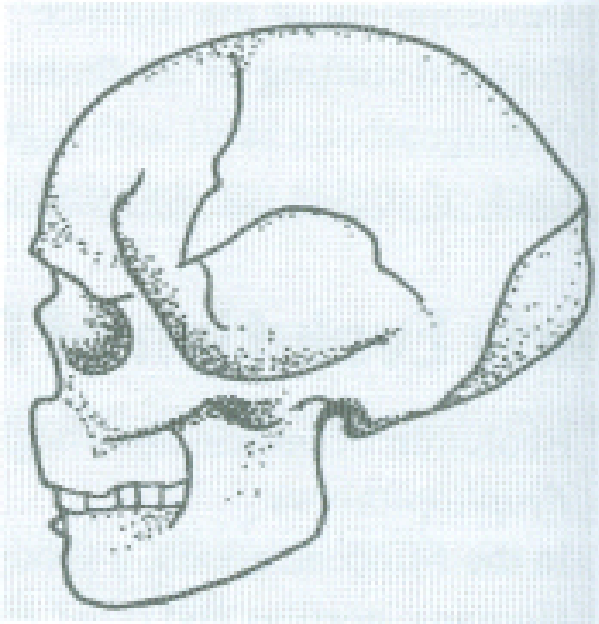
Neanderthal

Fig. 11 Skull of *Neanderthal*



Cro-Magnon

Fig. 12 Skull of *Cro-Magnon*



Homo Sapiens

Fig. 13 Skull of *Homo sapiens*

II. Origin of Genus *Homo (Homo Erectus)*

- In the middle of Pleistocene epoch, the Java human and the Peking human originated. As both shared common basic features, they were included in the genus *Homo erectus.*

- They had the following characteristics:

(a) Habitually erect and bipedal
(b) Skull flat with little or no forehead
(c) Large prognathous jaws
(d) Broad nasal aperture
(e) Larger teeth and eyebrow ridges

(t) No simian shelf
(g) No chin
(h) Cranial capacity 725 cc to 90 cc (Java man) and 915 cc to 1225 cc (Peking man)
(i) Used fires for protection and cooking

(j) *Homo erectus* represents a level of organisation that permits its possessors to spread into new niches

(k) *Homo erectus* was not only confined to Asia but also spread through Africa as *Homo habilis*

III. Origin of *Homo Sapiens*

- The *Homo erectus* gradually evolved into *Homo sapiens.* In this transitional event, two types of humans were found in later deposits of the Pleistocene epoch.
- Of these, one was identified as the primitive human called the *Neanderthal man,* who has been labelled as *Homo sapiens neanderthalensis* and the other, the modern human being called *Homo sapiens sapiens.*

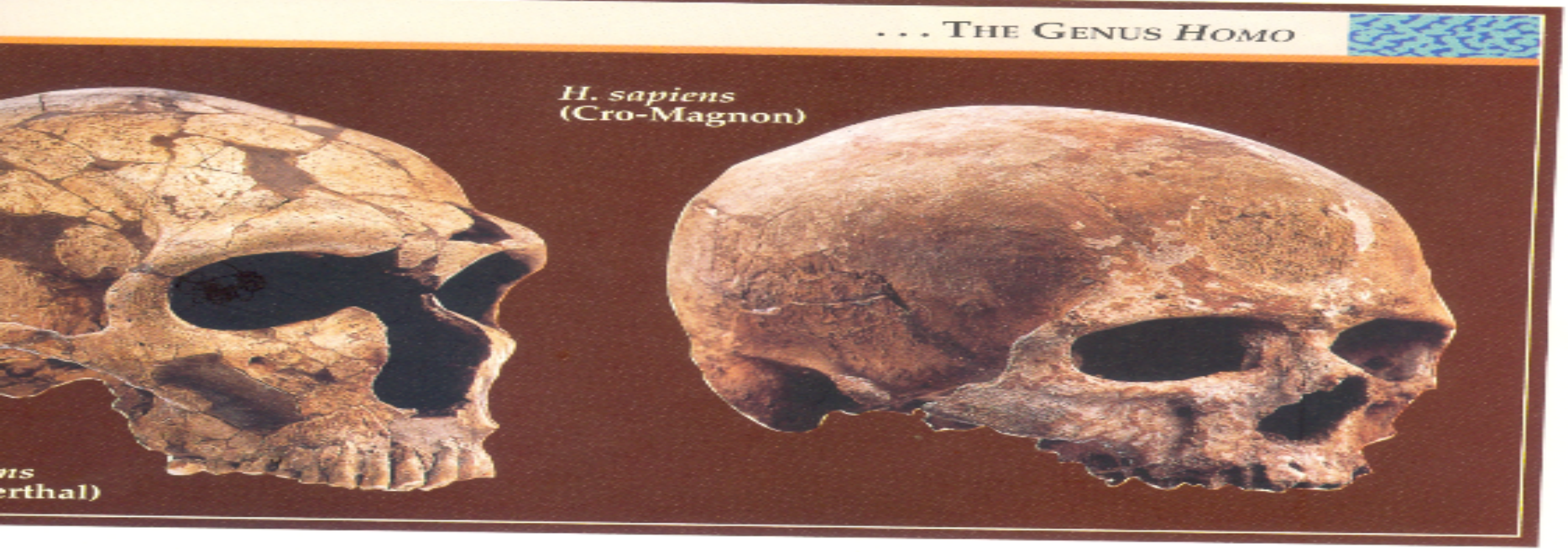
Homo Sapiens Neanderthalensis

- Its fossil was discovered by C Fuhlrott (1856) from the Neandertal river valley (Germany).
- They were abundant in Europe.
- Their forehead was low and slanting.
- They had heavy eyebrow ridges.
- They had a long prognathous and narrow face.
- Cranial capacity was about 1200 cc to 1600 cc.

- They lived in caves.
- They buried dead bodies. The burial of the dead reveals the emergence of religious beliefs in human records.
- They were capable of big game hunting.
- They used tools.
- Neanderthal humans were succeeded by *Homo sapiens* of modern times; the first of these were Cro Magnon humans.

Homo Sapiens Fossilis (Cro-Magnon man)

- They were taller than Neanderthal man.
- They had teeth and jaws like modern humans.
- Their cranial capacity was 1600 cc.
- They had an orthognathous skull.
- The appendicular skeleton is adapted for an upright posture and gait.
- The foramen magnum faces directly downwards.



carry many mitochondria within them that become part of a new baby, while sperm contribute no mitochondria to the new baby. Sperm carry their mitochondria wrapped around their tails, and so do not inject them into the ovum during fertilization.) It is thus possible to trace particular versions of a mitochondrial gene back through a family tree, from mother to grandmother to great-grandmother.

Human races evolved only recently in the evolutionary scale, and not enough time has yet elapsed for a large number of variations to accumulate, so the exact human tree cannot be reliably traced using this approach. However, some differences are evident, and it turns out that the greatest number of different mitochondrial DNA sequences occur among modern Africans. Because DNA accumulates mutations over time, the oldest DNA should show the largest number of mutations. This result argues that humans have been living in Africa longer than on any other continent. While there is no firm consensus among researchers yet, this line of investigation appears to suggest that our species evolved in Africa, and that the races of living humans evolved after that, not independently from separate species of *H. erectus*. If this is correct, our species was born in Africa, and from there spread to all parts of the world, retracing the path taken by *H. erectus* half a million years earlier (figure 22.13).

Neanderthal Man

H. sapiens first appeared in Europe as *H. erectus* was becoming rarer, about 130,000 years ago. The first fossils of *H. sapiens* were found in 1856 in the Neander Valley of Germany. Thus these early European humans were called **Neanderthals** (*thal* means "valley" in old German). Compared with ourselves, the European Neanderthals were powerfully built, short, and stocky. Their skulls were massive, with protruding faces and heavy bony ridges over the brows. Their brains were even larger than those of modern humans.

- They used to domesticate dogs and hunt in groups.
- From the Cro-Magnon man, due to a great cultural evolution, the modern human *(Homo sapien sapiens)* has resulted. Modern human beings are still acquiring more complex structures and their evolution is still a work in progress.

Critical Thinking: You Decide

- In 1992 the frozen body of a stone age man was discovered in the Australian Alps. Although this "Iceman" died about 5,300 years ago, his body is amazingly intact and researchers have begun to analyse DNA extracts from bits of his tissue. Can this studies tell us something about early human evolution? Explain your reasoning.

Homo sapiens

- By 100,000 years ago, H. *sapiens* (modern humans) had evolved from H. *erectus.*
- Neanderthals lived in Europe and the Near East from 200,000 to 35, 000 years ago.
- From 40,000 years ago to today, human evolution has been mostly cultural, not biological. - THE NEOLITHIC REVOLUTION

NEOLITHIC REVOLUTION

- However, the Neolithic Revolution involved far more than the adoption of a limited set of food-producing techniques. During the next millennia it would transform the small and mobile groups of hunter-gatherers that had hitherto dominated human history, into sedentary societies based in built-up villages and towns, which radically modified their natural environment by means of specialized food-crop cultivation (e.g., irrigation and food storage technologies) that allowed extensive surplus food production. These developments provided the basis for concentrated high population densities settlements, specialized and complex labor diversification, trading economies, the development of non-portable art, architecture, and culture, centralized administrations and political structures, hierarchical ideologies and depersonalized systems of knowledge (e. g., property regimes and writing).

NEOLITHIC REVOLUTION

- The first full-blown manifestation of the entire Neolithic complex is seen in the Middle Eastern Sumerian cities (ca. 3,500 BC), whose emergence also inaugurates the end of the prehistoric Neolithic period.The relationship of the above-mentioned Neolithic characteristics to the onset of agriculture, their sequence of emergence and empirical relation to each other at various Neolithic sites remains the subject of academic debate, and seems to vary from place to place, rather than being the outcome of universal laws of social evolution.

NEOLITHIC REVOLUTION

The term *Neolithic Revolution* was coined in the 1920s by Vere Gordon Childe to describe the first in a series of agricultural revolutions in Middle Eastern history. The period is described as a "revolution" to denote its importance, and the great significance and degree of change affecting the communities in which new agricultural practices were gradually adopted and refined.The beginning of this process in different regions has been dated from perhaps 8000 BC in Melanesia[5][6] to 2500 BC in Subsaharan Africa, with some considering the developments of 9000–7000 BC in the Fertile Crescent to be the most important. This transition everywhere seems associated with a change from a largely nomadic hunter-gatherer way of life to a more settled, agrarian-based one, with the inception of the domestication of various plant and animal species—depending on the species locally available, and probably also influenced by local culture.

THEORIES OF NEOLITHIC REVOLUTION

The Oasis Theory, originally proposed by Raphael Pumpelly in 1908, popularized by Vere Gordon Childe in 1928 and summarised in Childe's book *Man Makes Himself*. This theory maintains that as the climate got drier due to the Atlantic depressions shifting northward, communities contracted to oases where they were forced into close association with animals, which were then domesticated together with planting of seeds. However, today this theory has little support amongst archaeologists because climate data for the time actually shows that at the time, the climate of the region was getting wetter rather than drier.

The Hilly Flanks hypothesis, proposed by Robert Braidwood in 1948, suggests that agriculture began in the hilly flanks of the Taurus and Zagros mountains, where the climate was not drier as Childe had believed, and fertile land supported a variety of plants and animals amenable to domestication.[9]

THEORIES OF NEOLITHIC REVOLUTION

- **The Feasting model** by Brian Hayden suggests that agriculture was driven by ostentatious displays of power, such as giving feasts, to exert dominance. This required assembling large quantities of food, which drove agricultural technology.
- **The Demographic theories** proposed by Carl Sauer and adapted by Lewis Binford and Kent Flannery posit an increasingly sedentary population that expanded up to the carrying capacity of the local environment and required more food than could be gathered. Various social and economic factors helped drive the need for food.

THEORIES OF NEOLITHIC REVOLUTION

The evolutionary/intentionality theory, developed by David Rindos and others, views agriculture as an evolutionary adaptation of plants and humans. Starting with domestication by protection of wild plants, it led to specialization of location and then full-fledged domestication.

Ronald Wright's book and Massey Lecture Series *A Short History of Progress*[14] makes a case for the development of agriculture coinciding with an increasingly stable climate.

The postulated Younger Dryas impact event, claimed to be in part responsible for megafauna extinction, and which ended the last ice age, could have provided circumstances that required the evolution of agricultural societies for humanity to survive. The agrarian revolution itself is a reflection of typical overpopulation by certain species following initial events during extinction eras; this overpopulation itself ultimately propagates the extinction event.

In contrast to the Paleolithic (2.6 million years ago to 10,000 BC) in which several hominid species existed, only one (Homo sapiens) reached the Neolithic.

Domestication of plants

Neolithic grind stone for processing grain. Once agriculture started gaining momentum, cereal grasses (beginning with emmer, einkorn and barley), and not simply those that would favour greater caloric returns through larger seeds, were selectively bred. Plants that possessed traits such as small seeds or bitter taste would have been seen as undesirable. Plants that rapidly shed their seeds on maturity tended not to be gathered at harvest, thus not stored and not seeded the following season; years of harvesting selected for strains that retained their edible seeds longer.

Domestication of plants

Figs, barley and, most likely, oats were cultivated in the Jordan Valley, represented by the early Neolithic site of Gilgal I, where in 2006 archaeologists found caches of seeds of each in quantities too large to be accounted for even by intensive gathering, at strata dateable c. 11,000 years ago. Some of the plants tried and then abandoned during the Neolithic period in the Ancient Near East, at sites like Gilgal, were later successfully domesticated in other parts of the world.

Domestication of plants

Once early farmers perfected their agricultural techniques, their crops would yield surpluses that needed storage. Most hunter gatherers could not easily store food for long due to their migratory lifestyle, whereas those with a sedentary dwelling could store their surplus grain. Eventually granaries were developed that allowed villages to store their seeds longer. So with more food, the population expanded and communities developed specialized workers and more advanced tools.The process was not as linear as was once thought, but a more complicated effort, which was undertaken by different human populations in different regions in many different ways.

NEOLITHIC AGRICULTURE ROUND THE WORLD

Agriculture in Asia The Neolithic Revolution is believed to have become widespread in southwest Asia around 8000 BC–7000 BC, several reasonable speculations have been put forward; for example, it might be expected that the common practice of discarding food refuse in middens would result in the regrowth of plants from the discarded seeds in the (fertilizer-enriched) soils. In all likelihood, a number of factors contributed to the early onset of agriculture in Neolithic human societies.

NEOLITHIC AGRICULTURE ROUND THE WORLD

Agriculture in the Fertile Crescent : Generalised agriculture apparently first arose in the Fertile Crescent because of many factors. The Mediterranean climate has a long dry season with a short period of rain, which made it suitable for small plants with large seeds, like wheat and barley. These were the most suitable for domestication because of the ease of harvest and storage and the wide availability.

NEOLITHIC AGRICULTURE ROUND THE WORLD

Agriculture in Africa: The Revolution developed independently in different parts of the world, not just in the Fertile Crescent. On the African continent, three areas have been identified as independently developing agriculture: the Ethiopian highlands, the Sahel and West Africa.The most famous crop domesticated in the Ethiopian highlands is coffee. In addition, Khat, Ensete, Noog, teff and finger millet were also domesticated in the Ethiopian highlands. Crops domesticated in the Sahel region include sorghum and pearl millet. The Kola nut, extracts from which became an ingredient in Coca Cola, was first domesticated in West Africa. Other crops domesticated in West Africa include African rice, African yams and the oil palm. A number of crops that have been cultivated in Africa for millennia came after their domestication elsewhere. Agriculture in the Nile River Valley developed from crops domesticated in the Fertile Crescent. Bananas and plantains, which were first domesticated in Southeast Asia, most likely Papua New Guinea, were re-domesticated in Africa possibly as early as 5,000 years ago. Asian yams and taro were also cultivated in Africa.

NEOLITHIC AGRICULTURE ROUND THE WORLD

Agriculture in the Americas Corn, beans and squash were among the earliest crops domesticated in Mesoamerica, with Maize beginning about 7500 BC, squash, as early as 8000 to 6000 BC and beans by no later than 4000 BC. Potatoes and manioc were domesticated in South America. In what is now the eastern United States, Native Americans domesticated sunflower, sumpweed and goosefoot around 2500 BC.

- **Social change**
- It is often argued that agriculture gave humans more control over their food supply, but this has been disputed by the finding that nutritional standards of Neolithic populations were generally inferior to that of hunter gatherers, and life expectancy may in fact have been shorter, in part due to diseases.[Average height, for example, went down from 5' 10" (178 cm) for men and 5' 6" (168 cm) for women to 5' 3" (165 cm) and 5' 1" (155 cm), respectively and it took until the twentieth century for average human height to come back to the pre-Neolithic Revolution levels

Consequences of the Neolithic Revolution

- The shift to agricultural food production supported a denser population, which in turn supported larger sedentary communities, the accumulation of goods and tools, and specialization in diverse forms of new labor. The development of larger societies led to the development of different means of decision making and to governmental organization. Food surpluses made possible the development of a social elite who were not otherwise engaged in agriculture, industry or commerce, but dominated their communities by other means and monopolized decision-making.

Consequences of the Neolithic Revolution

- Andrew Sherratt has argued that following upon the Neolithic Revolution was a second phase of discovery that he refers to as the secondary products revolution. Animals, it appears were first domesticated purely as a source of meat. The Secondary Products Revolution occurred when it was recognised that animals also provided a number of other useful products. These included:
- hides and skins (from undomesticated animals)
- manure for soil conditioning (from all domesticated animals)
- wool (from sheep, llamas, alpacas, and Angora goats)
- milk (from goats, cattle, yaks, sheep, horses and camels)
- traction (from oxen, onagers, donkeys, horses and camels)

Consequences of the Neolithic Revolution

Sherratt argues that this phase in agricultural development enabled humans to make use of the energy possibilities of their animals in new ways, and permitted permanent intensive subsistence farming and crop production, and the opening up heavier soils for farming. It also made possible nomadic pastoralism in semi arid areas, along the margins of deserts, and eventually led to the domestication of both the dromedary and bactrian camel. Overgrazing of these areas, particularly by herds of goats, greatly extended the areal extent of deserts. Living in one spot would have more easily permitted the accrual of personal possessions and an attachment to certain areas of land. From such a position, it is argued, prehistoric people were able to stockpile food to survive lean times and trade unwanted surpluses with others.

Consequences of the Neolithic Revolution

Once trade and a secure food supply were established, populations could grow, and society would have diversified into food producers and artisans, who could afford to develop their trade by virtue of the free time they enjoyed because of a surplus of food. The artisans, in turn, were able to develop technology such as metal weapons. Such relative complexity would have required some form of social organisation to work efficiently, so it is likely that populations that had such organisation, perhaps such as that provided by religion, were better prepared and more successful. In addition, the denser populations could form and support legions of professional soldiers. Also, during this time property ownership became increasingly important to all people. Ultimately, Childe argued that this growing social complexity, all rooted in the original decision to settle, led to a second Urban Revolution in which the first cities were built

Disease

Throughout the development of sedentary societies, disease spread more rapidly than it had during the time in which hunter-gatherer societies existed. Inadequate sanitary practices and the domestication of animals may explain the rise in deaths and sickness during the Neolithic Revolution, as diseases jumped from the animal to the human population. Some examples of diseases spread from animals to humans are influenza, smallpox, and measles. In concordance with a process of natural selection, the humans who first domesticated the big mammals quickly built up immunities to the diseases as within each generation the individuals with better immunities had better chances of survival

Consequences of the Neolithic Revolution

In their approximately 10,000 years of shared proximity with animals, Eurasians and Africans became more resistant to those diseases compared with the indigenous populations encountered outside Eurasia and Africa. For instance, the population of most Caribbean and several Pacific Islands have been completely wiped out by diseases. According to the Population history of American indigenous peoples, 90% of the population of certain regions of North and South America were wiped out long before direct contact with Europeans. Some cultures like the Inca Empire did have one big mammal domesticated, the Llama, but the Inca did not drink its milk or live in a closed space with their herds, hence limiting the risk of contagion.

Consequences of the Neolithic Revolution

The causal link between the type or lack of agricultural development, disease and colonisation is not supported by colonization in other parts of the world. Disease increased after the establishment of British Colonial rule in Africa and India despite the areas having diseases for which Europeans lacked natural immunity. In India agriculture developed during the Neolithic period with a wide range of animals domesticated. During colonial rule an estimated 23 million people died from cholera between 1865 and 1949, and millions more died from plague, malaria, influenza and tuberculosis.In Africa European colonisation was accompanied by great epidemics, including malaria and sleeping sickness and despite parts of colonised Africa having little or no agriculture Europeans were more susceptible than the Africans. The increase of disease has been attributed to increased mobility of people, increased population density, urbanisation, environmental deterioration and irrigation schemes that helped to spread malaria rather than the development of agriculture.

Technology

In his book *Guns, Germs, and Steel*, Jared Diamond argues that Europeans and East Asians benefited from an advantageous geographical location that afforded them a head start in the Neolithic Revolution. Both shared the temperate climate ideal for the first agricultural settings, both were near a number of easily domesticable plant and animal species, and both were safer from attacks of other people than civilizations in the middle part of the Eurasian continent. Being among the first to adopt agriculture and sedentary lifestyles, and neighboring other early agricultural societies with whom they could compete and trade, both Europeans and East Asians were also among the first to benefit from technologies such as firearms and steel swords.

Technology

- In addition, they developed resistances to infectious disease, such as smallpox, due to their close relationship with domesticated animals. Groups of people who had not lived in proximity with other large mammals, such as the Australian Aborigines and American indigenous peoples were more vulnerable to infection and largely wiped out by diseases.
- During and after the Age of Discovery, European explorers, such as the Spanish conquistadors, encountered other groups of people who had never or only recently adopted agriculture, such as in the Pacific Islands, or lacked domesticated big mammals such as the people of the New Guinea Highlands.