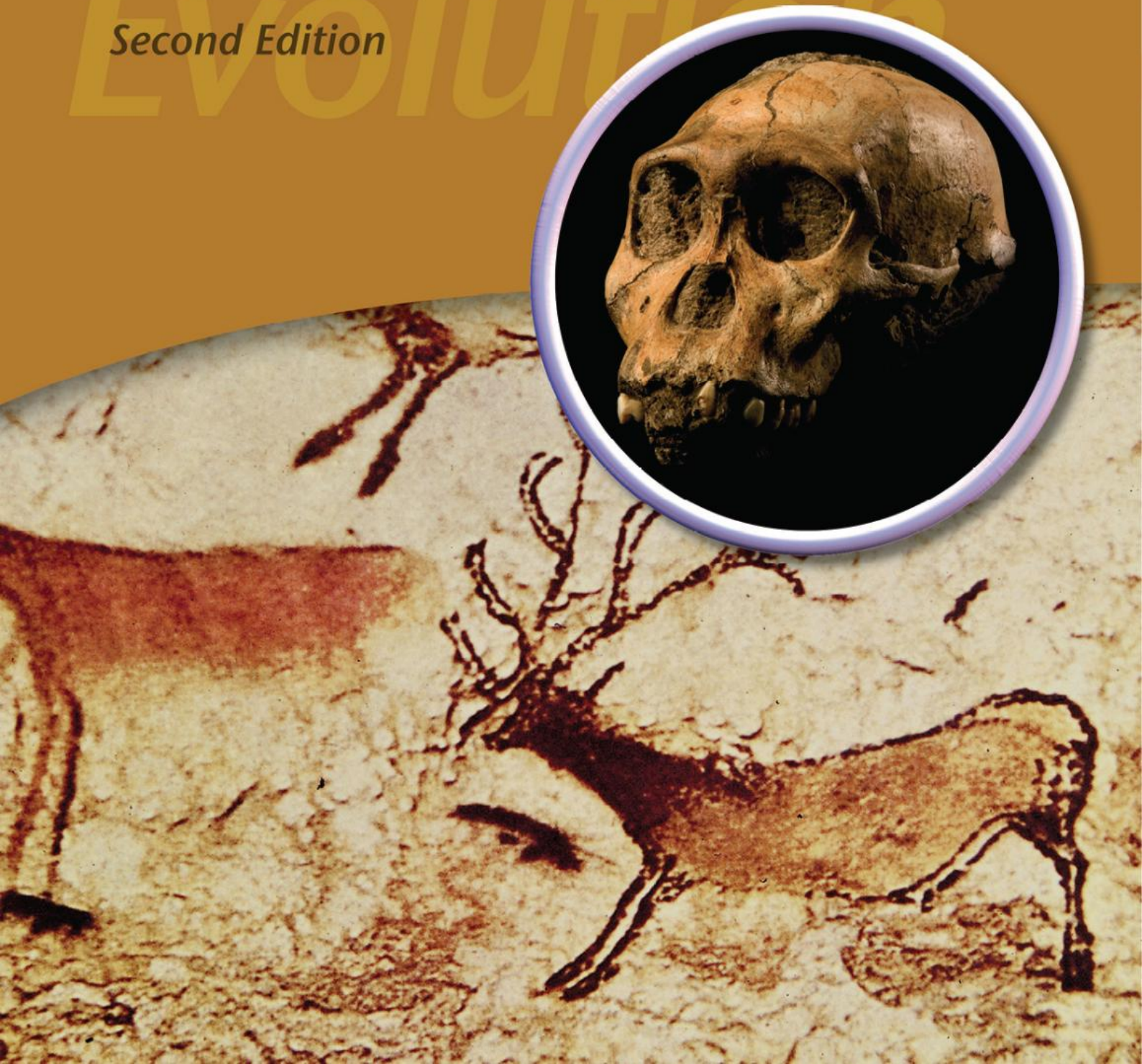
BIOZONE

Biology Modular Workbook Series

Human Evolution

Second Edition



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"Stag and Reindeer", Lascaux, Dordogne, France. Image from "Art of Antiquity", Corel Corporation, Professional Photos

The cranium of Malapa hominid 1 (MH1) from South Africa, named "Karabo". The combined fossil remains of this juvenile male is designated as the holotype for *Australopithecus sediba. Photo by Brett Eloff, courtesy Lee Berger and the University of the Witwatersrand http://en.wikipedia.org/wiki/File:Australopithecus_sediba.JPG*

Biology Modular Workbook Series

The BIOZONE *Biology Modular Workbook Series* has been developed to meet the demands of customers with the requirement for a flexible modular resource. Each workbook provides a collection of visually interesting and accessible activities, catering for students with a wide range of abilities and background. The workbooks are divided into a series of chapters, each comprising an introductory section with detailed learning objectives and a series of write-on activities ranging from paper practicals and data handling exercises, to questions requiring short essay style answers. Page tabs identifying "**Related activities**" and "**Weblinks**" help students to find related material within the workbook and locate weblinks that will enhance their understanding of the topic. During the development of this series, we have taken the opportunity to develop new content, while retaining the basic philosophy of a student-friendly resource, which spans the gulf between textbook and study guide. Its highly visual presentation engages students, increasing their motivation and empowering them to take control of their learning.

Human Evolution

This title in the *Biology Modular Workbook Series* provides students with a set of comprehensive guidelines and highly visual worksheets through which to explore aspects of hominin evolution. *Human Evolution* is the ideal companion for students in biology and anthropology, encompassing our position as primates, as well as the nature of human physical and cultural evolution. This workbook comprises four chapters each focusing on one particular area within this broad topic. These areas are explained through a series of activities, usually of one or two pages, each of which explores a specific concept (e.g. primate evolution or the development of intelligence). *Human Evolution* is a student-centered resource and is part of a larger package, which also includes the ***Human Evolution Presentation Media CD-ROM***. Students completing the activities, in concert with their other classroom and practical work, will consolidate existing knowledge and develop and practise skills that they will use throughout their course. This workbook may be used in the classroom or at home as a supplement to a standard textbook. Some activities are introductory in nature, while others may be used to consolidate and test concepts already covered by other means. Biozone has a commitment to produce a cost-effective, high quality resource, which acts as a student's companion throughout their biology study. Please do not photocopy from this workbook; we cannot afford to provide single copies of workbooks to schools and continue to develop, update, and improve the material they contain.

Acknowledgements and Photo Credits

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Biozone's authors also acknowledge the generosity of those who have kindly provided photographs for this edition: • Dept of Biological Sciences, University of Waikato, for access to their collection of hominin skulls • David Haring at the Duke Lemur Center for the photograph of the aye aye • Skulls Unlimited International: www.skullsunlimited.com • Grotte de Rouffignac, for drawings and photographs of the Rouffignac Cave • Jan Morrison, for her drawings • The Melbourne Zoo for their assistance in photographing their splendid collection of primates • Fiona Hicks for her artistic representation of Otzi.

We also acknowledge the photographers that have made their images available through Wikimedia Commons under Creative Commons Licences 2.0, 2.5. or 3.0: • Bjørn Christian Tørrissen • Obersachse • Brett Eloff • Rosinos • Avandergeer • Didier Descouens • José-Manuel Benito • Sandstein • Dr. John F. Burka • Jojojoe

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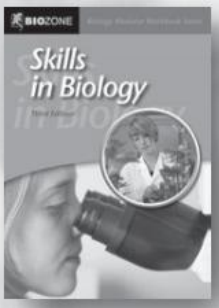
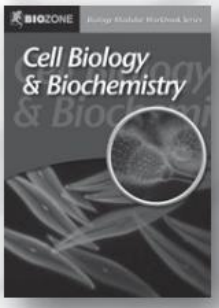
Related Titles:



Skills in Biology



Cell Biology & Biochemistry

Genes & Inheritance

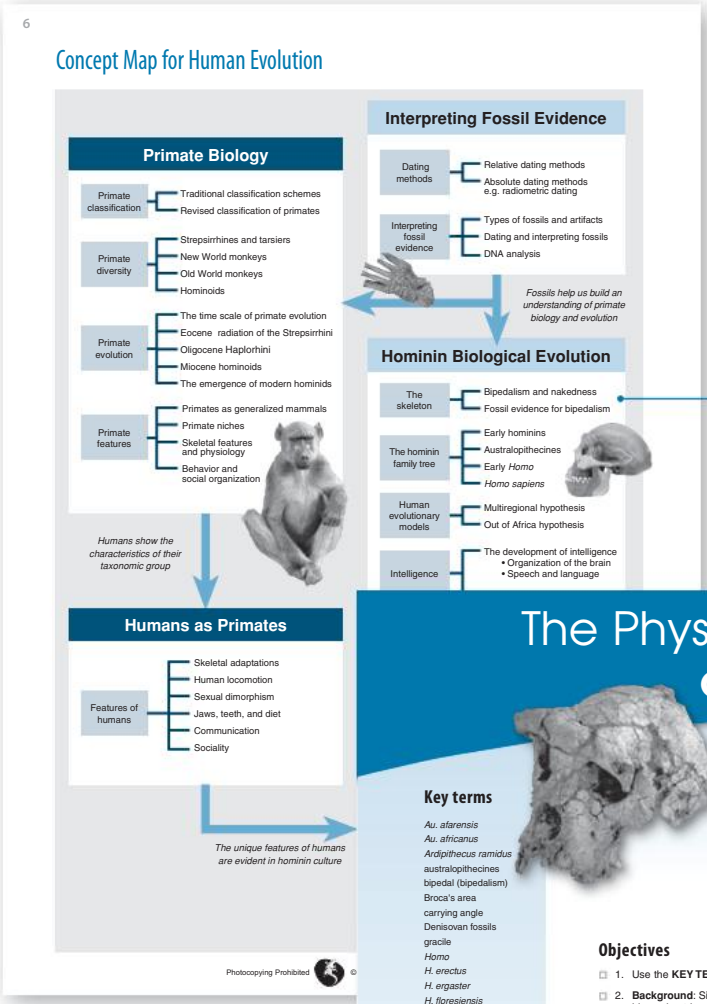
Evolution

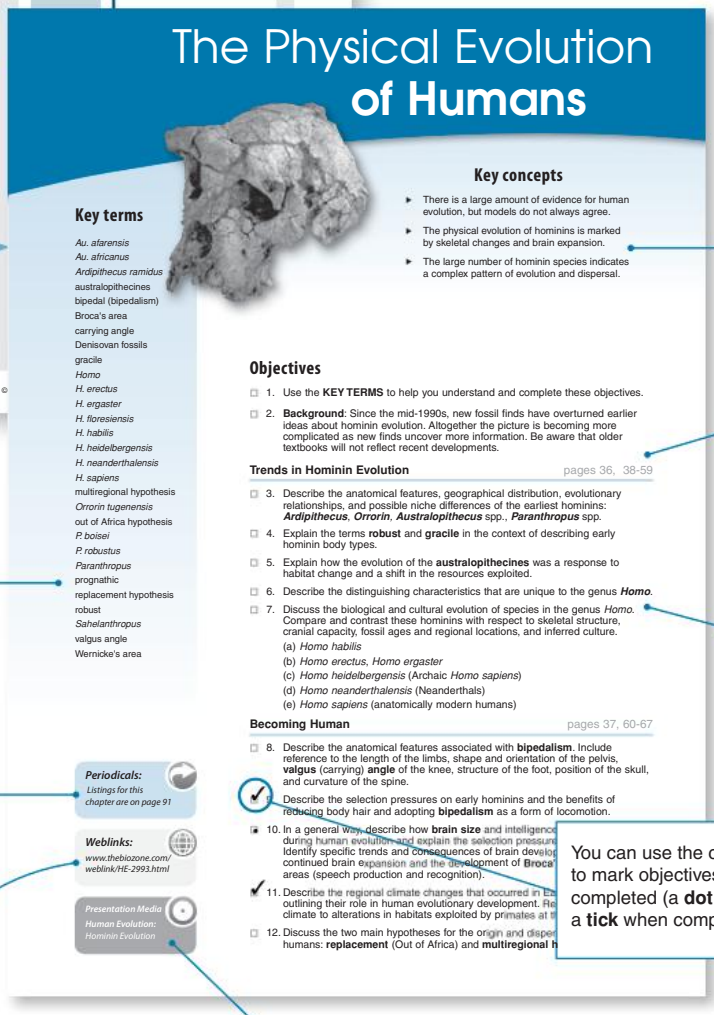
Contents

CODES: Δ **Upgraded** this edition ☆ **New** this edition **Activity** is marked: ☐ to be done; ☑ when completed

How to Use this Workbook

Human Evolution is designed to provide students with a resource that will make it easier to acquire skills and knowledge in this exciting and controversial area. An understanding of human origins is essential for students of anthropology and an important component of many standard biology courses. Moreover, this subject is of high interest, with many competing ideas based of differing interpretations of the fossil record. This workbook is suitable for all students. It is thorough and engaging, and provides ample opportunity for students to consolidate and extend their knowledge in this area. It is **not a textbook**; its aim is to complement the texts written for your particular course. *Human Evolution* provides the following resources in each chapter. You should refer back to them as you work through each set of worksheets.





Features of the Concept Map

A summary of the emphasis in each major section of the workbook. Each major part of the workbook deals with aspects relating to human evolution: the primates, methods for investigating human evolution, and the physical and cultural evolution of humans.

Features of the Chapter Topic Page

The important key ideas in this chapter. You should have a thorough understanding of the concepts summarized here.

The page numbers for the activities covering the material in this subsection of objectives.

The objectives provide a point by point summary of what you should have achieved by the end of the chapter. They can also be used to derive **essential questions** for this chapter.

A list of important key terms used throughout the chapter. These will help you focus on important ideas.

Periodicals of interest are identified by title on a tab on the activity page to which they are relevant. The full citation appears in the **Appendix** on the page indicated.

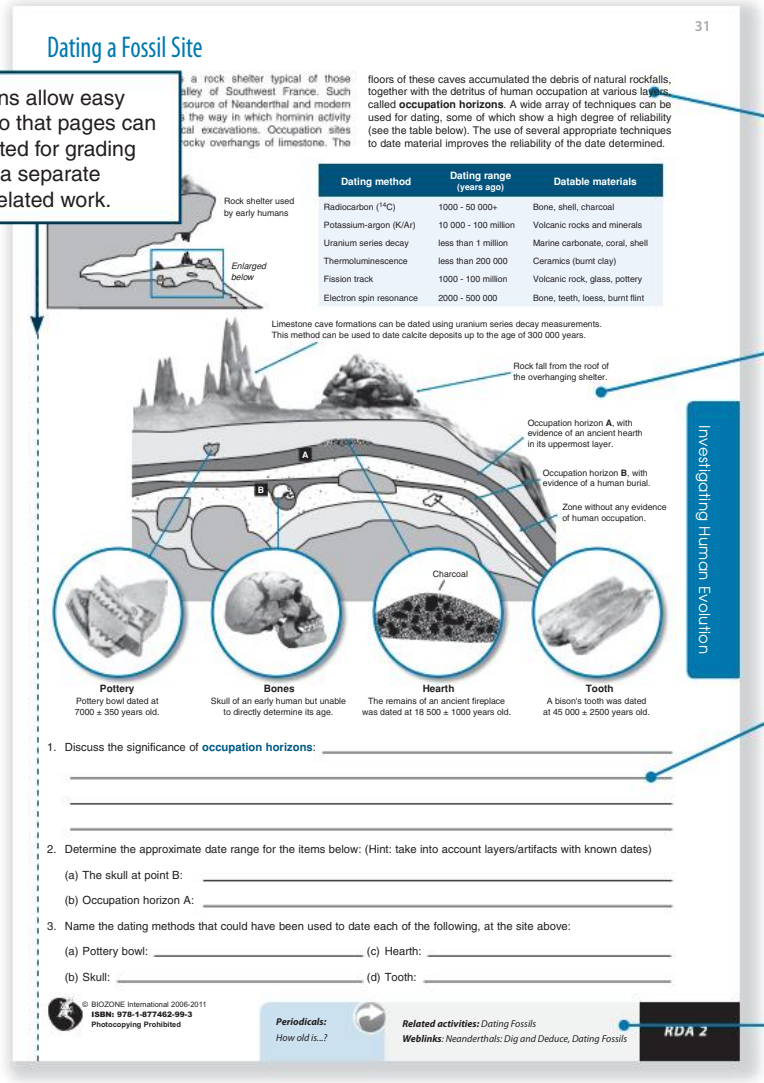
You can use the check boxes to mark objectives to be completed (a **dot** to be done; a **tick** when completed).

The Weblinks on many of the activities can be accessed through the web links page at: *www.thebiozone.com/weblink/HE-2993.html*
See page 3 for more details.

The Human Evolution Presentation Media covers the material listed under this heading.

Using the Activities

The activities and exercises make up most of the content of this workbook. They are designed to reinforce concepts in the topic. Your teacher may use the activity pages to introduce a topic for the first time, or you may use them to revise ideas already covered. They are excellent for use in the classroom, and as homework exercises and revision. In most cases, the activities should not be attempted until you have carried out the necessary background reading from your textbook.



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Dating a Fossil Site

Perforations allow easy removal so that pages can be submitted for grading or kept in a separate folder of related work.

...a rock shelter typical of those ...alley of Southwest France. Such ...source of Neanderthal and modern ...the way in which hominin activity ...cal excavations. Occupation sites ...ocky overhangs of limestone. The floors of these caves accumulated the debris of natural rockfalls, together with the detritus of human occupation at various layers called **occupation horizons**. A wide array of techniques can be used for dating, some of which show a high degree of reliability (see the table below). The use of several appropriate techniques to date material improves the reliability of the date determined.

Rock shelter used by early humans

Enlarged below

Dating method	Dating range (years ago)	Datable materials
Radiocarbon (^{14}C)	1000 - 50 000+	Bone, shell, charcoal
Potassium-argon (K/Ar)	10 000 - 100 million	Volcanic rocks and minerals
Uranium series decay	less than 1 million	Marine carbonate, coral, shell
Thermoluminescence	less than 200 000	Ceramics (burnt clay)
Fission track	1000 - 100 million	Volcanic rock, glass, pottery
Electron spin resonance	2000 - 500 000	Bone, teeth, loess, burnt flint

Limestone cave formations can be dated using uranium series decay measurements. This method can be used to date calcite deposits up to the age of 300 000 years.

Rock fall from the roof of the overhanging shelter.

Occupation horizon **A**, with evidence of an ancient hearth in its uppermost layer.

Occupation horizon **B**, with evidence of a human burial.

Zone without any evidence of human occupation.

A

B

Charcoal

Pottery
Pottery bowl dated at 7000 ± 350 years old.

Bones
Skull of an early human but unable to directly determine its age.

Hearth
The remains of an ancient fireplace was dated at 18 500 ± 1000 years old.

Tooth
A bison's tooth was dated at 45 000 ± 2500 years old.

Investigating Human Evolution

1. Discuss the significance of **occupation horizons**: _____

2. Determine the approximate date range for the items below: (Hint: take into account layers/artifacts with known dates)
   (a) The skull at point B: _____
   (b) Occupation horizon A: _____

3. Name the dating methods that could have been used to date each of the following, at the site above:
   (a) Pottery bowl: _____ (c) Hearth: _____
   (b) Skull: _____ (d) Tooth: _____

ISBN: 978-1-877462-99-3

Periodicals:
How old is...?

Related activities: *Dating Fossils*
Weblinks: *Neanderthals: Dig and Deduce, Dating Fossils*

RDA 2

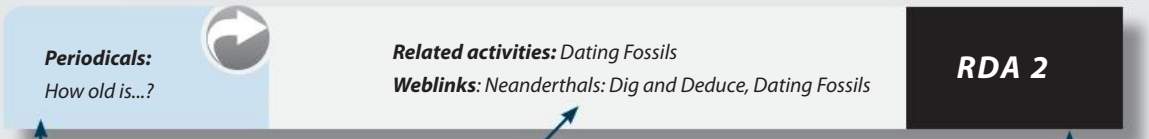
Introductory paragraph:
The introductory paragraph provides essential background and provides the focus of the page. Note words that appear in bold, as they are 'key words' worthy of including in a glossary of terms for the topic.

Easy to understand diagrams:
The main ideas of the topic are represented and explained by clear, informative diagrams.

Write-on format:
Your understanding of the main ideas of the topic is tested by asking questions and providing spaces for your answers. Where indicated by the space available, your answers should be concise. Questions requiring more explanation or discussion are spaced accordingly. Answer the questions adequately according to the questioning term used (see the introduction).

A tab system at the base of each activity page identifies resources associated with the activity on that page. Use the guide below to help you use the tab system most effectively.

Using page tabs more effectively



Students (and teachers) who would like to know more about this topic area are encouraged to locate the periodical cited on the Periodicals tab.
Articles of interest directly relevant to the topic content are cited. The full citation appears in the Appendix as indicated at the beginning of the topic chapter.

Related activities

Other activities in the workbook cover related topics or may help answer the questions on the page. In most cases, extra information for activities that are coded R can be found on the pages indicated here.

Weblinks

This citation indicates a valuable video clip or animation that can be accessed from the Weblinks page specifically for this workbook.
www.thebiozone.com/weblink/HE-2993.html

INTERPRETING THE ACTIVITY CODING SYSTEM

Type of Activity

D = includes some data handling or interpretation
P = includes a paper practical
R = *may* require extra reading (e.g. text or other activity)
A = includes application of knowledge to solve a problem
E = extension material

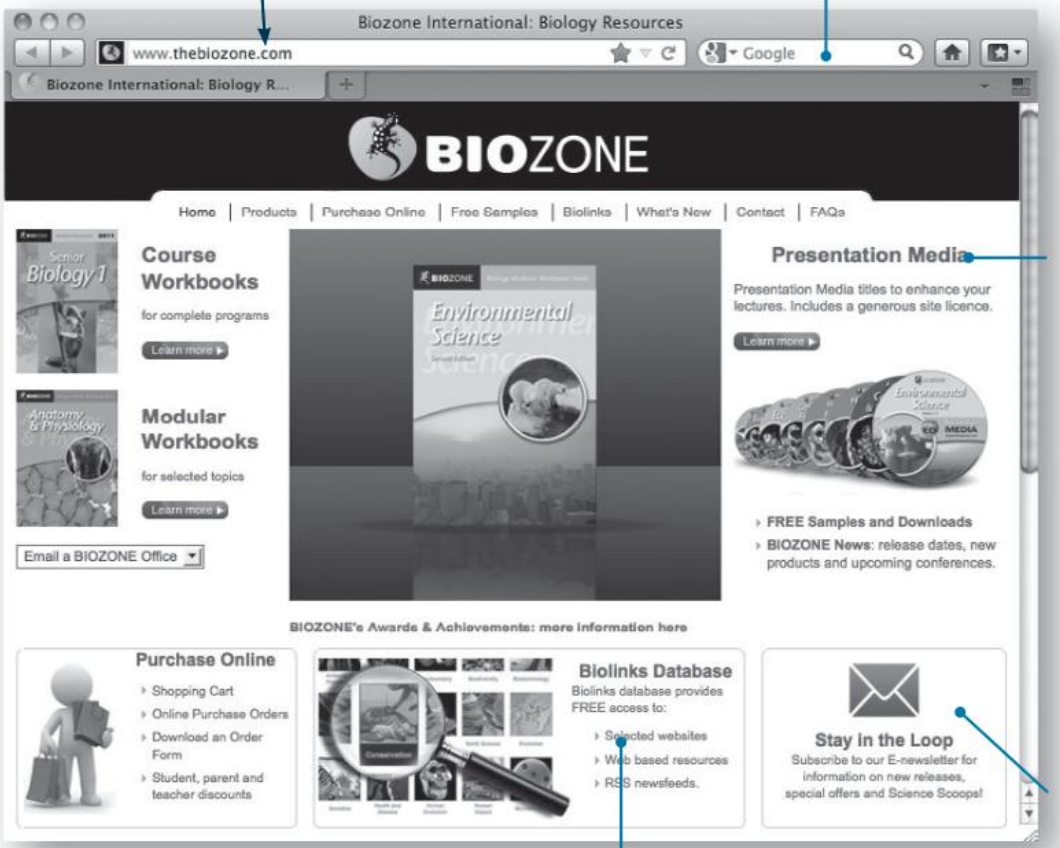
Level of Activity

1 = generally simpler, including mostly describe questions
2 = more challenging, including explain questions
3 = challenging content and/or questions, including discuss

Using BIOZONE's Website

The current internet address (URL) for the web site is displayed here. You can type a new address directly into this space.

Use Google to search for web sites of interest. The more precise your search words are, the better the list of results. EXAMPLE: If you type in "biotechnology", your search will return an overwhelmingly large number of sites, many of which will not be useful to you. Be more specific, e.g. "biotechnology medicine DNA uses".



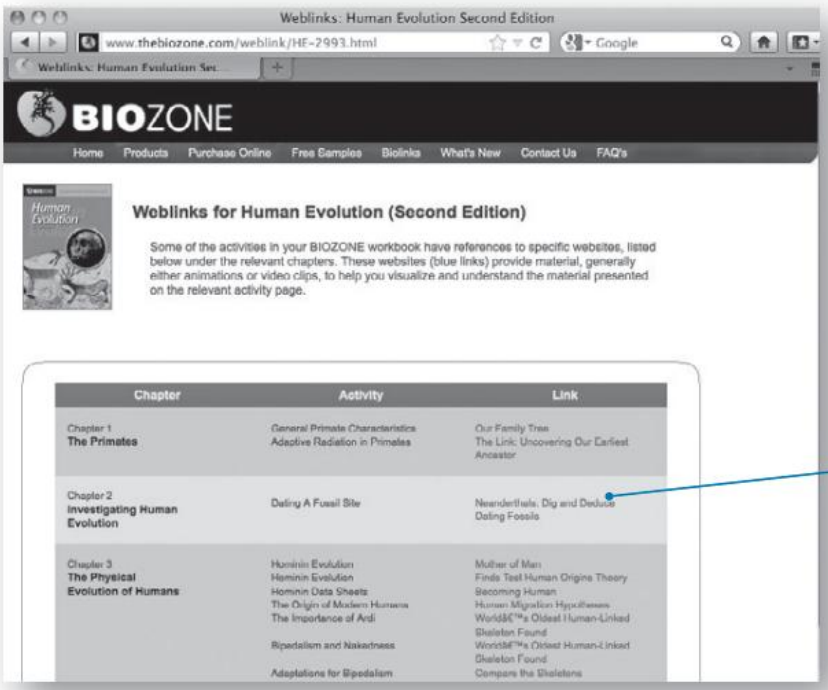
Find out about our superb **Presentation Media**. These slide shows are designed to provide in-depth, highly accessible illustrative material and notes on specific areas of biology.

News: Find out about product announcements, shipping dates, and workshops and trade displays by Biozone at teachers' conferences around the world.

Access the **Biolinks** database of web sites related to each major area of biology. It's a great way to quickly find out more on topics of interest.

Weblinks: www.thebiozone.com/weblink/HE-2993.html

BOOKMARK WEBLINKS BY TYPING IN THE ADDRESS: IT IS NOT ACCESSIBLE DIRECTLY FROM BIOZONE'S WEBSITE



Throughout this workbook, some pages make reference to Weblinks and periodicals that are particularly relevant to the activity on which they are cited. They provide great support to aid understanding of basic concepts:

Periodicals: Full citations are provided in the Appendix for those that wish to read further on a topic.

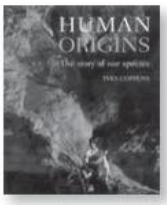
Weblink: Provides a link to an **external web site** with supporting information for the activity.

Resources Information

Your set textbook should always be a starting point for information, but there are also many other resources available. A list of some readily available resources is provided below. Access to the publishers of these resources can be made directly from Biozone's web site through our resources hub: **www.thebiozone.com/links.html**. Please note that listing any product in this workbook does not, in any way, denote Biozone's endorsement of that product and Biozone does not have any business affiliation with the publishers listed herein.

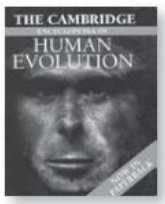
Supplementary Texts

The literature base for this topic is immense and often aimed at specialist readers. The titles listed here have been chosen on the basis of their accuracy, up-to-date content, and accessibility and appeal to students.



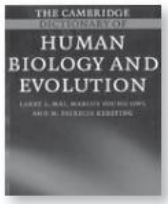
Coppens, Y., 2004 (English language edn)
Human Origins: The Story of Our Species, 180 pp. **Publisher**: Hachette Illustrated UK, Octopus Publishing Group Ltd
ISBN: 1-84430-095-1
Comments: *An appealing but informative read based on reconstructions for film of the history of human physical and cultural evolution.*

Dunbar, R. and L. Barrett, 2000
Cousins: Our Primate Relatives, 240 pp.
Publisher: BBC Worldwide Ltd
ISBN: 0-563-55115-1
Comments: *An excellent resource for studying primate origins, and the physical and behavioural features of the primate order. Well organised and superbly illustrated.*

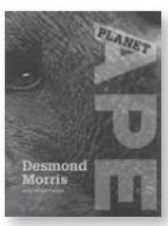


Jones, S., R. Martin, and D. Pilbeam (eds), 1994
The Cambridge Encyclopedia of Human Evolution, 524 pp.
Publisher: Cambridge University Press
ISBN: 978-0-521467-86-5
Comments: *Primarily a teacher's reference, which includes material on primates as well as full coverage of hominin evolution.*

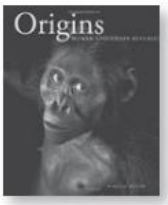
Lynch, J. and L. Barrett, 2003
Walking With Cavemen, 224 pp.
Publisher: Headline Book Publishing
ISBN: 0-7553-1177-9
Comments: *The story of hominin evolution, presented as an appealing student read and illustrated throughout with reconstructions based on the film of the same name.*



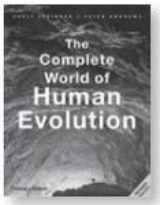
Mai, L.L., M. Young Owl. and M.P. Kersting, 2005
The Cambridge Dictionary of Human Biology and Evolution, 668 pp. including appendices
Publisher: Cambridge University Press
ISBN: 0-521-66486-1
Comments: *More encyclopaedia than dictionary, this is an excellent, authoritative, and up-to-date reference with a number of useful appendices.*



Morris, D 2009
Planet Ape, 288 pp.
Publisher: Firefly Books
ISBN: 978-1554075669
Comments: *A beautifully illustrated and informative book focusing on the great apes. Topics cover physiology, diet, intelligence, social life and communication skills, and reproduction.*



Palmer, D 2010
Origins Human Evolution Revealed, 256 pp.
Publisher: Mitchell Beazley
ISBN: 978-1845334741
Comments: *An excellent overview of human evolution. The book is divided into two sections, the first focuses on early hominid species, and the second on hominin migration. Excellent diagrams and photos.*



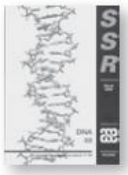
Stringer, C, and Andrews, P, 2011 **Human The Complete World of Human Evolution**, 240 pp.
Publisher: Thames & Hudson
ISBN: 978-0500288986
Comments: *A well illustrated text providing a comprehensive account of human evolution. This edition includes the importance of recent fossils finds, including the Denisovan fossils.*

Periodicals, Magazines, & Journals

Biological Sciences Review: *An informative quarterly publication for biology students.* Enquiries:
UK: Philip Allan Publishers **Tel**: 01869 338652
Fax: 01869 338803 **E-mail**: sales@philipallan.co.uk
Australasia: **Tel**: 08 8278 5916, **E-mail**: rjmorton@adelaide.on.net

New Scientist: *Widely available weekly magazine with research summaries and features.* Enquiries: Reed Business Information Ltd, 51 Wardour St. London WIV 4BN **Tel**: (UK and intl):+44 (0) 1444 475636 **E-mail**: ns.subs@qss-uk.com
or subscribe from their web site.

Scientific American: *A monthly magazine containing specialist features. Articles range in level of reading difficulty and assumed knowledge.* Subscription enquiries: 415 Madison Ave. New York. NY10017-1111 **Tel**: (outside North America): 515-247-7631 **Tel**: (US & Canada): 800-333-1199



School Science Review: *A quarterly journal which includes articles, reviews, and news on current research and curriculum development. Free to Ordinary Members of the ASE or available on subscription.* Enquiries: **Tel**: 01707 28300
Email: info@ase.org.uk *or visit their web site.*

The American Biology Teacher: *The peer-reviewed journal of the NABT. Published nine times a year and containing information and activities relevant to biology teachers.* Contact: NABT, 12030 Sunrise Valley Drive, #110, Reston, VA 20191-3409
Web: www.nabt.org

Command Words

Questions come in a variety of forms. Whether you are studying for an exam or writing an essay, it is important to understand exactly what the question is asking. A question has two parts to it: one part of the question will provide you with information, the second part of the question will provide you with instructions as to how to answer the question. Following these instructions is most important. Often students in examinations know the material but fail to follow instructions and do not answer the question appropriately. Examiners often use certain key words to introduce questions. Look out for them and be clear as to what they mean. Below is a description of terms commonly used when asking questions in biology.

Commonly used Terms in Biology

The following terms are frequently used when asking questions in examinations and assessments. Students should have a clear understanding of each of the following terms and use this understanding to answer questions appropriately.

Account for: Provide a satisfactory explanation or reason for an observation.

Analyze: Interpret data to reach stated conclusions.

Annotate: Add **brief** notes to a diagram, drawing or graph.

Apply: Use an idea, equation, principle, theory, or law in a new situation.

Appreciate: To understand the meaning or relevance of a particular situation.

Calculate: Find an answer using mathematical methods. Show the working unless instructed not to.

Compare: Give an account of similarities and differences between two or more items, referring to both (or all) of them throughout. Comparisons can be given using a table. Comparisons generally ask for similarities more than differences (see contrast).

Construct: Represent or develop in graphical form.

Contrast: Show differences. Set in opposition.

Deduce: Reach a conclusion from information given.

Define: Give the precise meaning of a word or phrase as concisely as possible.

Derive: Manipulate a mathematical equation to give a new equation or result.

Describe: Give an account, including all the relevant information.

Design: Produce a plan, object, simulation or model.

Determine: Find the only possible answer.

Discuss: Give an account including, where possible, a range of arguments, assessments of the relative importance of various factors, or comparison of alternative hypotheses.

Distinguish: Give the difference(s) between two or more different items.

Draw: Represent by means of pencil lines. Add labels unless told not to do so.

Estimate: Find an approximate value for an unknown quantity, based on the information provided and application of scientific knowledge.

Evaluate: Assess the implications and limitations.

Explain: Give a clear account including causes, reasons, or mechanisms.

Identify: Find an answer from a number of possibilities.

Illustrate: Give concrete examples. Explain clearly by using comparisons or examples.

Interpret: Comment upon, give examples, describe relationships. Describe, then evaluate.

List: Give a sequence of names or other brief answers with no elaboration. Each one should be clearly distinguishable from the others.

Measure: Find a value for a quantity.

Outline: Give a brief account or summary. Include essential information only.

Predict: Give an expected result.

Solve: Obtain an answer using algebraic and/or numerical methods.

State: Give a specific name, value, or other answer. No supporting argument or calculation is necessary.

Suggest: Propose a hypothesis or other possible explanation.

Summarize: Give a brief, condensed account. Include conclusions and avoid unnecessary details.

In Conclusion

Students should familiarize themselves with this list of terms and, where necessary throughout the course, they should refer back to them when answering questions. The list of terms mentioned above is not exhaustive and students should compare this list with past examination papers and essays etc. and add any new terms (and their meaning) to the list above. The aim is to become familiar with interpreting the question and answering it appropriately.

Concept Map for Human Evolution

Primate Biology

- **Primate classification**
  - Traditional classification schemes
  - Revised classification of primates
- **Primate diversity**
  - Strepsirrhines and tarsiers
  - New World monkeys
  - Old World monkeys
  - Hominoids
- **Primate evolution**
  - The time scale of primate evolution
  - Eocene radiation of the Strepsirrhini
  - Oligocene Haplorhini
  - Miocene hominoids
  - The emergence of modern hominids
- **Primate features**
  - Primates as generalized mammals
  - Primate niches
  - Skeletal features and physiology
  - Behavior and social organization

Humans show the characteristics of their taxonomic group

Humans as Primates

- **Features of humans**
  - Skeletal adaptations
  - Human locomotion
  - Sexual dimorphism
  - Jaws, teeth, and diet
  - Communication
  - Sociality

The unique features of humans are evident in hominin culture

Interpreting Fossil Evidence

- **Dating methods**
  - Relative dating methods
  - Absolute dating methods e.g. radiometric dating
- **Interpreting fossil evidence**
  - Types of fossils and artifacts
  - Dating and interpreting fossils
  - DNA analysis

Fossils help us build an understanding of primate biology and evolution

Hominin Biological Evolution

- **The skeleton**
  - Bipedalism and nakedness
  - Fossil evidence for bipedalism
- **The hominin family tree**
  - Early hominins
  - Australopithecines
  - Early *Homo*
  - *Homo sapiens*
- **Human evolutionary models**
  - Multiregional hypothesis
  - Out of Africa hypothesis
- **Intelligence**
  - The development of intelligence
    - Organization of the brain
    - Speech and language
  - Increasing social complexity

Biological and cultural evolution in humans are interdependent

Hominin Cultural Evolution

- **Culture**
  - What is culture?
  - Selection pressures for cultural development
- **Tool cultures**
  - Early stone tool cultures
    - Oldowan tools
    - Acheulean technology
    - Mousterian tools
    - Upper Paleolithic tools
  - Mesolithic & Neolithic cultures
  - Copper and Bronze age cultures
  - Recent cultural evolution
- **Becoming human**
  - The rise of agriculture
  - Art and spirituality

The Primates

Key concepts

- Primates are characterized by a suite of relatively generalized features.
- Modern genetic analyses have resulted in a reclassification of primates.
- Sociality in primates is associated with a range of complex behaviors.

Key terms

anthropoid
ape
arboreal
brachiation
Catarrhini
common ancestor
dryomorph
great ape
Haplorhini (haplorhines)
hominid
hominin
hominoid
human
knuckle walking
lesser ape
New World monkey
Old World monkey
Platyrrhini
pongid
prehensile
primate
prosimian
quadrupedalism
ramamorph
Strepsirrhini (strepsirrhines)
tarsier

Objectives

☐ 1. Use the **KEY TERMS** to help you understand and complete these objectives.

Primate Classification

pages 8-13

☐ 2. Define the terms: **primate**, **Strepsirrhini**, **Haplorhini**, **hominoid**, **hominid**, **pongid**, **hominin**. Describe the features that all primates have in common. Appreciate that the taxonomy of primates has been revised but the older terms prosimian (for the strepsirrhines) and anthropoid (for the simian haplorhines) still persist in some texts as general descriptive terms.

☐ 3. Understand that the term hominid correctly refers to the family Hominidae, which includes the great apes and humans, but that older texts may use the term to refer only humans and their ancestors.

☐ 4. Classify primates into the following taxa, with examples: **strepsirrhines**, **tarsiers, New World monkeys**, **Old World monkeys**, **hominoids**, **hominids**.

☐ 5. Recognise the **Platyrrhini** and **Catarrhini** as two parvorders (a taxon between infraorder and superfamily). The Platyrrhini comprise only the superfamily of New World monkeys, so effectively functions as a superfamily. The Catarrhini includes the Old World monkeys and the hominoids.

☐ 6. Describe new classifications for the **hominids** that accommodate the genetic similarities and differences between the modern **great apes** and humans.

Primate Characteristics

pages 8-10, 3-22

☐ 7. Clearly understand what is meant by a **distinguishing characteristic** (feature). List the distinguishing **physical** characteristics of different primate groups. Include reference to each of the following:

- Facial structure and dentition
- Snout and nostril structure and development of olfactory organs
- Limb structure, hand and foot structure, and tail function (**prehensile** or not)
- Extent of bifocal and color vision

☐ 8. Describe the distinguishing behavioral characteristics of different primate taxa. Describe each of the following as appropriate: social behavior, communication, locomotion, behavior towards young (parental care).

Primate Origins

pages 11-12, 23-25

☐ 9. Describe the likely origin of the primates from a **common ancestor** about 60 million years ago.

☐ 10. Explain how the primates have adapted to different habitats. Identify the diets and modes of locomotion associated with the various primate niches.

☐ 11. Describe the evolution of apes during the Miocene-Early Pleistocene. Describe the characteristics of the early ancestral forms that gave rise to the modern hominoids: **dryomorphs** (e.g. *Dryopithecus*, *Proconsul*) and **ramamorphs** (e.g. *Sivapithecus*, *Gigantopithecus*, *Ouranopithecus*).

Periodicals:
Listings for this chapter are on page 91

Weblinks:
www.thebiozone.com/weblink/HE-2993.html

Presentation Media
Human Evolution:
Primate Evolution

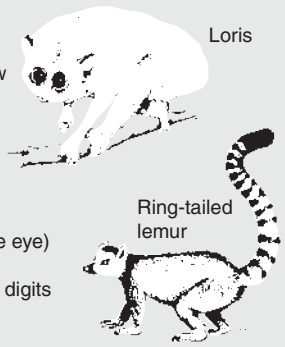
Strepsirrhines and Tarsiers

The suborder **Strepsirrhini (**previously the prosimians) includes the lemurs, lorises, aye-aye, and bushbabies. The lorises are found in southern Asia, the bush babies in Africa, while all members of the superfamily Lemuroidea (the lemurs, indrids, and aye-aye) are found on the island of Madagascar. The strepsirrhines are considered to be more primitive than other primates because some of their anatomical characteristics are found in some other mammals but not in haplorhine primates (monkeys, apes, and humans). The nocturnal, tree-dwelling **tarsiers**, which were once classified with the apparently similar lemurs and lorises, exhibit characteristics of both strepsirrhines and haplorhines, while maintaining characteristics unique to themselves. They are now included in the suborder **Haplorhini**. Tarsiers are found in Indonesia and the Philippines, and are named for their elongated tarsal bones, which form their ankles and enable them to leap up to three meters between trees. Tarsiers are nocturnal hunters, and their large, mobile eyes are a notable feature, each one being bigger than the tarsier's brain.

Strepsirrhini

Features common to most strepsirrhines:

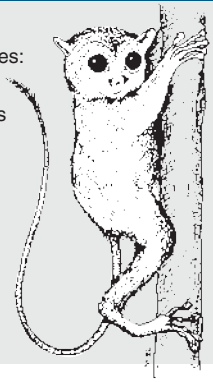
- Tooth comb and grooming claw
- Wet naked nose with whiskers
- Arboreal (tree dwelling)
- Grasping hands and feet
- Long, mobile limbs
- Quadrupedal
- Binocular vision
- Tapetum (reflective layer in the eye)
- Upright sitting position
- Nails instead of claws on most digits
- Simpler placenta



Tarsiers

Strepsirrhini features:

- Jawbone made of two separate parts
- Multiple nipples
- Grooming claws
- Uterus split into two chambers



Haplorhini features:

- Dry hairy nose
- Reduced whiskers
- No tooth comb
- No tapetum (reflective layer in the eye)
- Mobile, furry upper lip
- Complex placenta
- Lacks the ability to make vitamin C

Ring-tailed lemurs are more terrestrial than other lemurs and live in relatively large social groups.

Slow lorises prefer forest edges, which have plentiful supports and insect prey.

The nocturnal **aye-aye** is the most structurally specialized of the lemurs, with an elongated middle digit

David Haring/Duke Lemur Center

Tarsiers hunt animal prey at night. They move by clinging and leaping using their elongated tarsals.

1. Describe the significance of the following three features of strepsirrhines that are absent in haplorhine primates:

   (a) Moist rhinarium (structure of the nasal area): _____

   _____

   (b) Reflective tapetum (structure of the eye): _____

   _____

   (c) Dental tooth comb and grooming claw (usually on the second toe of their feet): _____

   _____

2. Describe a feature of tarsiers that is:

   (a) Shared with strepsirrhines: _____

   (b) Shared with haplorhines: _____

   (c) Unique to tarsiers: _____

3. Suggest why biologists have assigned the tarsiers to a taxonomic group distinctwww from the strepsirrhines: _____

   _____

***Related activities**: Primate Classification, Physical Features of Primates*

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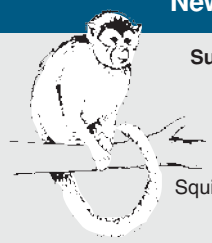
New World and Old World Monkeys

The suborder **Haplorhini** (formerly Anthropoidea) are a diverse taxon and include tarsiers and all the simian (higher) primates**.** Haplorhines do not have a grooming claw, tooth comb, or a tapetum in their eyes. The Haplorhini comprises three superfamilies: the New World monkeys, the Old World monkeys, and the hominoids. The **New World monkeys** are found in Central and South America and, in general, have rounded nostrils that face towards their ears. The **Old World monkeys** of Africa and Asia are diurnal and generally larger than their New World counterparts. Like others in the parvorder Catarrhini (which also includes the hominoids), they have narrow nostrils that point downwards and flattened nails on their digits. They are divided into two subfamilies: the cheek pouch monkeys (Cercopithecinae), which includes macaques and baboons, and the leaf eating monkeys (Colobinae), which includes langurs, colobus monkeys, and proboscis monkeys.

New World monkeys

Superfamily: Ceboidea



Squirrel monkey

Spider monkey

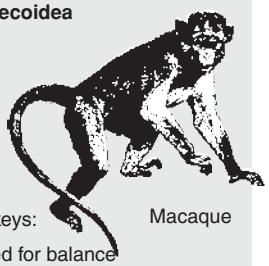
Characteristic features of New World monkeys:

- Strictly arboreal (tree dwelling)
- Many have a prehensile tail (used as a fifth limb)
- Typically lack color vision
- Flat nose and widely separated nostrils
- Quadrupedal (use all four limbs to move about)
- Twelve premolars unlike the eight of all catarrhines

Old World monkeys

Superfamily: Cercopithecoidea

Olive baboon



Macaque

Characteristic features of Old World monkeys:

- Tail, if present, is not prehensile but used for balance
- Hindlimbs longer than forelimbs
- Quadrupedal (use all four limbs to move about)
- Diurnal, with color vision. Many are partly terrestrial
- Nostrils are close together and open downwards
- Most species sexually dimorphic, and most live in social groups

Spider monkeys have long, slender limbs and a prehensile tail.

The **marmosets** (above) and tamarins are all small. The tail is not prehensile.

Macaques are widespread and found in many habitats and climates.

Proboscis monkeys are arboreal and diurnal. Males have a pendulous nose.

1. Describe three features that distinguish Old World monkeys from New World monkeys:

   (a) _____

   (b) _____

   (c) _____

2. Describe one feature of the haplorhines that distinguishes them clearly from the strepsirrhines: _____

   _____

3. What does the absence of the tapetum tell you about the haplorhine primates? _____

   _____

4. Describe the geographical distribution of:

   (a) The Old World monkeys: _____

   (b) The New World monkeys: _____

5. Describe one feature common to all catarrhines: _____

6. Describe one feature common to all New World monkeys: _____

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Related activities: *Primate Classification, Physical Features of Primates*

The Hominoids

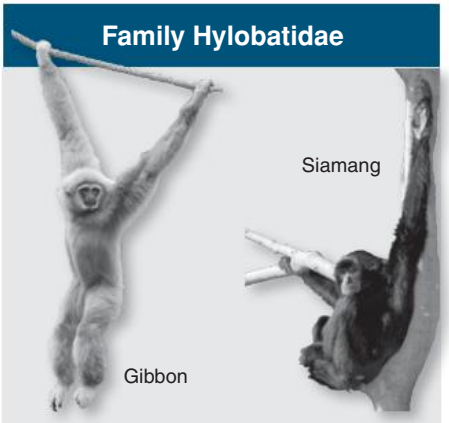
The second superfamily within the Catarrhini is the **Hominoidea**, which includes the apes and hominins (humans and their ancestors). All apes are relatively large primates, with bony eye ridges and flattened noses. The latest cladistic revisions of primate taxonomy distinguish the lesser apes (the **Hylobatidae**), from the great apes and humans (the **Homindae**). The hominids have larger bodies and bigger brains than other primates. Unlike the hylobatids, they have no ischial callosities (fleshy, nerveless pads on the rump to allow comfortable and stable seating on branches). Hominids exhibit pronounced sexual dimorphism, with the males being much larger than the females. Hominids are also less arboreal and more terrestrial than the hylobatids. The hominids are further divided into the subfamilies Ponginae (orangutans) and Homininae (gorillas, chimpanzees, and humans). Orangutans are more arboreal and more solitary than other hominids. The inclusion of gorillas and chimpanzees in the same subfamily as humans reflects our recognition of genetic similarities and shared evolutionary history.

Superfamily Hominoidea

Hominoid features (lesser apes & hominids)

- No tail
- Semi-erect or fully erect posture
- Broad chest, pelvis, and shoulders
- Relatively long arms and mobile shoulder joints
- Larger brain

Family Hylobatidae



Characteristic features of the **lesser apes**:

- All found in Southeast Asia
- Long forearms with hook-like fingers specialised for **brachiation**
- Pads on the rump (**ischial callosities**)
- Arboreal; sleep on tree branches and do not build nests

Family Hominidae (Hominids)

Subfamily Ponginae

Subfamily Homininae

Tribe Gorillini gorillas

Characteristic features of the hominids:

- Large and sexually dimorphic
- Most predominately quadrupedal
- Most omnivorous
- Typical catarrhine dentition but teeth large in gorillas and small in humans
- Complex social behavior

Features possessed to varying degrees by tribe Hominini (excluding chimps):

- Partially or habitually bipedal
- Large cerebral cortex
- Reduced canines
- Prominent nose and chin
- Reduced brow ridges
- Highly sensitive skin, body hair reduced

Australopithecus afarensis

Tribe Hominini
humans & their ancestors, chimpanzees

1. Describe three ways in which apes differ from both the Old World and the New World monkeys:

   (a) _____

   (b) _____

   (c) _____

2. Describe three ways in which the hylobatids differ from the hominids:

   (a) _____

   (b) _____

   (c) _____

3. Discuss the features of the tribe hominini (excluding chimpanzees) that set them apart from other hominids:

_____

_____

_____

_____

_____

***Related activities**: Primate Classification, Physical Features of Primates*

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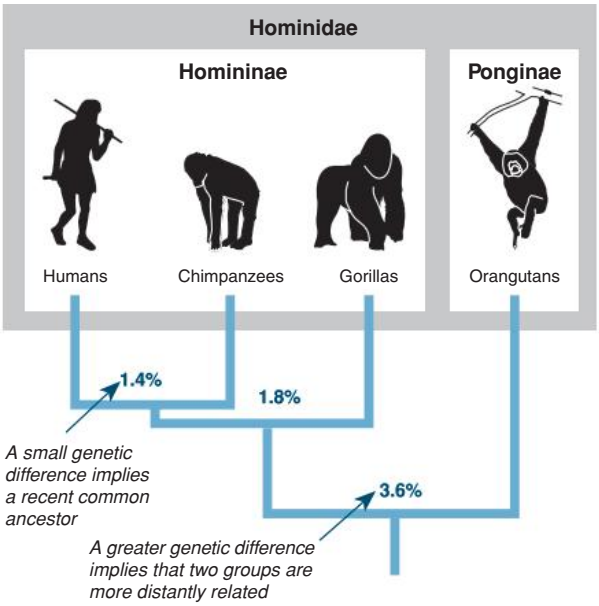
Primate Classification

The classification of primates has been considerably revised several times in the last few decades. Classification should reflect evolutionary history, and the modern classifications of primates are supported by genetic, as well as morphological, evidence of phylogeny. Current classifications favor two primate suborders: the **Strepsirrhini** (lemurs and lorises) and the **Haplorhini** (tarsiers, monkeys, apes, and humans). Within the haplorhines, the classification of the apes has been particularly controversial, and heavily influenced by the historical perception that humans were special and worthy of their own family. Thus, all great apes were placed in the family Pongidae, and the family Hominidae was reserved for humans and their direct fossil relatives. This older view was overturned in the light of more objective ways to evaluate phylogeny. Based on the evidence of genetic differences (right), chimps and gorillas are more closely related to humans than to orangutans, and chimps are more closely related to humans than they are to gorillas. Under this scheme, there is no true family of great apes. The family Hominidae includes two subfamilies: Ponginae (orangutans) and Homininae (humans, chimps, and gorillas). The classification is monophyletic because the Hominidae includes all the species that arise from a common ancestor. The table below illustrates the classification of living primates. Note that the parvorder **Platyrrhini** includes only the New World monkeys so the terms are often used interchangeably. The names that apply to each level for our own species (*Homo sapiens*) are shown in bold.



Order	Sub-order	Infraorder	Superfamily		Family	Examples
Primates	Strepsirrhini	Lemuriformes	Lemuroidea		Cheirogaleidae	dwarf and mouse leumurs
					Daubentoniida	aye-aye
					Indriidae	woolly lemurs, indrids, and sifakas
					Lemuridae	brown lemurs
					Lepilemuridae	sportive lemurs
		Lorisiformes	Lorisoidea		Lorisidae	loris
					Galagidae	galago (bush baby)
	Haplorhini	Tarsiiformes			Tarsiidae	tarsier
		Simiiformes	Platyrrhini	Ceboidea (New World monkeys)	Callitrichidae	marmoset, tamarin
					Cebidae	capuchins and squirrel monkeys
					Aotidae	night or owl monkeys
					Pitheciidae	titis, sakis, uakaris
					Atelidae	howler, spider, and woolly monkeys
			Catarrhini	Cercopithecoidea (Old World monkeys)	Cercopithecidae	colobus, langurs, macaque, baboon
				Hominoidea (apes and humans)	Hylobatidae	gibbon, siamang
					Hominidae	orangutan, gorilla, chimpanzee ***humans (Homo sapiens)***

1. Provide the classification for the following primates, using the chart above as a guide:

Primate	Order	Suborder	Infraorder	Superfamily	Family
(a) Brown lemur					
(b) Spider monkey					
(c) Baboon					
(d) Gibbon					
(e) Humans					

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Periodicals: *What makes us human?*

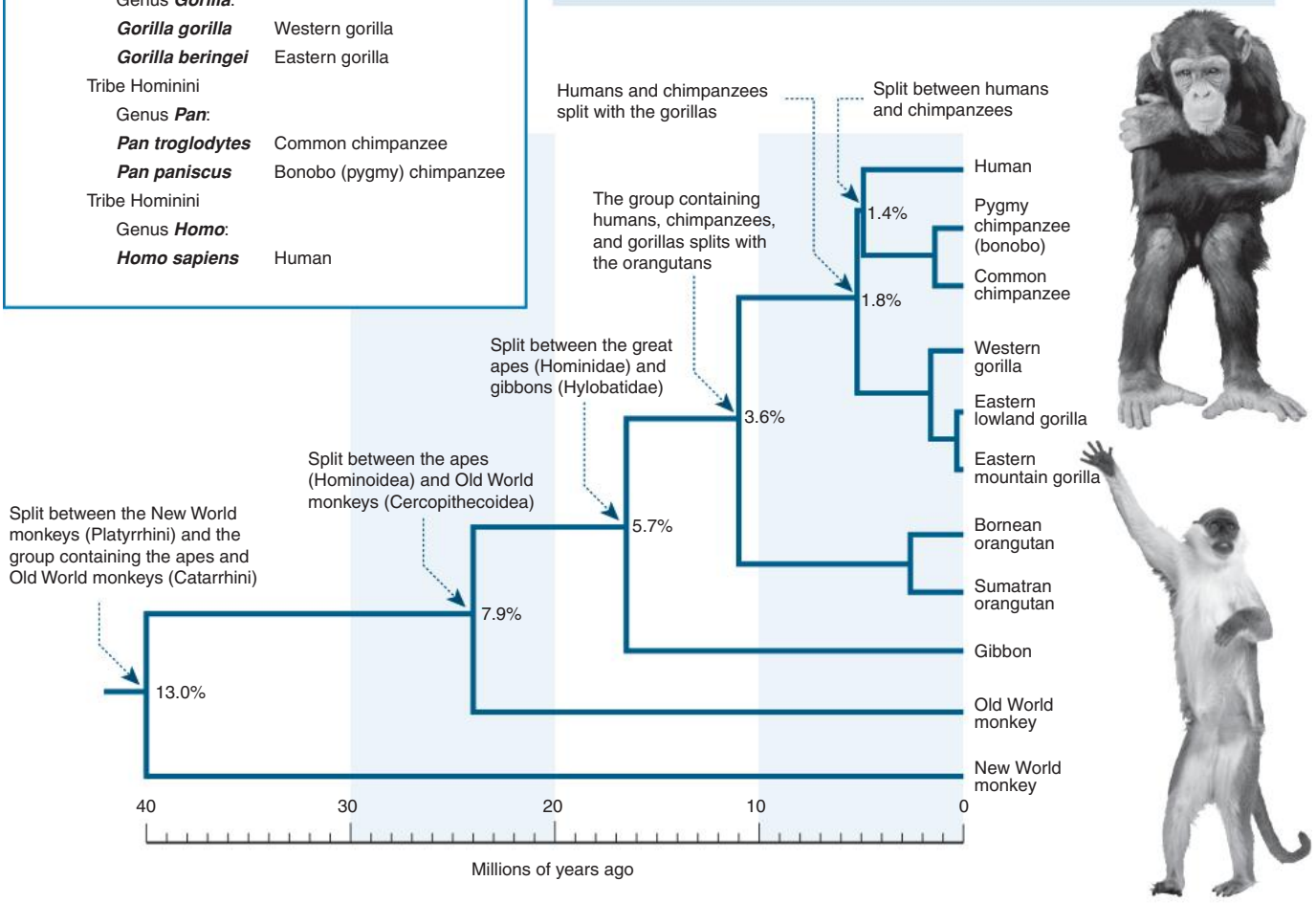
Related activities: *Identifying Primates*

Superfamily Hominoidea

Family Hylobatidae:	{various gibbon species}
Family Hominidae:	
Subfamily Ponginae	
Genus ***Pongo***:	
Pongo pygmaeus	Bornean orangutan
Pongo abelii	Sumatran orangutan
Subfamily Homininae	
Tribe Gorillini	
Genus ***Gorilla***:	
Gorilla gorilla	Western gorilla
Gorilla beringei	Eastern gorilla
Tribe Hominini	
Genus ***Pan***:	
Pan troglodytes	Common chimpanzee
Pan paniscus	Bonobo (pygmy) chimpanzee
Tribe Hominini	
Genus ***Homo***:	
Homo sapiens	Human

Genetic relatedness of primates

The diagram below illustrates a new way of classifying the superfamily Hominoidea (apes and humans) based on genetic similarities. The percentages next to each of the points where a split occurs indicates the amount of difference in the total genetic makeup (genomes) of the two groups being considered. For example, the genome of the gibbons compared to the rest of the apes (orangutans, gorillas, chimpanzees) and humans differs by 5.7%. The resulting diagram based on successive splitting of divergent groups is calibrated according to these genetic differences. A large genetic difference between any two groups implies that they are distantly related, whereas small genetic differences suggest they share a recent common ancestor.



2. According to the diagram above, showing relatedness according to genetic similarity:

   (a) Identify the hominoid group that is most closely related to the two chimpanzee species: _____

   (b) Name the two chimpanzee species: _____

3. Determine from the diagram how long ago:

   (a) The two species of chimpanzee split from a common ancestor: _____

   (b) The chimpanzees split from the line to humans: _____

   (c) The African apes (and humans) split from the Asian apes (orangutans and gibbons): _____

4. What assumption must be made in order to use the degree of genetic diversity as a measure of evolutionary distance?

   _____

   _____

5. Describe two major departures that emerge from this new classification system over the older, traditional one:

   (a) _____

   (b) _____

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Identifying Primates

The twelve photographs below show representatives from the major primate groups. Use the list provided to assign each one to one of the five **primate taxa** listed (write down the letter and name), and **describe three main characteristics** of each group. **Examples**: cottontop tamarin, hamadryas baboon, ruffed lemur, galago or lesser bush baby (appears tarsier-like, but not closely related), lowland gorilla, slow loris, common chimpanzee, gibbon, spider monkey, orangutan, australopithecine, macaque.

1. (a) Identify three **strepsirrhine** examples: _____

   (b) Characteristics: _____

2. (a) Identify two **New World monkey** examples: _____

   (b) Characteristics: _____

3. (a) Identify two **Old World monkey** examples: _____

   (b) Characteristics: _____

4. (a) Identify four examples of **apes**: _____

   (b) Characteristics: _____

5. (a) Identify one **hominin** example (there are two): _____

   (b) Characteristics: _____

_____

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***Related activities**: General Primate Characteristics*

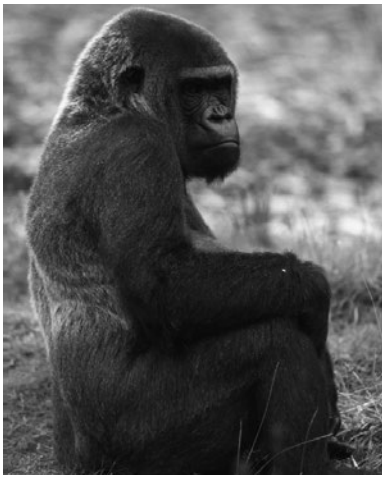
General Primate Characteristics

The primates exhibit a combination of features that are unique to their group. These features can be morphological (e.g. five digits in the hands and feet), physiological (a longer gestation period than other mammals), or behavioral (e.g. prolonged infant dependency). Some commonly observed primate characteristics are described below.

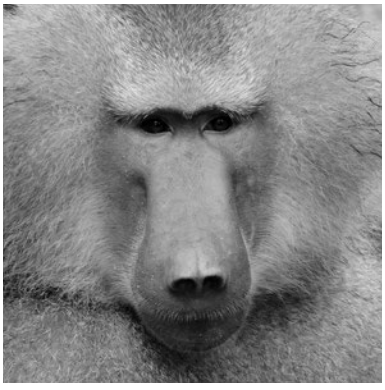
The **gestation** (pregnancy period) in primates is longer than most other mammals. Primates typically have one young per pregnancy (below). Infancy is prolonged with longer periods of infant dependency and a large **parental investment** in each offspring. This nurturing increases the survival rate of the young. Fetal nourishment (below, left) is efficient.

The life span of a primate is generally longer than most other mammals and there is a greater dependency on highly flexible learned behavior. Primates tend to be **highly sociable** (above). Unusually for mammals, adult males of many primate species often associate permanently with the group.

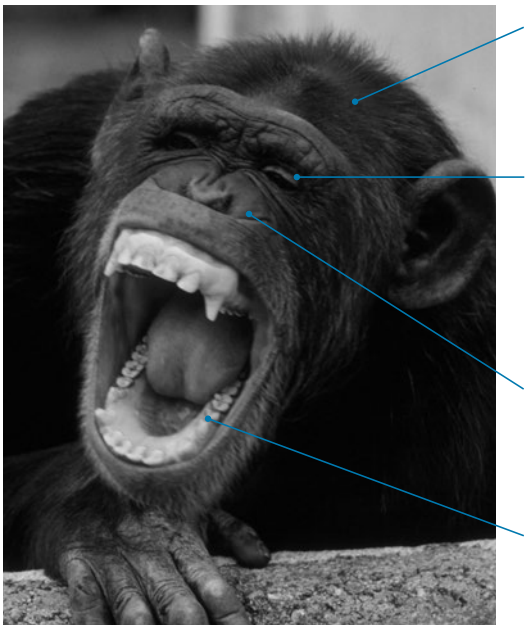
Primates have a tendency toward **erectness**, particularly in the upper body, as seen in the gorilla, below. This tendency is associated with sitting, standing, leaping, and (in some) walking. The **collarbone** (clavicle) has been retained, which allows more flexibility of the shoulder joint. In many quadrupedal mammals, the clavicle has been lost as an adaptation to striding.



All primates have retained five digits in the hands (above)and feet (**pentadactyly**) although some have one digit markedly reduced (e.g. thumb in spider monkeys). **Nails** are found on at least some digits in all modern primates. Climbing is achieved by grasping (not by using claws) and is aided by tactile pads at the end of the digits. Primates have flexible hands and feet with a good deal of **prehensility** (grasping ability), as seen in the photo, right.



Bjørn Christian Tørrissen



The **brain** is large and generally more complex than in other mammals.

There is an emphasis on **vision**, the visual areas of the brain are enhanced. Well developed binocular, stereoscopic vision provides overlapping visual fields and good depth perception. Color vision is probably present in all primates, except specialized nocturnal forms.

A trend towards a **reduced snout** and flattened face and reduced olfactory regions in the brain. Baboons (far left) go against this trend, with a secondary increase in muzzle length.

Primates have a generalized **dental pattern** particularly in the back teeth. Unspecialized teeth enabled primates to adopt a flexible omnivorous diet.

***Related activities**: Physical Features of Primates, Primate Behavior*
***Weblinks**: Our Family Tree*

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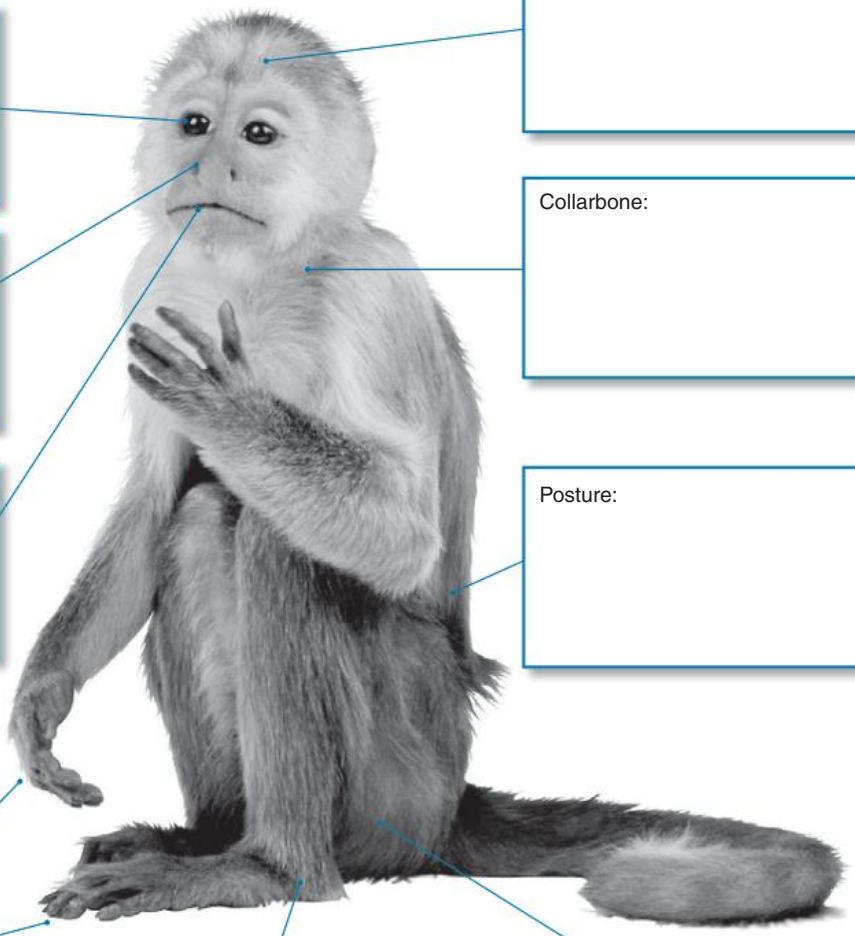
1. On the diagram of the capuchin below, briefly describe the general physical characteristics of all primates as indicated:

The primate pictured is a **white-fronted capuchin monkey** (*Cebus albifrons*) from northern South America. These monkeys inhabit the mid-canopy deciduous, gallery forests.



Vision:

Face shape and snout:

Teeth shape and dental arrangement:

Brain size and specialization:

Collarbone:

Posture:

Hands and feet:

Limb joints:

Reproduction:

Social organization:

2. Humans belong to the order Primates. Describe the characteristics of humans that characterize their primate heritage:

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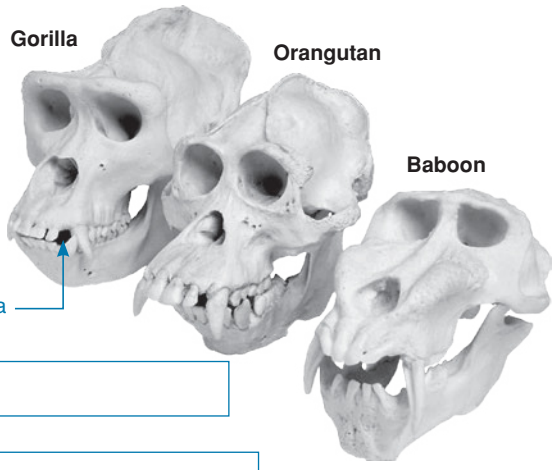
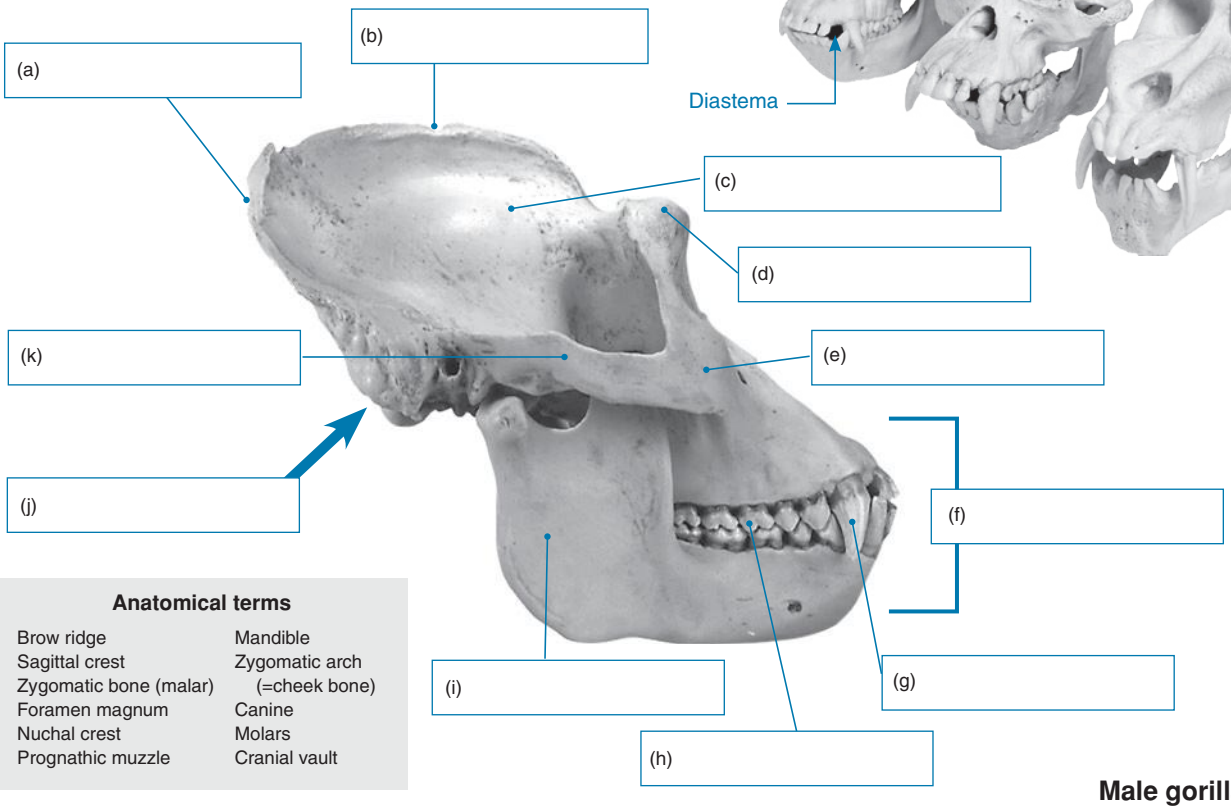
Primate Skull Features

The skull of the gorilla is not typical of primate skulls in general. It is highly specialized for its niche, which includes processing a low-grade diet of foliage. It has been used here to acquaint you with the terms used in describing the features of primate skulls. The skulls shown on the right are of two apes (a male gorilla and an orangutan), and an Old World monkey (a baboon). The baboon skull is clearly quite different from those of the apes.





Anatomical terms

Brow ridge	Mandible
Sagittal crest	Zygomatic arch (=cheek bone)
Zygomatic bone (malar)	Canine
Foramen magnum	Molars
Nuchal crest	Cranial vault
Prognathic muzzle	

Male gorilla skull

1. Label the gorilla skull above, using the list of **anatomical terms** in the box above.
2. Briefly describe the function or significance of each of the **seven** features below that are found on gorilla skulls:

   (a) Large sagittal crest: _____

   (b) Nuchal crest: _____

   (c) Massive zygomatic arch: _____

   (d) Massive molars: _____

   (e) Foramen magnum at rear: _____

   (f) Large canines: _____

   (g) Heavy brow ridge: _____

3. The female skull differs markedly from the male skull in a number of ways. Briefly describe four features that are different between the male skull (above) and the female skull (right) which is shown smaller here:

   (a) _____

   (b) _____

   (c) _____

   (d) _____

4. Name the term used to describe this type of difference between the sexes:

   _____

Female gorilla skull

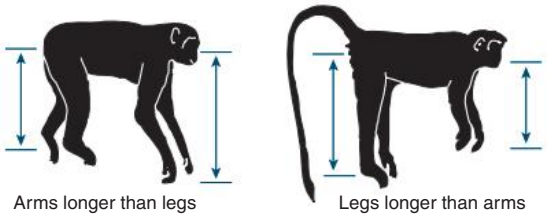
Related activities: *Human Skull Anatomy*

ISBN: 978-1-877462-99-3

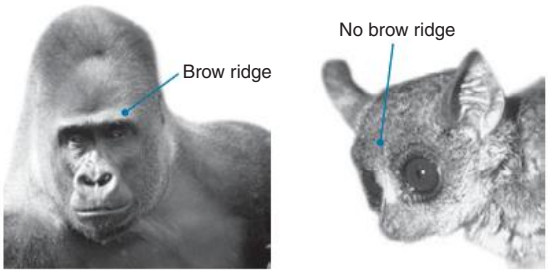
Physical Features of Primates

For this exercise, you will need to view digital material on primates, or visit a zoo with primate species on display. Visits are best made early in the morning when these animals are most active. If access to a zoo or video material is not possible, primate physical features could be studied by reference to a good source book. The order Primates includes about 200 species and is unusual among mammals in that living representatives range from primitive forms (e.g. lemurs) that are similar to some of the earliest fossil primates, to advanced forms (e.g. apes) that are probably similar to a human last common ancestor. By comparing the physical features of different primates we can add information to support a possible phylogeny that includes humans. This does not mean that humans evolved from these modern primates, but from ancestors that probably resembled them.

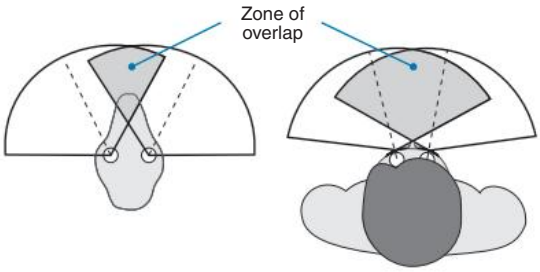
Distinguishing Physical Features of Primates



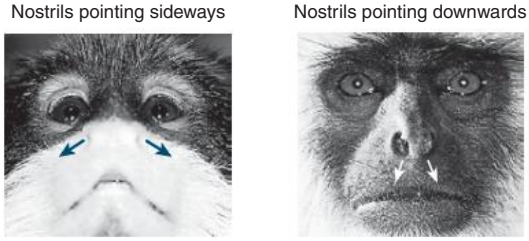
Limb length: Relative length of forelimbs and hindlimbs.



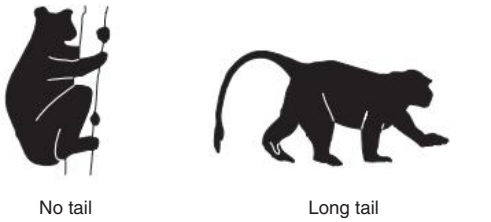
Brow ridges: Relative prominence of the ridge of bone above the eyes.

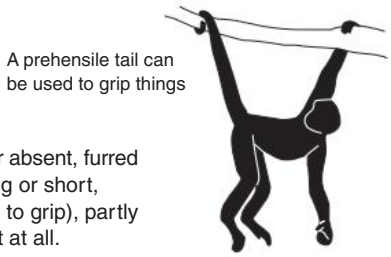


Eyes: Directed forwards or sideways.

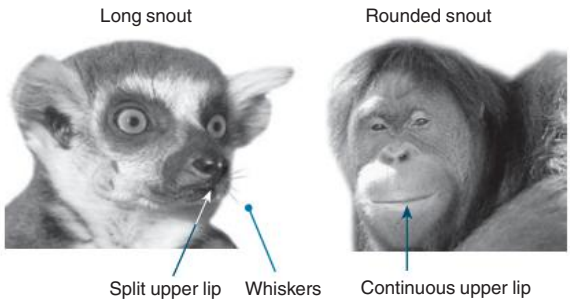


Nostrils: Position on the snout, separation, direction of opening (forward, sideways or downwards).

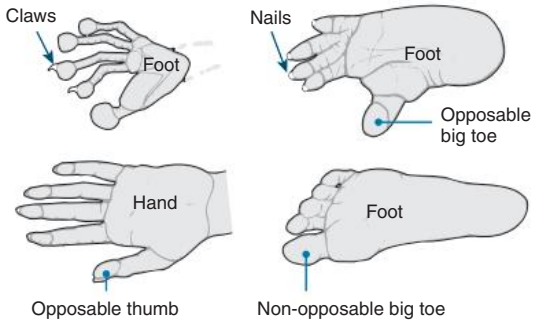




Tails: Present or absent, furred or not furred, long or short, prehensile (used to grip), partly prehensile or not at all.



Snout and lips: Snout obvious or reduced, pointed, rounded or flattened. Whiskers present or absent. Upper lip divided or continuous.



Feet and hands: Length of fingers, thumb opposable or not. Length of toes, big toe opposable or not, nails on all hands and feet.

1. Study the features above to identify the distinguishing physical characteristics of each of the major groups of primate.
2. Fill in the record sheet on the following page with reference to these guidelines.

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***Related activities**: General Primate Characteristics*

Primate Physical Features – Record Sheet

Name of primate	Lemurs & lorises	New World monkey	Old World monkey	Ape	Human
Limbs					
Tail					
Snout					
Nostrils					
Eyes					
Brow ridges					
Hands					
Feet					

ISBN: 978-1-877462-99-3

Primate Niches

While the majority of primates live in tropical rainforests, they do occupy a wide range of terrestrial habitats. Baboons live in the savannah and woodlands of Africa, langurs in the dry thorn-scrub of India, and Japanese macaques in the mountains of northern Honshu. Primate sizes range from the 10 cm and 55 g red mouse lemur to the 1.5 m and 175 kg male gorilla. Primates have diverse ways of moving about. Each enables exploitation, through physical adaptation, of a particular aspect of the environment. Primates also show dietary flexibility. Essentially, they are fruit eaters, but smaller primates supplement fruit with animal matter, and the larger species usually have some leaf-eating adaptations. To illustrate their niche differentiation, describe the mode of locomotion and diet of the primate groups illustrated. Choose answers from the lists provided below:

Modes of locomotion:

Primate locomotion can be divided into six general categories: **arboreal quadrupedalism** (walking and running on all fours along branches); **terrestrial quadrupedalism** (moving on all fours on the ground); **knuckle-walking** (a variation of terrestrial quadrupedalism); **leaping** (moving between tree trunks and branches by rapid extension of the legs); **suspension** (hanging below branches, including brachiation); **bipedalism** (walking and running on two limbs).

Types of diet:

Omnivore, faunivorous (eats insects or mammals), seed eater, flower eater, frugivore (fruit eater), gum and sap eater, foliovore (leaf eater).

(e) Gibbons

Locomotion: _____

_____

_____

Diet: _____

_____

_____

(a) Lemurs and lorises

Locomotion: _____

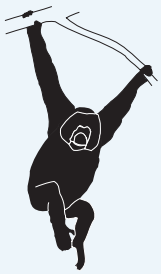
_____

_____

Diet: _____

_____

_____



(f) Orangutans

Locomotion: _____

_____

_____

Diet: _____

_____

_____

(b) Tarsiers

Locomotion: _____

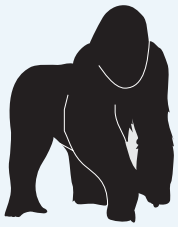
_____

_____

Diet: _____

_____

_____



(g) Gorillas

Locomotion: _____

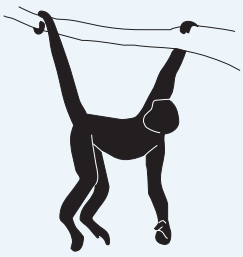
_____

_____

Diet: _____

_____

_____



(c) New World monkeys

Locomotion: _____

_____

_____

Diet: _____

_____

_____

(h) Chimpanzees

Locomotion: _____

_____

_____

Diet: _____

_____

_____

(d) Old World monkeys

Locomotion: _____

_____

_____

Diet: _____

_____

_____

(i) Humans

Locomotion: _____

_____

_____

Diet: _____

_____

_____

ISBN: 978-1-877462-99-3

Periodicals: *Birth of a tool maker, The culture of chimpanzees*

Related activities: *Physical Features of Primates, Primate Behavior*

Primate Behavior

Prolonged infant dependency

Primate infants (e.g. the infant **olive baboon** with its mother above) have a long period of parental dependency. This provides food and protection, and offers more opportunity for the young to learn from their parents. In apes and humans, the period of dependency is longer and allows the development of culture.

Grooming behavior

Grooming of other group members is a social behavior that has little to do with hygiene. It involves the careful removal of flakes of skin and grass seeds. It helps to create a bond between individuals in a family group and is thought to reduce stress. Here two **crab-eater macaques** from Asia are seen grooming.

Visual and olfactory signals

Ring-tailed lemurs, like all lemurs, are found on the island of Madagascar, off the east coast of Africa. They communicate using a combination of visual signals and scent marks to map out their territory. Their bushy tail with distinctive markings is held erect like a flag for other members of the family group to see.

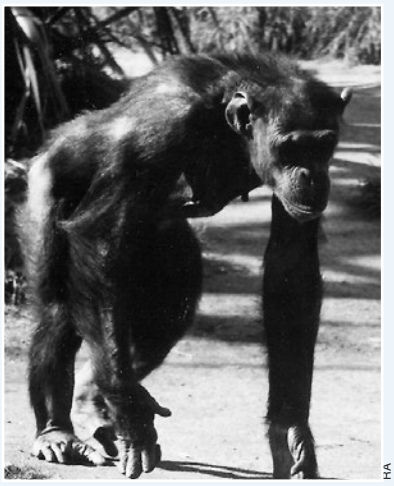
Types of Primate Locomotion

Monkey locomotion

Monkeys, such as the **olive baboon** above, walk **quadrupedally** on the palms of their hands and the soles of their feet. In the trees, they walk along the tops of branches, gripping them with their hands and feet.

Brachiation in gibbons

Gibbons are the smallest of the apes and are specialized to use **brachiation** (a technique of under-branch swinging), in combination with rapid climbing, midair leaps, and bipedal running, to move quickly through the forest.



Knuckle walking in chimpanzees

Chimpanzees and **gorillas** spend more time out of trees than do either of the Asian apes. The chimpanzee above shows typical **knuckle-walking** behavior. The relatively long arms facilitate this mode of locomotion.

1. Discuss types of primate locomotion: _____

_____

_____

_____

2. Describe one feature of primate biology that is important in human sociality and give a reason for your answer:

_____

_____

***Related activities**: Primate Behavior Study*

Periodicals:
A curious kinship: apes and humans

ISBN: 978-1-877462-99-3

Primate Behavior Study

In this exercise you will record behavioral patterns of some nonhuman primates and relate these to humans. To compare the behavior of different groups of primate, you should observe:

1. A lemur or loris
2. A New World monkey
3. Two Old World monkeys
4. At least two ape species

Include in the animals studied at least one species that has a fairly large number of individuals in one enclosure. You should spend at least **15 minutes** observing the behavior of each species. Use the record sheet on the following page to record your observations. The following is a guide to some of the observations you can make. Write your observations in the spaces provided opposite, and note any behaviors that you think may be relevant.

Many primates have a complex social organization, but a few do not form social groups. Social behavior depends on activity. Nocturnal primates (e.g. many strepsirrhines) either live alone or in monogamous family groups. Diurnal species usually live in relatively large, stable groups, ranging in size from family groups to large bands (e.g. baboons). In primates, communication by smell is most prevalent among the strepsirrhines, and to a lesser extent the New World monkeys. Old World monkeys, apes, and humans have a very reduced sense of smell and rely more on visual and vocal signals. These can change rapidly, may convey complex information, and are instantaneous. Chemical signals, by contrast, are relatively slow, spread in all directions and persist.

Behavior Examples

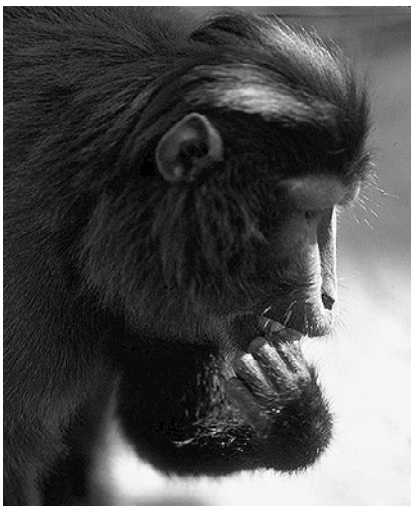
Locomotion	Quadrupedal, bipedal, knuckle-walking, suspension, brachiation (branch-swinging), climbing, branch-leaping, use of prehensile tail
Feeding	Seizing of food by muzzle or hands, breaking of food by hands, muzzle or teeth, storage of food in cheek pouches, movement of jaw, lips, teeth
Vocalizing	Vocal or instrumental (such as palm-slapping or chest beating)
Body language	Body posture: submissive, aggressive, 'presenting'. Color pattern showing sex differences, movements including: swaying, head-bobbing, tail-lashing, eye-contact and smell
Facial displays	Facial expressions; moods expressed such as aggression, submission, anger, threat, pleasure, fear (e.g. baring of teeth, eye-lid flashing)
Social behavior	Mutual grooming, order of flight, food dominance, play, territorial defence, sexual behavior
Behavior towards young	Maternal behavior, attitude of other group members

The forest-dwelling mandrill baboons exhibit obvious sexual dimorphism. Apart from the difference in size, the male's face is brightly colored with blue muzzle, red nose, white whiskers and orange beard. In the photo above, a female is presenting herself to the male to initiate mating.

An infant primate depends on its mother for all its food for 2 to 6 months after birth, depending on its size. Most infant primates are carried by their mothers for a further 6 to 12 months. They will depend on them (and perhaps close relatives) for support during fights and protection from danger for 3 to 4 years.

All baboon-like primates have long, sharp canines in long jaws, used in frequent exaggerated yawns. This is part of their social regulatory system.

The "moustache" of the emperor tamarin makes head movements more conspicuous. This makes body language messages less ambiguous.



Most primates do not specialize on one plant but selectively feed on a variety of species, choosing plant parts with low toxicity (e.g. new leaves).

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Primate Behavior – Record Sheet

Name of primate	Lemurs & lorises	New World monkey	Old World monkey	Ape	Human
Locomotion					
Feeding					
Vocalising					
Body language					
Facial display					
Social					
Young					

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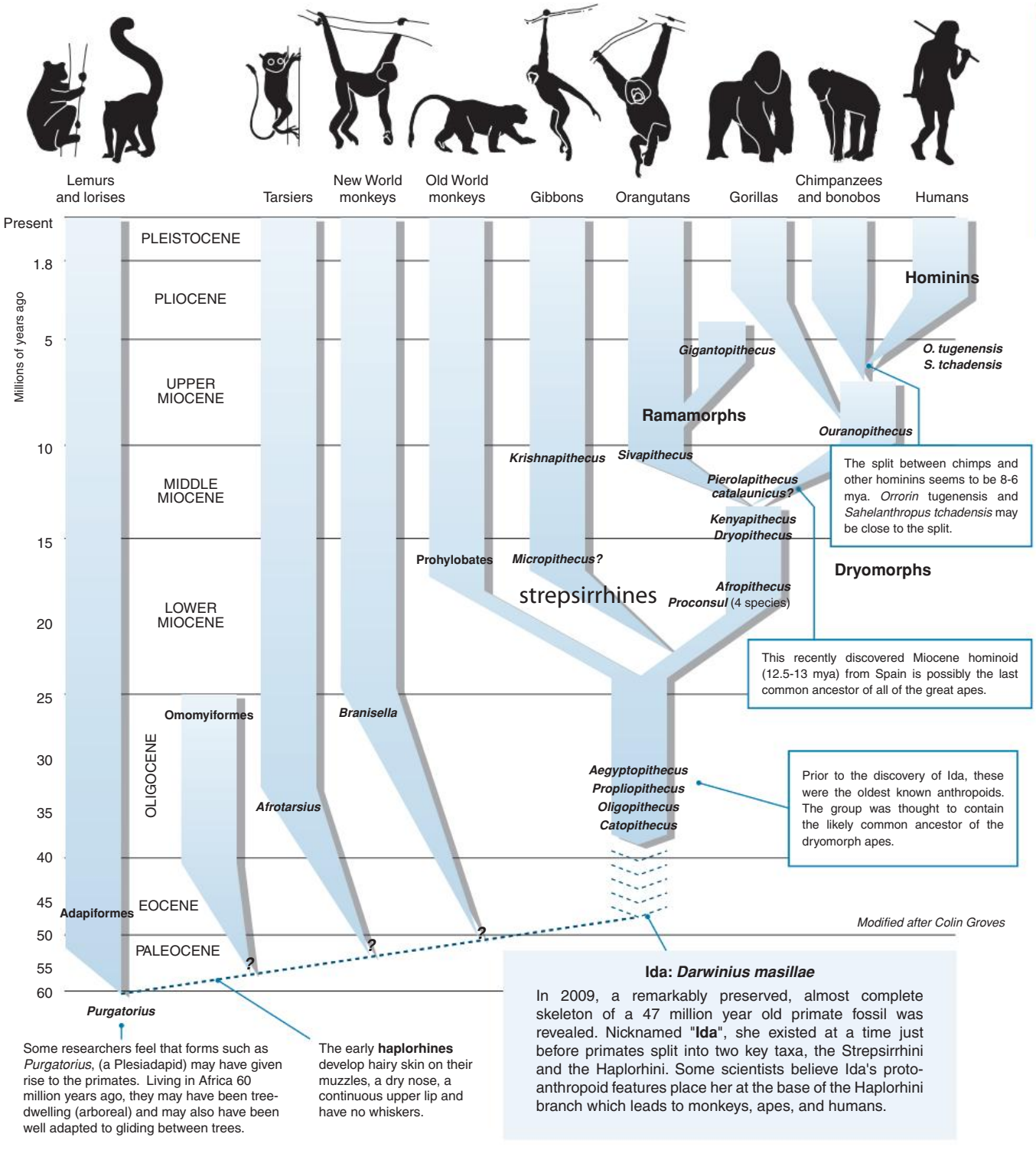
Adaptive Radiation in Primates

Recent discoveries of new fossils have clarified our current picture of primate evolution. There are still areas of disagreement. It is uncertain whether the omomyiformes were ancestral to the tarsiers and other haplorhines, or whether they constitute an evolutionary 'dead end' (as portrayed below). The gibbon was the earliest of the ape lines to diverge from the line leading to humans. There is general agreement from the phylogenetic analyses that *Sivapithecus* is the ancestor of the living orangutan, which is now the only living representative of the group of Miocene apes called the **ramamorphs**. The **dryomorphs** were probably ancestral to the later hominoid groups, although the position of *Dryopithecus* has long been controversial. The latest phylogenetic analyses indicate *Dryopithecus* is closely related to *Ouranopithecus*, and that one of these two European genera was the likely ancestor of modern African apes and humans. There is still great debate about the timing of the split between the African apes (chimpanzees and gorillas) and the early humans. Genetic comparisons of the modern apes and humans suggest a recent split. This has been supported by the discovery of *Ardipithecus ramidus* dated at about 4.4 million years. It had strong chimpanzee-like features, but also exhibited the beginnings of some human features as well. The discovery of the 6-7 million year old *Orrorin tugenensis* and *Sahelanthropus tchadensis* possibly represent some of the earliest hominins.



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Related activities: *Primate Classification, Ancestors of Modern Apes*
Weblinks: *The Link: Uncovering Our Earliest Ancestor*

1. (a) Identify the earliest known primate fossil: _____

   (b) State the approximate dating for this fossil: _____

2. The **strepsirrhines** are a group of 'primitive' primates with features that distinguish them from the other primates.

   (a) Identify two examples of primates from this group: _____

   (b) Describe the features that characterise this group: _____

3. The remaining primate groups constitute the **haplorhines**.

   (a) Identify the major primate groups included in this classification: _____

   (b) Describe the features that characterise this group: _____

4. The fossil called *Aegyptopithecus* is thought to have been a common ancestor to some later primate groups.

   (a) State the approximate dating for this fossil: _____

   (b) Identify the modern primate groups that it is thought to have given rise to: _____

5. Explain the evolutionary significance of *Orrorin tugenensis* ("Millennium Man"): _____

6. List all of the modern primate groups (in the diagram on the previous page) in the order that they diverged from the line of descent to modern humans:

7. Discuss the significance of finds such as 'Ida'. What do such finds tell us about branch points in primate evolution?

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Ancestors of Modern Apes

Early ape ancestors (dryomorphs) probably emerged from the family Pliopithecidae (below top) during a period of great climatic change at the end of the Oligocene and the start of the Miocene (about 25 mya). However, there is still disagreement over the identity and the evolutionary relationships of many fossils. It seems that there was a much greater diversity of hominid groups in the mid-Miocene than was previously recognized. As greater numbers of specimens (and particularly more complete specimens) are recovered, our understanding of the early stages of human evolution should increase correspondingly. Note the *Sivapithecus* (*Ramapithecus*) is firmly off the line to the hominins and is not an ancestor of humans.

Pliopithecids

There are a group of early apes that were present at the end of the Oligocene (about 28 million years ago). One of them, called *Propliopithecus* (also called *Aegyptopithecus*), is thought to be a primitive ancestral hominoid (ape). A modern form that is thought to have diverged from this group is the gibbon.

Includes: *Pliopithecus, Propliopithecus* (also called *Aegyptopithecus*), *Dendropithecus*
Period: 28 million years ago
Brain size: 400 cc
Height: 1.0 m
Distribution: Egypt

Dryomorphs

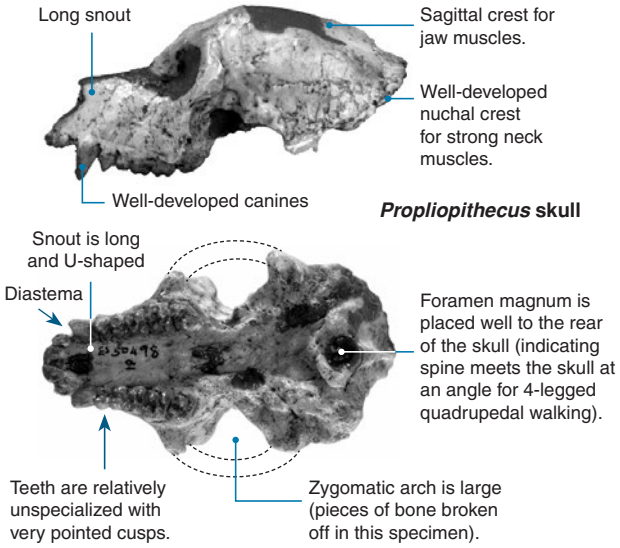
This widespread extinct group consisted of a large number of species. Dryomorphs were probably the ancestors of all the great apes and humans. The dryopithecines were early apes that probably evolved in Miocene Africa and reached Europe during the shrinkage of the prehistoric Tethys Sea. They may have been the ancestors of the ramamorphs.

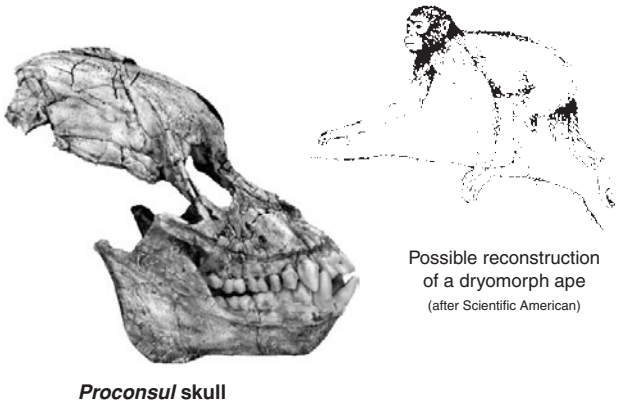
Includes: *Dryopithecus, Proconsul, Kenyapithecus, Rangwapithecus, Afropithecus*
Period: 22-9 million years ago
Brain size: 370 cc
Height: 1.0 m
Distribution: Europe, Africa and Asia

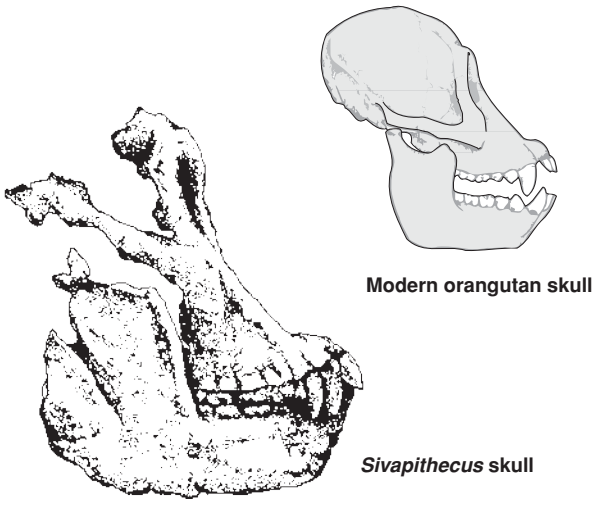
Ramamorphs

Asia's sole living great ape is a member of the sub-family Ponginae. This group probably evolved in Africa but spread to Europe and Asia where it continued to persist from about 17-1 million years ago. Until the early 1980s, it was generally accepted that *Ramapithecus* was a direct ancestor to the modern human lineage. Now reclassified as *Sivapithecus*, it is considered a likely ancestor of the modern orangutan (see right). However, recently discovered leg bones from *Sivapithecus* are not similar to modern hominoids (including orangutans), raising doubts about its links even with orangutans. *Gigantopithecus* (another ramamorph) was the largest primate that ever lived - considerably larger than the modern gorilla.

Includes: *Sivapithecus* (once called *Ramapithecus*, now considered to be the same species), *Gigantopithecus*, and *Ouranopithecus* (a recently discovered species).
Period: 17-1 million years ago
Brain size: Within ape range
Height: 1.0-3.0 m
Distribution: Europe, Africa and Asia







ABOVE: A modern orangutan skull has many points of similarity with ramamorph skulls (such as the skull of *Sivapithecus* above)

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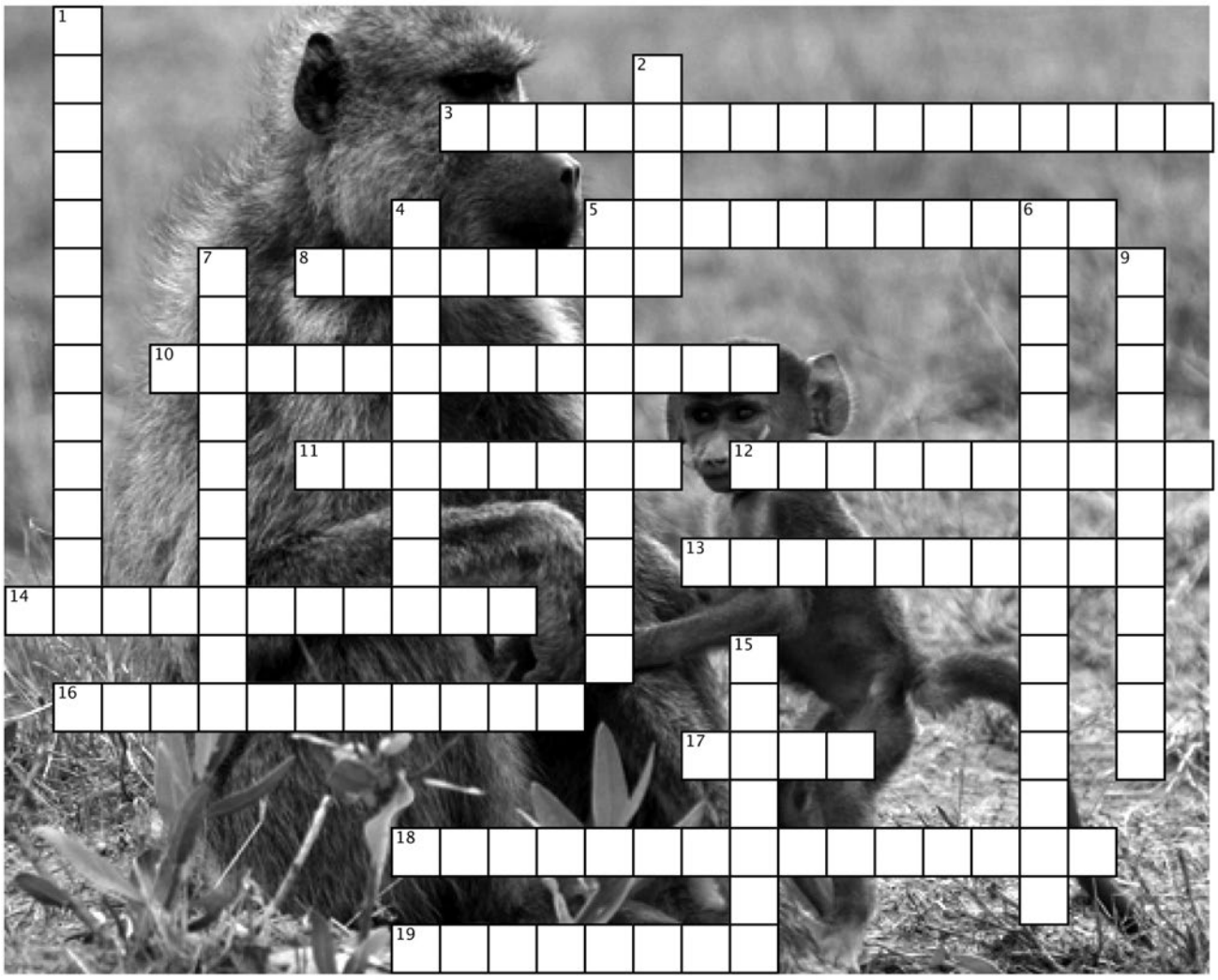
***Related activities**: The Early Hominins of Africa*

KEY TERMS: Crossword

Complete the crossword below, which will test your understanding of key terms in this chapter and their meanings



Clues Across

3. Differentiation in size and morphology between genders. (2 words: 6, 10)
5. Meaning flat nose.
8. The nocturnal primates which were once classified with the lemurs and lorises.
10. Primate suborder which includes the lemurs and lorises.
11. The tribe containing chimpanzees, humans and their ancestors.
12. The orangutan is the only living representative from this group of Miocene apes.
13. Primate superfamily comprising the apes and humans.
14. The common name for the primate taxon that includes the tarsiers, Old and New World monkeys, apes, and humans.
16. Walks primarily on four legs.
17. A general term for members of the superfamily Hominoidea (but usually excluding humans and their ancestors).
18. Superfamily of monkeys found naturally outside the Americas with non-prehensile tails and downward opening nostrils. (3 words: 3, 5, 7)
19. Living in trees.

Clues Down

1. The kind, number and arrangement of the teeth in the tooth rows. (2 words: 6, 7)
2. The hands and feet of primates have these structures instead of claws.
4. The old term for the taxon that includes the lemurs and lorises.
5. Adapted for grasping and holding.
6. Superfamily of strictly arboreal monkeys, some with prehensile tails.
7. The old term for the simian-like primates
9. Mode of locomotion involving under-branch swinging.
15. Tendency to walk on two legs.

ISBN: 978-1-877462-99-3

Investigating Human Evolution

Image: Skulls unlimited

Key terms

chronometric dating
craniometry
dating (of fossils)
Denisova fossils
DNA analysis
fossil
human characteristics
mtDNA
Neanderthal
occupation horizon
radioisotope
relative dating
skull

Key concepts

- Humans belong to the order Primates, but exhibit a number of unique behavioral and anatomical traits.
- Analysis of hominin fossils can help establish a timeline for human evolution.
- Fossils remains can be dated using both chronometric (absolute) and relative methods.
- DNA analysis of fossils can provide comparative data to support or clarify any existing morphological evidence.

Objectives

☐ 1. Use the **KEY TERMS** to help you understand and complete these objectives.

Characteristics of Humans

pages 28-29

☐ 2. Describe **behavioral characteristics** that are unique to humans.

☐ 3. Describe the **anatomical traits** that are unique to humans. In particular, identify features that are characteristic of modern human skulls. Appreciate that **craniometry** precisely measures skull features and can help identify and classify hominin skull remains.

Dating Methods

pages 30-32

☐ 4. Explain how **dating methods** are used to establish a timeline for human evolution.

☐ 5. Distinguish between **relative** and **chronometric** (absolute) **dating**. Explain why chronometric dating gives an approximate age, whereas relative dating gives the relative order of past events, without necessarily determining an absolute age.

☐ 6. Describe relative dating techniques using fossil sequence in strata.

☐ 7. Identify the difficulties associated with interpreting fossil evidence.

DNA Analysis of Fossils

pages 33-34

☐ 8. Using the analysis of Denisova and Neanderthal DNA as examples, explain how **DNA analysis** can be used to help classify fossils. Describe its advantages over morphological analysis of fossils.

☐ 9. Discuss why DNA analysis of fossils is not always possible. Your discussion could include reference to the following points:

- How the physical environment degrades DNA, and why this is a problem when undertaking DNA analysis.
- How DNA sample contamination can occur, and why this is a problem when undertaking DNA analysis.
- Why mitochondrial DNA (mtDNA) analysis might provide only limited information (relative to a full genome analysis).

Periodicals:
Listings for this chapter are on page 91

Weblinks:
www.thebiozone.com/weblink/HE-2993.html

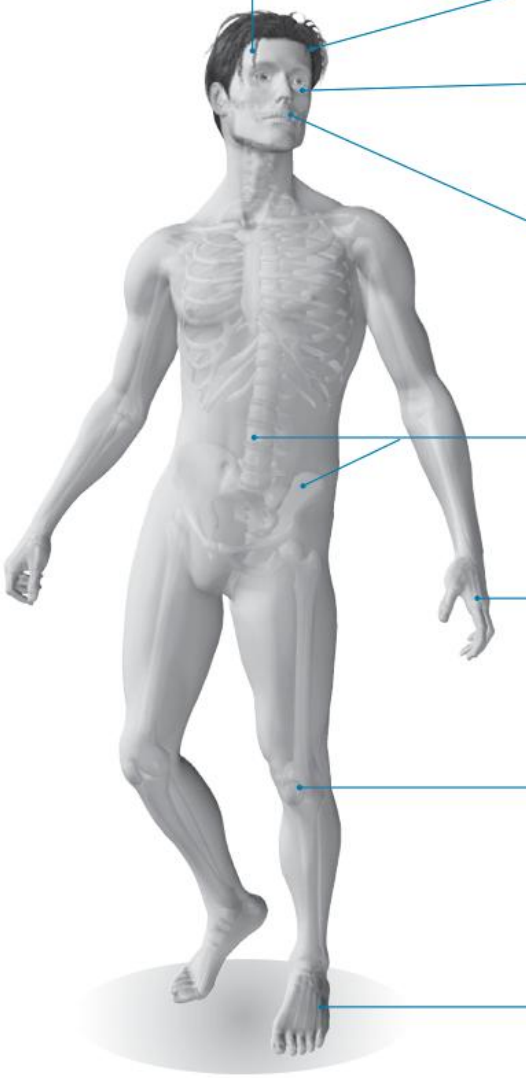
Presentation Media
Human Evolution:
Hominin Evolution

Human Characteristics

Humans have features that set them apart from other primates. Looking at the differences between modern humans and apes helps to identify a progression of evolutionary changes in the fossils of human ancestors.

Brain size and organization:

Skull shape:



Facial features:

Teeth size and shape:

Spine and pelvis shape (male and female):

Hands (degree of prehension, dexterity):

Leg shape, hip joint (carrying angle) and knee joint:

Feet adaptations to bipedalism:

1. In the spaces provided above, describe the characteristics that distinguish humans from other primates.
2. Discuss the significance of **culture**, **abstract thought**, and **social organization** as attributes that define humans:

***Related activities**: Adaptations for Bipedalism, The Development of Intelligence, Cultural Evolution, Art and Spirituality*

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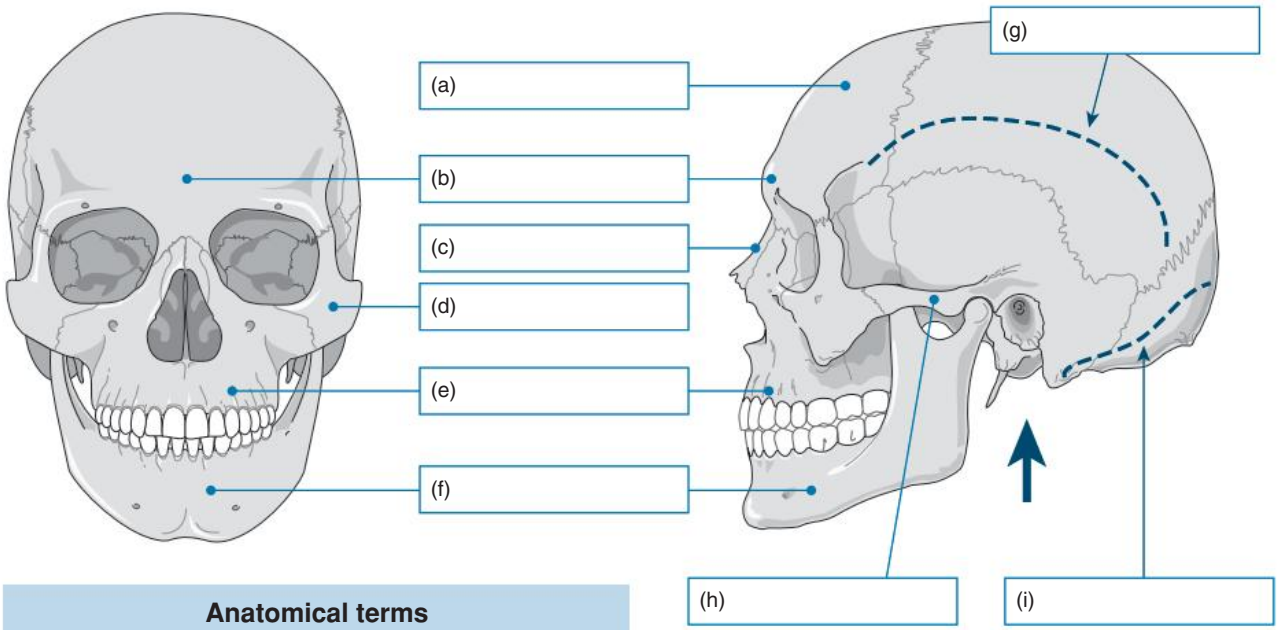
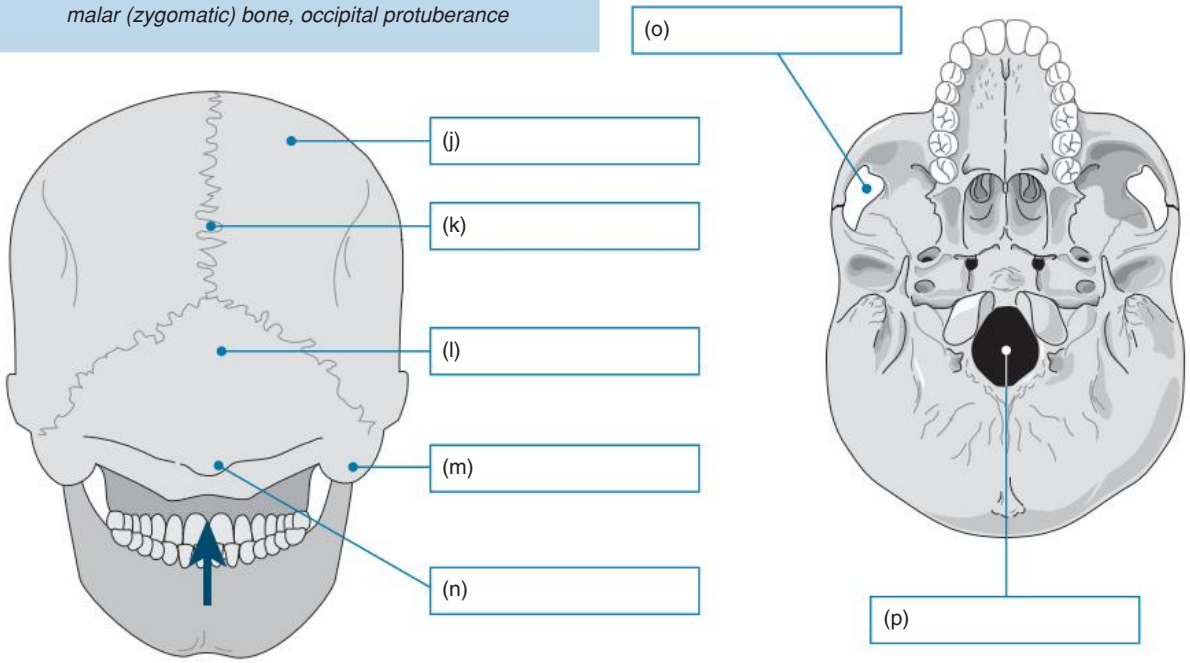
Human Skull Anatomy

An understanding of simple skull anatomy is useful when studying the skulls of human ancestors. **Craniometry** makes precise measurements of specific features and dimensions of the skull. It can be used to help determine sex, species, and body type, and so is used in **paleoanthropology** to study and classify hominin skull remains. Recognizing the major bones, as well as the features associated with a modern human skull, will help you to identify some of the important 'landmarks' in human evolution.



Anatomical terms

Glabella, frontal bone, zygomatic arch, nasal bones, maxilla, occipital bone, nuchal line, mastoid process, sagittal suture, mandible, temporal line, parietal bone, foramen magnum, malar (zygomatic) bone, occipital protuberance



1. Label the three views of a modern human skull using the list of anatomical terms in the box above.

2. Describe six features considered to be characteristic of modern human skulls:

(a) _____

(b) _____

(c) _____

(d) _____

(e) _____

(f) _____

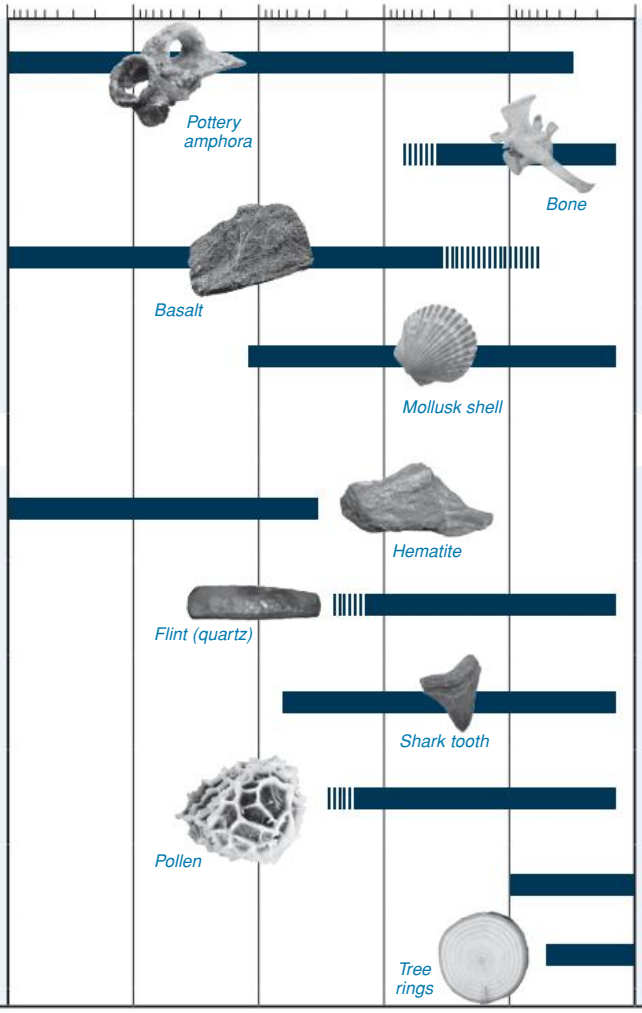
ISBN: 978-1-877462-99-3

***Related activities**: Human Characteristics, Hominin Data Sheets*

Dating Fossils

Prior to the 20th century, fossils could only be dated by establishing the sequential order of events in a rock profile and correlating one stratigraphic column with another (**relative dating**). With the development of **radiometric dating** methods in the early 20th century, fossils could also be assigned an absolute date (usually by dating the rocks around them). In the early days of developing these techniques there were problems in producing dependable results, but the methods have been much refined and often now provide dates with a high degree of certainty. Multiple dating methods for samples provides cross-referencing, which gives further confidence in a given date. Absolute, or chronometric, dating methods most often involve radiometric dating (e.g. **radiocarbon**, **potassium-argon**, **fission track**), which relies on the radioactive decay of an element. Non-radiometric methods (e.g. **tree-rings**, **paleomagnetism**) can be used in certain specific circumstances.

Dating method	Usable dating range (years)	Datable materials
Methods using radioisotopes:	100 million · 10 million · 1 million · 100,000 · 10,000 · 1000 *(Log scale)*	
Fission track: Uranium (^{235}U) sometimes undergoes spontaneous fission, and the subatomic particles emitted leave tracks through the mineral.		Pottery, glass, and volcanic minerals.
Radiocarbon (^{14}C): Measures the loss of the isotope *carbon-14*, taken up by an organism when it was alive, within its fossilized remains.		Wood, shells, peat, charcoal, bone, animal tissue, calcite, soil.
Potassium/Argon (K/Ar): Measures the decay of *potassium-40* to *argon-40* in volcanic rocks that lie above or below fossil bearing strata.		Volcanic rocks and minerals.
Uranium series: Measures the decay of the two main isotopes of uranium (^{235}U and ^{238}U) into thorium (^{230}Th) and another isotope (^{234}U) respectively.		Marine carbonate, coral, mollusk shells
Non-isotopic methods:		
Paleomagnetism: Shows the alignment of the Earth's magnetic field at the time when the rock sample was last heated above a critical level.		Rocks that contain iron-bearing minerals
Thermoluminescence: Measures the light emitted by a sample of quartz and/or zircon grains that has been exposed to sunlight or fire in the distant past.		Ceramics, quartz, feldspar, carbonates
Electron spin resonance (ESR): Measures the microwave energy absorbed by samples previously heated or exposed to sunlight in the distant past.		Burnt flints, cave sediments, bone, teeth, loess (wind-blown deposits)
Amino acid racemization: Measures the gradual conversion of left- to right-handed amino acid isomers in the proteins preserved in organic remains.		Organic remains
Varve: Measures the distinct, annually deposited layers of sediments (varves) found in many lakes.		Mainly glacial lakes
Tree-ring: Measures the annual growth rings of trees (can be cross referenced with C-14 dating).		Trees, timber from buildings, ships



1. Examine the diagram above and determine the approximate dating range (note the logarithmic time scale) and datable materials for each of the methods listed below:

	Dating Range	Datable Materials
(a) Potassium-argon method:		
(b) Radiocarbon method:		
(c) Tree-ring method:		
(d) Thermoluminescence:		

2. When the date of a sample has been determined, it is common practice to express it in the following manner: Example: **1.88 ± 0.02** million years old. Explain what the **± 0.02** means in this case:

3. Suggest a possible source of error that could account for an incorrect dating measurement using a radioisotope method:

***Related activities**: Dating A Fossil Site*

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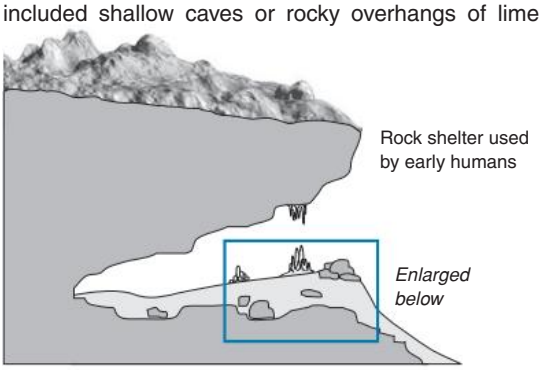
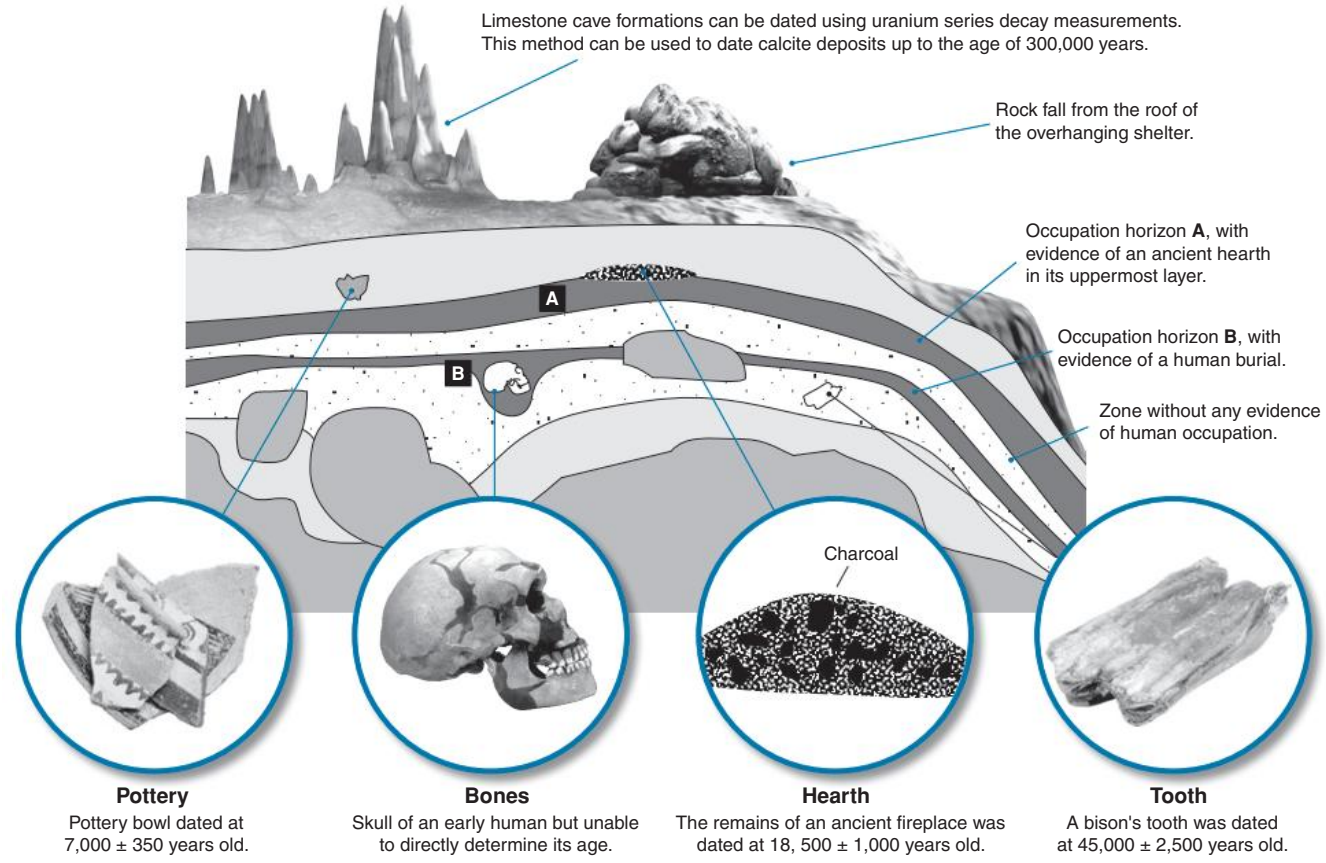
Dating a Fossil Site

The diagram below shows a rock shelter typical of those found in the Dordogne Valley of Southwest France. Such shelters have yielded a rich source of Neanderthal and modern human remains. It illustrates the way in which hominin activity is revealed at archaeological excavations. Occupation sites included shallow caves or rocky overhangs of limestone. The floors of these caves accumulated the debris of natural rockfalls, together with the detritus of human occupation at various layers, called **occupation horizons**. A wide array of techniques can be used for dating, some of which show a high degree of reliability (see the table below). The use of several appropriate techniques to date material improves the reliability of the date determined.



Dating method	Dating range (years ago)	Datable materials
Radiocarbon (^{14}C)	1000 - 50,000+	Bone, shell, charcoal
Potassium-argon (K/Ar)	10,000 - 100 million	Volcanic rocks and minerals
Uranium series decay	less than 1 million	Marine carbonate, coral, shell
Thermoluminescence	less than 200,000	Ceramics (burnt clay)
Fission track	1000 - 100 million	Volcanic rock, glass, pottery
Electron spin resonance	2000 - 500,000	Bone, teeth, loess, burnt flint



Pottery
Pottery bowl dated at 7,000 ± 350 years old.

Bones
Skull of an early human but unable to directly determine its age.

Hearth
The remains of an ancient fireplace was dated at 18, 500 ± 1,000 years old.

Tooth
A bison's tooth was dated at 45,000 ± 2,500 years old.

1. Discuss the significance of **occupation horizons**: _____

_____

_____

_____

2. Determine the approximate date range for the items below: (Hint: take into account layers/artifacts with known dates)

   (a) The skull at point B: _____

   (b) Occupation horizon A: _____

3. Name the dating methods that could have been used to date each of the following, at the site above:

   (a) Pottery bowl: _____ (c) Hearth: _____

   (b) Skull: _____ (d) Tooth: _____

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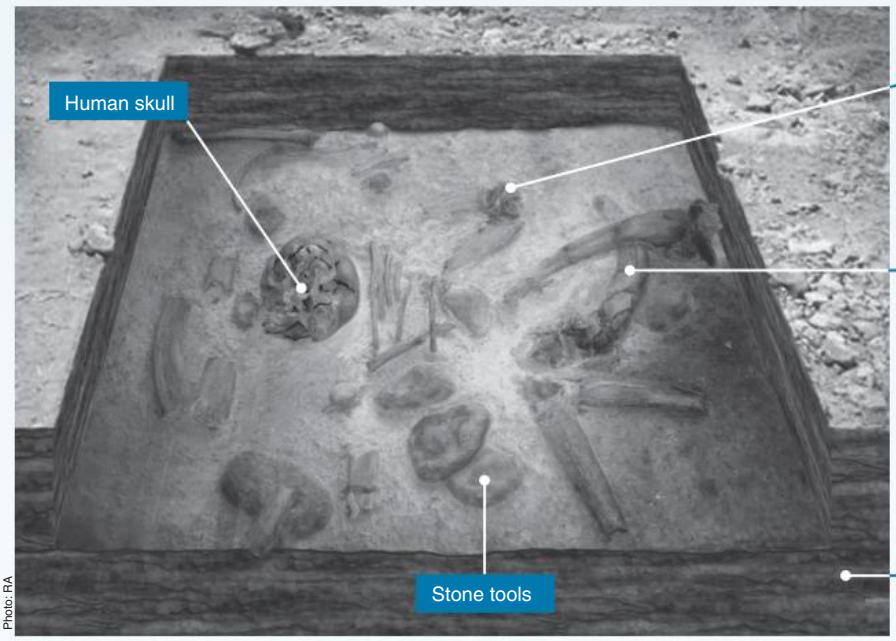
Interpreting Fossil Sites



Charcoal fragments (possible evidence of fire use and excellent for radiocarbon dating).

Bones from a large mammal with evidence of butchering (cut and scrape marks from stone tools). These provide information on the past ecology and environment of the hominins in question.

Excavation through rock strata (layers). The individual layers can be dated using both chronometric (absolute) and relative dating methods.

Searching for ancient human remains, including the evidence of culture, is the work of **paleoanthropologists**. Organic materials, such as bones and teeth, are examined and analyzed by physical anthropologists, while cultural materials, such as tools, weapons, shelters, and artworks, are examined by archaeologists. Both these disciplines, **paleoanthropology** and **archaeology**, are closely associated with other scientific disciplines, including **geochemistry** (for **chronometric dates**), **geology** (for reconstructions of past physical landscapes), and **paleontology** (for knowledge of the past species assemblages).

The reconstruction of a **dig site**, pictured above, illustrates some of the features that may be present at a site of hominin activity. Naturally, the type of information recovered from a site will depend on several factors, including the original nature of the site and its contents, the past and recent site environment, and earlier disturbance by people or animals. During its period of occupation, a site represents an interplay between additive and subtractive processes; building vs destruction, growth vs decay. Organic matter decays, and other features of the site, such as tools, can be disarranged, weathered, or broken down. The archaeologists goal is to maximise the recovery of information, and recent trends have been to excavate and process artifacts immediately, and sometimes to leave part of the site intact so that future work, perhaps involving better methodologies, is still possible.

4. Explain why paleoanthropologists date and interpret all of the remains at a particular site of interest (e.g. animal bones, pollen, and vegetation, as well as hominin remains):

5. Discuss the importance of involving several scientific disciplines when interpreting a site of hominin activity:

ISBN: 978-1-877462-99-3

Analyzing Ancient DNA

Hominin fossil finds are rarely extensive enough to enable researchers to accurately classify or assess the morphology of the remains. In some instances, DNA analysis can be used to classify the specimens. New technologies have allowed ancient DNA to be extracted, enabling researchers to compare the relatedness or genetic differences between species. The information gained from these types of comparative analyses can lead to new knowledge about human evolution and species relatedness.

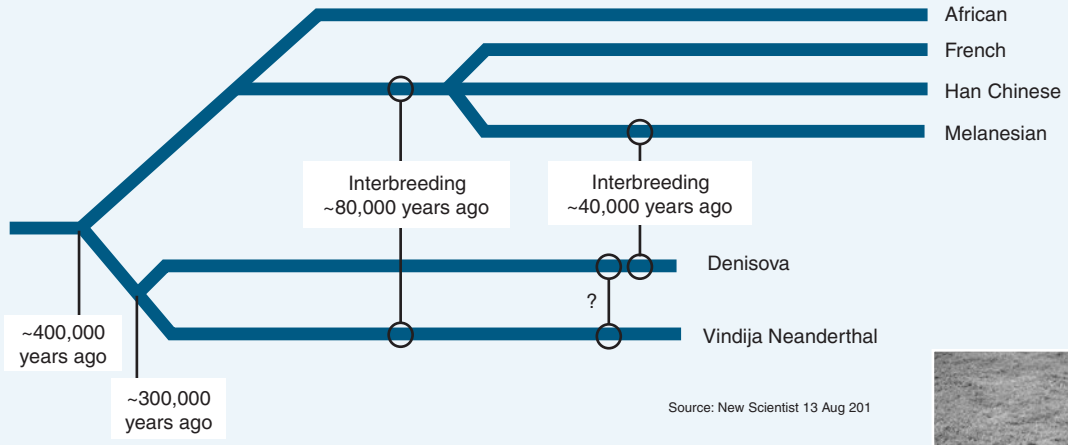
Obersachse

The Denisova cave, in the Altai mountains, Siberia, Russia

The Denisova Cave Finds

- In 2008, archeologists discovered a fragment of finger bone in the **Denisova cave**, in Siberia. The bone fragment belonged to a juvenile female (named X-woman).
- Artifacts, such as a bracelet, were found at the same level as the finger bone.
- In 2010, a molar tooth was found at a different level to the finger bone, indicating it belonged to a different individual. A toe bone found in 2011 was at the same level and contemporary with the tooth.
- The molar found in the Denisova cave has unique characteristics, which are not present in the molars of Neanderthals or modern humans.
- Carbon dating estimates the age of the artifacts and bone fragment at 40,000 years.
- Fossil DNA degrades quite rapidly with increasing temperature and in acidic soil conditions. The cool temperatures within the Denisova cave preserved the DNA in the fossil fragments. The fossils contained very low levels of DNA contamination from other organisms.

Using Genome Analysis to Classify the Denisova Cave Fossils



Source: New Scientist 13 Aug 201

Nuclear DNA analysis suggests the Denisova fossils belong to a previously unknown hominin species that existed at the same time as modern humans and Neanderthals, but was genetically distinct from them (above). The fossils are called the **Denisovans**, because they have not yet been formally classified.

Nuclear genome analysis suggests the Denisovans were a sister group to the Neanderthals. They probably shared a more recent common ancestor with Neanderthals (~300,000 years ago) than with present day humans (~400,000 years ago).

The Denisovan's interbred with the ancestors of the present day Melanesian's (right), and possibly with the Neanderthals, but not the ancestors of other present day populations, such as the Han Chinese. Melanesian DNA includes between 4% and 6% Denisovan DNA.

A Melanesian women

1. What are some of the limitations of relying solely on the **appearance** of fossils to classify new fossil finds?

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Periodicals:
The man rewriting human evolution

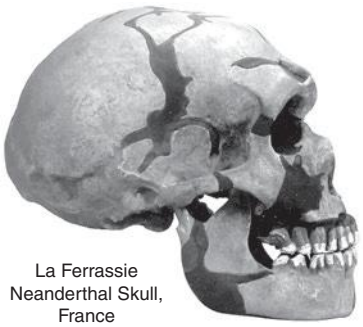
***Related activities**: Hominin Data Sheets: Denisovan Fossils*

The Neanderthal Genome Project

Neanderthals appeared about 400,000 years ago, and disappeared 25,000-30,000 years ago. They lived in Europe and parts of western and central Asia. Neanderthals are the closest relative to modern humans, so there is considerable interest in mapping the Neanderthal genome. By comparing the Neanderthal genome to the genome of present-day humans, it may be possible to identify genes in modern humans that have been influenced by positive selection.

Front view Neanderthal Skull

Image: Bone clones



La Ferrassie Neanderthal Skull, France

DNA being extracted from a Neanderthal fossil

NIH

Difficulties in Analyzing Neanderthal DNA

- The DNA is often degraded to small fragments less than 200 base pairs long. This makes it difficult to obtain sequence overlaps (critical for assembly of the genome).
- The DNA is often of poor quality because it has been chemically modified and degraded by the environment.
- Samples are often contaminated with the DNA of other organisms. Between 95-99% of the DNA obtained from the Neanderthal fossils analyzed was from microbes that colonized the bone after the Neanderthal died. Great care must be taken by the researchers not to contaminate the sample with their own DNA.

The Findings

- The Neanderthal genome is about four billion base pairs long.
- The genome of modern human and Neanderthals is 99.7% identical.
- Interbreeding with anatomically modern humans may have occurred between 80,000 and 50,000 years ago in the Middle East. As a result, between 1-4% of the genomes of Eurasians is derived from Neanderthals.
- Neanderthals are more closely related to present-day non-Africans than to Africans. This may change the view of human origins and dispersal.
- The sequences of mtDNA fragments from 12 Neanderthal fossils indicate that three (and possibly a fourth) sub-group existed.

2. (a) Describe some problems associated with analyzing DNA from fossils: _____

(b) The DNA obtained from the Denisova fossils was in excellent condition. Explain why: _____

3. (a) Explain how the Neanderthal genome project can help our understanding of the evolution of modern humans:

(b) Why might the data suggesting Neanderthals belonged to three sub-groups be regarded cautiously by some?

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The Physical Evolution of Humans

Key concepts

- There is a large amount of evidence for human evolution, but models do not always agree.
- The physical evolution of hominins is marked by skeletal changes and brain expansion.
- The large number of hominin species indicates a complex pattern of evolution and dispersal.

Key terms

Au. afarensis
Au. africanus
Ardipithecus ramidus
australopithecines
bipedal (bipedalism)
Broca's area
carrying angle
Denisovan fossils
gracile
Homo
H. erectus
H. ergaster
H. floresiensis
H. habilis
H. heidelbergensis
H. neanderthalensis
H. sapiens
multiregional hypothesis
Orrorin tugenensis
out of Africa hypothesis
P. boisei
P. robustus
Paranthropus
prognathic
replacement hypothesis
robust
Sahelanthropus
valgus angle
Wernicke's area

Objectives

- ☐ 1. Use the **KEY TERMS** to help you understand and complete these objectives.
- ☐ 2. **Background**: Since the mid-1990s, new fossil finds have overturned earlier ideas about hominin evolution. Altogether the picture is becoming more complicated as new finds uncover more information. Be aware that older textbooks will not reflect recent developments.

Trends in Hominin Evolution

pages 36, 38-59

- ☐ 3. Describe the anatomical features, geographical distribution, evolutionary relationships, and possible niche differences of the earliest hominins: ***Ardipithecus***, ***Orrorin***, ***Australopithecus*** spp., ***Paranthropus*** spp.
- ☐ 4. Explain the terms **robust** and **gracile** in the context of describing early hominin body types.
- ☐ 5. Explain how the evolution of the **australopithecines** was a response to habitat change and a shift in the resources exploited.
- ☐ 6. Describe the distinguishing characteristics that are unique to the genus ***Homo***.
- ☐ 7. Discuss the biological and cultural evolution of species in the genus *Homo*. Compare and contrast these hominins with respect to skeletal structure, cranial capacity, fossil ages and regional locations, and inferred culture.
  - (a) *Homo habilis*
  - (b) *Homo erectus*, *Homo ergaster*
  - (c) *Homo heidelbergensis* (Archaic *Homo sapiens*)
  - (d) *Homo neanderthalensis* (Neanderthals)
  - (e) *Homo sapiens* (anatomically modern humans)

Becoming Human

pages 37, 60-67

- ☐ 8. Describe the anatomical features associated with **bipedalism**. Include reference to the length of the limbs, shape and orientation of the pelvis, **valgus** (carrying) **angle** of the knee, structure of the foot, position of the skull, and curvature of the spine.
- ☐ 9. Describe the selection pressures on early hominins and the benefits of reducing body hair and adopting **bipedalism** as a form of locomotion.
- ☐ 10. In a general way, describe how **brain size** and intelligence have changed during human evolution and explain the selection pressures involved in this. Identify specific trends and consequences of brain development such as continued brain expansion and the development of **Broca's** and **Wernicke's** areas (speech production and recognition).
- ☐ 11. Describe the regional climate changes that occurred in East Africa 7-3 mya, outlining their role in human evolutionary development. Relate the changes of climate to alterations in habitats exploited by primates at the time.
- ☐ 12. Discuss the two main hypotheses for the origin and dispersal of modern humans: **replacement** (Out of Africa) and **multiregional hypotheses**.

Periodicals:
Listings for this chapter are on page 91

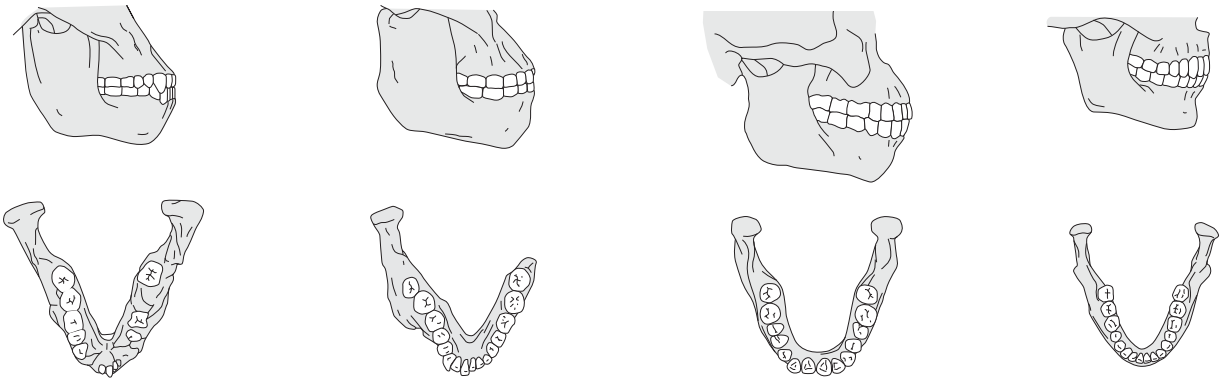
Weblinks:
www.thebiozone.com/weblink/HE-2993.html

Presentation Media
Human Evolution:
Hominin Evolution

Changes in Dentition

Changes in **dentition** (the type, number, and arrangement of teeth) in our hominin ancestors can reveal information about their evolution. During early hominin evolution teeth (especially the molars) and jaws tended to be large. The paranthropines are the extreme example of this trend. Their diet of coarse vegetation required very large and powerful jaws and molars. During the course of hominin evolution, there was a general trend for a reduction in the size of the teeth tooth and jaw. This was a likely consequence of including a greater proportion of cooked foods, which required less chewing, in the diet. The teeth of modern humans are relatively small and generalized, reflecting an omnivorous diet of mainly processed (e.g. cooked) foods.

Early Hominins → **Late Hominins**



Australopithecus afarensis

- Relatively large canine teeth
- Relatively large jaw
- V-shaped dental arcade
- Thin tooth enamel
- Diet probably consisted of fruits with some tougher material

Australopithecus africanus

- Reduced canine teeth
- Large molars
- Dental arcade intermediate between *A. afarensis* and *H. sapiens*
- Thick tooth enamel
- Diet probably included vegetable matter, nuts, seeds, insects, and eggs

Homo erectus

- Thick jaw bones
- No chin
- Relatively large molars
- Parabolic (U-shaped) dental arcade
- Thick tooth enamel
- Diet probably included vegetable material and a large proportion of meat

Homo sapiens

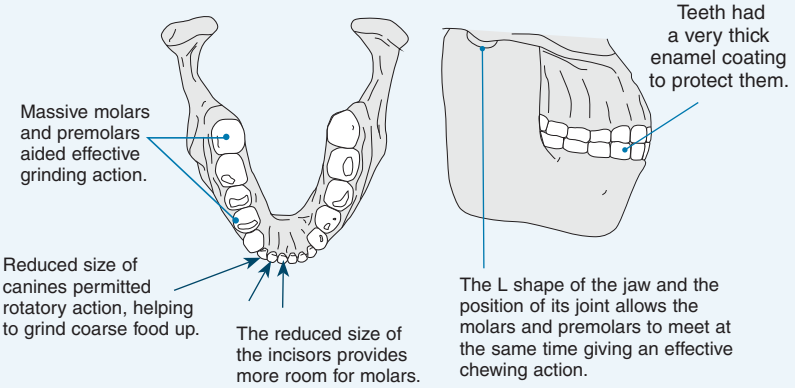
- Shortened jaw, allows large bite force to be generated with little effort
- Chin reinforces jaw, but leaves room for tongue muscles
- Thick tooth enamel
- Small molars adapted to chewing cooked and soft food
- Parabolic dental arcade

Dental formulae all follow: I-2, C-1, P-2, M-3

In many primates, the canine teeth are used in behavioral and social interactions, especially in species which show marked sexual dimorphism. Threat gestures, such as yawning (above), help maintain social order.

Adaptations to a Coarse Diet

Paranthropus boisei had jaws and teeth adapted to a diet of coarse vegetation and hard seeds. Their jaws produced a massive bite force of 2161 Newtons, which helped to break food up.



1. Describe the general trend in the evolution of hominin teeth: _____

_____

_____

2. (a) Explain why the molars and jaws of *Paranthropus boisei* were so large: _____

_____

(b) How did the advent of food processing (e.g. through cooking) provide a selection pressure for reduction in tooth size:

_____

_____

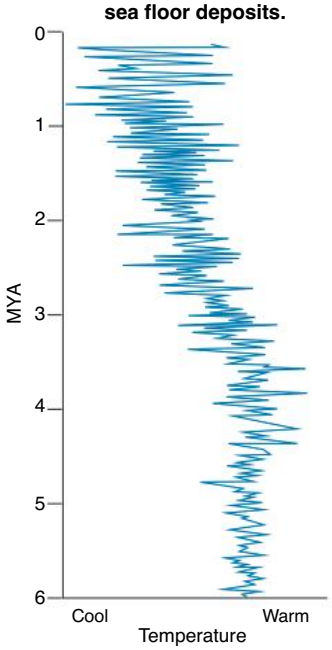
***Related activities**: Distinguishing Features of Hominins*

ISBN: 978-1-877462-99-3

The Changing Environment

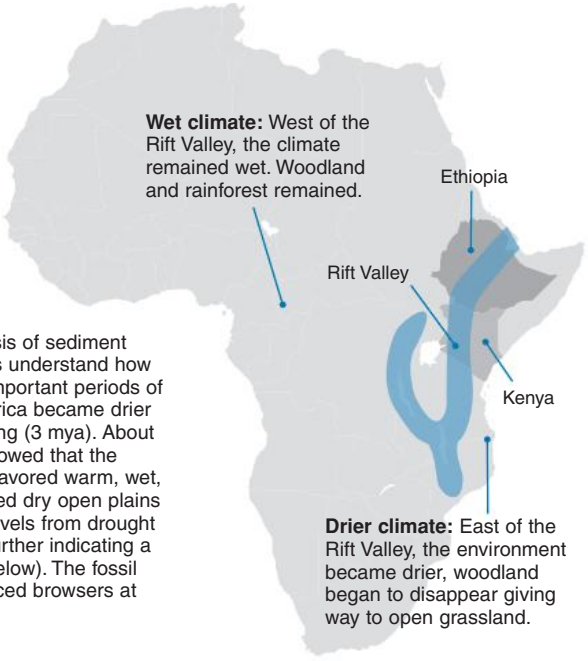
Earth's climate has fluctuated between warm and cool periods through its history. The fluctuations have many causes, including changes in the Earth's orbit and rotation, and changes to the Earth's surface (e.g. mountain building and continental drift). Climate change usually alters the distribution patterns of vegetation and animals. Understanding how both the climate and the distribution patterns of plants and animals have changed over time gives an insight into the selection pressures that may have influenced hominin evolution.

Global temperature indicated by sea floor deposits.

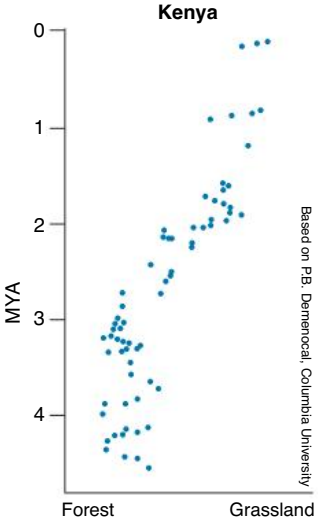


Analysis of deep sea sediment and deep ice cores provides evidence about Earth's paleoclimate. Different depths in the core represent different periods of geological history. By analyzing the isotope ratios of specific elements at different depths, it is possible to determine what the Earth's paleoclimate was like. Evidence from these ocean cores show the Earth began cooling about 3 million years ago (left).

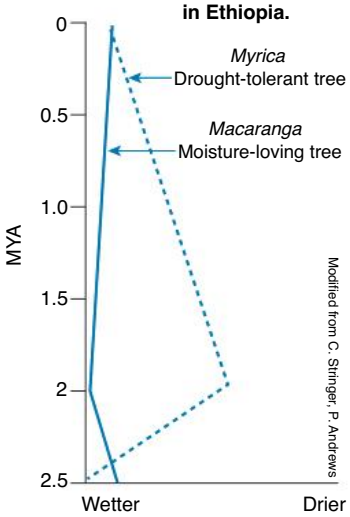
The isotope composition and pollen analysis of sediment samples from Africa have helped scientists understand how the African climate was changing during important periods of hominin evolution. Analysis shows East Africa became drier at the same time as the Earth began cooling (3 mya). About the same time, carbon isotope analysis showed that the vegetation was changing from plants that favored warm, wet, forested environments, to plants that favored dry open plains (below, left). Pollen analysis show pollen levels from drought tolerant trees increased rapidly 2.5 mya, further indicating a change from a wet climate to a dry one (below). The fossil record shows that grazing mammals replaced browsers at about this time.

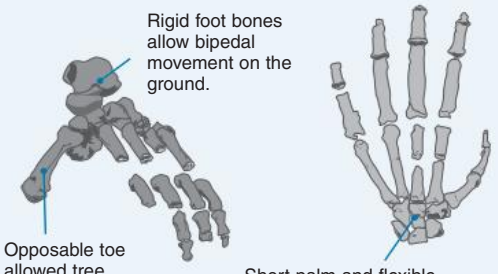


Soil carbon^{13} isotope record, Kenya



Abundance of pollen from drought/moisture tolerant trees in Ethiopia.





Fossil specimens, such as those of *Ardipithecus ramidus* (above), show that early hominins possessed features for tree climbing and some ability for terrestrial bipedalism. The change in the environment from largely woodland to predominately grassland represented a new selection pressure favoring terrestrial bipedalism and led to the evolution of the characteristics associated with modern humans.

1. (a) How did the African environment begin to change around 3 million years ago? _____

   _____

   _____

   (b) Describe the evidence that supports this change: _____

   _____

   _____

2. Explain how the changes in the environment 3 mya may have influenced hominin evolution: _____

   _____

   _____

ISBN: 978-1-877462-99-3

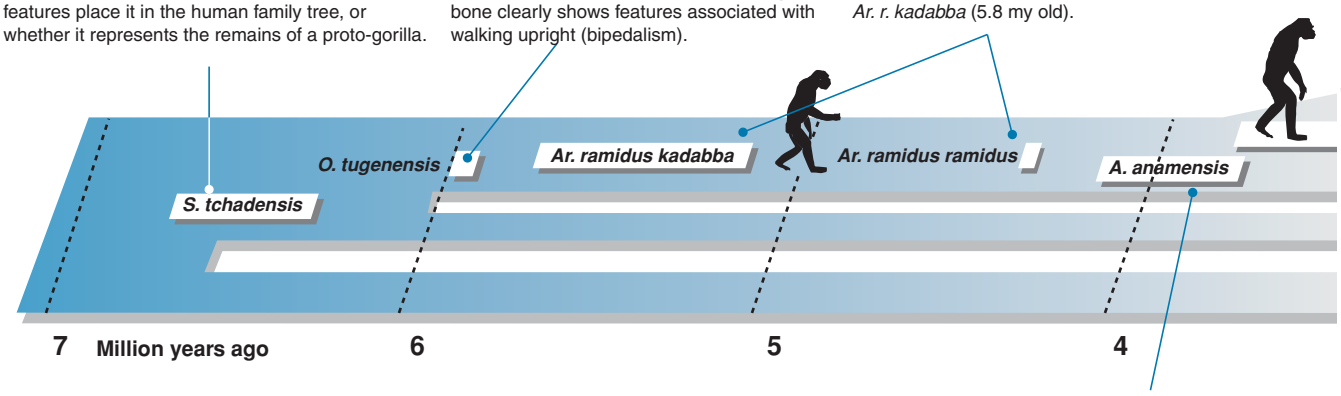
Hominin Evolution

The diagram below shows a provisional 'consensus' view of the family tree for the hominins (the group that includes the modern humans and pre-humans). There is much controversy over the interpretation of fossil data from the period 4-2 million years ago (mya). Some **paleoanthropologists** (scientists who study fossil hominin remains) believe that more branches existed than are shown here, with a number of adaptive radiations occurring over this period. It is almost certain that the early Australopithecines evolved into *Homo habilis*, which was ancestral to modern humans, by about 2 mya. A divergent branch, genus ***Paranthropus***, coexisted with early ***Homo***, but eventually became extinct about one million years ago. The diagram below does not attempt to show species relationships. A number of important fossils dated 5-7 mya have been discovered recently.

In 2001, the 6-7 my old remains of a nearly complete skull with gorilla-like features was unearthed in Chad. Nicknamed "Toumai" and assigned to a new genus, ***Sahelanthropus tchadensis***, scientists debate whether the skull's features place it in the human family tree, or whether it represents the remains of a proto-gorilla.

The 6 my old remains of five chimpanzee-sized ***Orrorin tugenensis*** specimens were unearthed at Baringa in Kenya in 2000. The teeth are very humanlike and a perfectly preserved thigh bone clearly shows features associated with walking upright (bipedalism).

Ardipithecus ramidus was an early hominin. Fossils suggest that it was at least partially bipedal with teeth that were also more humanlike. Two subspecies have been identified: *Ar. r. ramidus* (4.4 my old) and the older *Ar. r. kadabba* (5.8 my old).



New DNA and biochemical evidence suggests that the **last common ancestor** of hominins and apes occurred between 5 and 10 million years ago. The last common ancestor should have a combination of features reminiscent of both humans and apes.

There is a large gap in the fossil record that has until recently been very deficient in early hominin remains. The 1995 discovery of hominin fossils in Kenya, dated about 4 million years old have been named ***Australopithecus anamensis***.

1. Distinguish between **hominins**, **hominids** and **hominoids**: _____

2. (a) Describe the key identifying features of the (gracile) **australopithecines**: _____

   (b) Which species are normally assigned to this group? _____

3. (a) Which species is considered to be the common ancestor to later australopithecines and also to genus *Homo*?

   (b) State the date range for this hominin: _____

4. People who do not understand hominin evolution often argue that:

   "*If humans evolved from chimpanzees, then today's chimpanzees should be continuing to evolve into humans everyday*"

   (a) State the date range paleoanthropologists believe the hominini and chimpanzees last shared a common ancestor:

   (b) Describe two sources of evidence by which researchers have determined this date: _____

   (c) Rewrite the quotation above to correctly describe the evolutionary relationship between modern chimps and humans:

Related activities: *The Emerging View*
Weblinks: *Mother of Man, Finds Test Human Origins Theory*

Periodicals:
Becoming human

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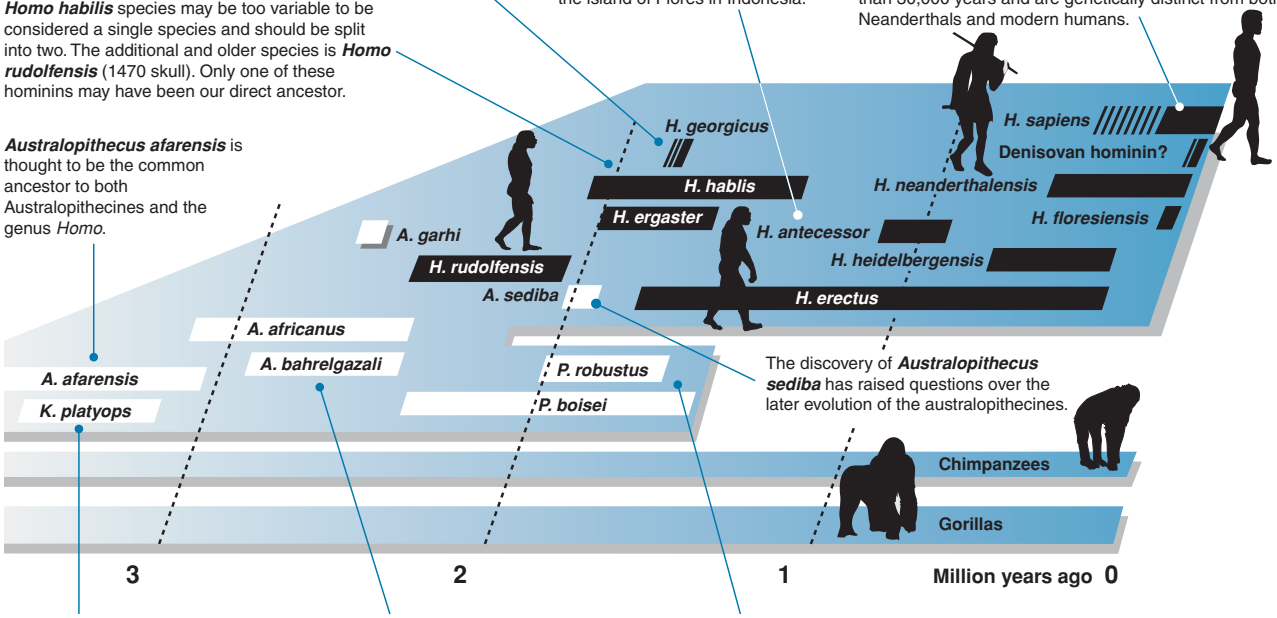
Small-brained fossils, found at **Dmanisi** and dated at 1.8 million years old, have been assigned as *Homo georgicus*. Their location in the former Soviet republic of Georgia, suggests an unexpectedly early hominin exodus from Africa.

Homo habilis species may be too variable to be considered a single species and should be split into two. The additional and older species is ***Homo rudolfensis*** (1470 skull). Only one of these hominins may have been our direct ancestor.

Australopithecus afarensis is thought to be the common ancestor to both Australopithecines and the genus *Homo*.

Homo erectus was a long lived species thought to be the first to venture out of Africa. The small hominin *H. floresiensis* appears to have been an offshoot of *H. erectus*, evolving in isolation on the island of Flores in Indonesia.

Modern humans may have appeared more than 160,000 years ago. **Neanderthals** were not the direct ancestors of modern humans. Recent comparison of DNA suggest that Neanderthals split from the human lineage as far back as 600,000 years ago. Recent finds in Russia of a tooth and a finger bone have been assigned to a **Denisovan hominin**. The finds are dated at older than 30,000 years and are genetically distinct from both Neanderthals and modern humans.



The discovery of ***Australopithecus sediba*** has raised questions over the later evolution of the australopithecines.

Kenyanthropus platyops, a 3.5 my old hominin, coexisted with *A. afarensis*.

Australopithecus bahrelghazali was discovered in Chad in 1995, some 2400 km west of the East African Rift, greatly extending the known geographic range of early hominins.

The **megadonts** (genus *Paranthropus*) were larged toothed vegetarians that disappeared from the fossil record at about 1.5 million years ago. The cause of this extinction is not known but it may have been the result of competition with more advanced humans or changes in their habitat.

5. (a) What is a **megadont**? _____

   (b) Identify two species belonging to this group: _____

   (c) Suggest why they may have become extinct: _____

   _____

6. Using the diagram above determine:

   (a) The total number of hominin species (i.e. from 6 mya to the present day): _____

   (b) The number of hominin species that existed between 3 and 2 million years ago: _____

7. The recent discovery of the oldest hominin has yielded important information about that stage in human evolution.

   (a) Identify the oldest, clearly described hominin fossil: _____

   (b) Describe two features of this species that suggest that it was not just an ancient chimpanzee: _____

   _____

   _____

8. Explain why it is most unlikely that the Neanderthals were ancestors to modern humans: _____

   _____

   _____

   _____

9. Explain why hominin fossils older than about 4.5 million years have been difficult to find: _____

   _____

   _____

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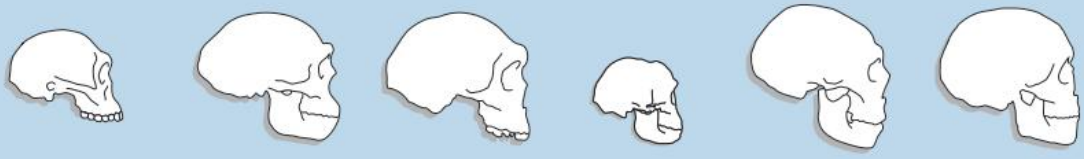
Distinguishing Features of Hominins

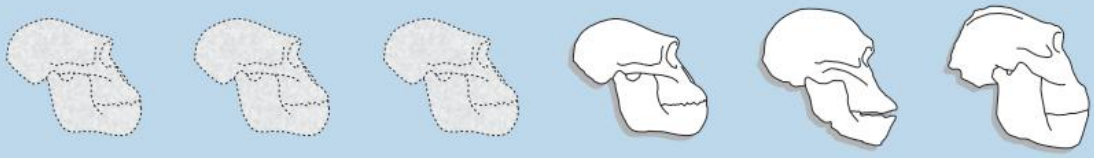
The data below provide you with lists of features that distinguish the many hominin species from each other. In your reading, the 'known dates' provided may vary from those given below, mainly due to varying interpretations on the dating of sites by different researchers. Some early hominin species, including various australopithecines and *Kenyanthropus*, are not listed.

Distinguishing Features of Early Human Species



	Homo habilis (small)	*Homo erectus*	Archaic *Homo sapiens*	*Homo floresiensis*	*Homo neanderthalensis*	Early *Homo sapiens*
Other name	None	*Homo ergaster* for older African forms	*Homo heidelbergensis*	None	The Neanderthals	Early anatomically modern humans
Known date (years ago)	2 – 1.6 million	1.8 – 0.3 million	400,000 - 100,000	13,000 - 38,000	150,000 - 30,000	160,000 - 60,000
Brain size	500-650 cc	750-1250 cc	1100-1400 cc	380 cc	1200-1750 cc	1200-1700 cc
Height	1.0 m	1.3 - 1.5 m	?	1.06 m	1.5-1.7 m	1.6-1.85 m
Physique	Relatively long arms	Robust but 'human' skeleton	Robust but 'human' skeleton	Very small	Robust but 'human' skeleton, adapted for cold	Modern skeleton possibly adapted for warmth
Skull shape	Small face with developed nose	Flat, thick skull with sagittal 'keel' and large brow ridge	Higher cranium, face less protruding	Fairly large brow ridge, no chin.	Reduced brow ridge, midface projection, long low skull	Small or no brow ridge, shorter and higher skull
Teeth and jaws	Smaller, narrow molars; thinner jaw	Smaller teeth than *H. habilis*, robust jaw in larger individuals	Similar to *H. erectus* but smaller teeth	Relatively modern dentition, but large teeth.	Similar to Archaic *H. sapiens*; except for incisors, smaller teeth	Teeth may be smaller; shorter jaws than Neanderthals; chin developed
Geographical distribution	Eastern, and possibly Southern Africa	Africa, Asia, Indonesia, and possibly Europe	Africa, Asia and Europe	Island of Flores, Indonesia	Europe and western Asia	Africa and western Asia

Distinguishing Features of Early Hominins



	Orrorin tugenensis	*Ardipithecus ramidus*	*Australopithecus anamensis*	*Australopithecus afarensis*	*Australopithecus africanus*	*Paranthropus robustus*
Other name	"Millennium Man"	Two subspecies: *ramidus & kadabba*	None	None	None	*Australopithecus robustus*
Known date (years ago)	6.0 million	4.4 – 5.8 million	4.2 – 3.9 million	3.9 – 2.5 million	~3.0 – 2.3 million	2.2 – 1.5 million
Brain size	? cc	? cc	? cc	400 – 500 cc	400 – 500 cc	530 cc
Height	? m	*c.* 1.22 m	*?* m	1.07 – 1.52 m	1.1 – 1.4 m	1.1 – 1.3 m
Physique	Possibly bipedal forest dweller. Little else known	Possibly bipedal forest dweller. Little else known	Partial leg bones strongly suggest bipedalism; humerus extremely humanlike	Light build. Some apelike features: relatively long arms, curved fingers/toes, sexual dimorphism	Light build. Probably long arms, more 'human' features, probably less sexual dimorphism	Heavy build. Relatively long arms. Moderate sexual dimorphism
Skull shape	Not yet described	Foramen magnum more forward than apes	Primitive features in the skull, possibly apelike	Apelike face, low forehead, bony brow ridge, flat nose, no chin	Brow ridges less prominent; higher forehead and shorter face	Long, broad, flat face; crest on top of skull; moderate facial buttressing
Teeth and jaws	Not yet described	Teeth are inter-mediate between those of *A. afarensis* and earlier apes. Smaller, narrow molars; thinner jaw	Very similar to those of older fossil apes, but canines vertical; teeth have thicker tooth enamel like in humans	Human-like teeth, canines smaller than apes, larger than humans. Jaw shape half way between an ape's and human.	Teeth and jaws much larger than in humans; tooth row fully parabolic like humans; canine teeth further reduced	Very thick jaws; small incisors and canines; large molar-like premolars; very large molars
Geographical distribution	Eastern Africa	Eastern Africa	Eastern Africa	Eastern Africa	Southern Africa	Southern Africa

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The Emerging View

The view of 'evolutionary tree' illustrated in the previous activity is simplified to make it easier to understand where the various hominin groups lie in relationship to each other. There has been a tendency over the last 40 years to try to fit the assembled fossil evidence into a **linear progression** view of human evolution (see next page). In the late 1980s and early 1990s, a large number of new hominin fossils were discovered and some of the earlier finds were also reassessed. This led to an acknowledgement of the **bushier** nature of the human evolutionary tree. Recently this revised view has been further refined to harmonize the view of human evolution with the evidence gathered on the better understood evolution of other mammals. Human evolution can now be thought of as a succession of **adaptive radiations**, some of which were 'sidelines' to the modern human lineage and all but one species (our own) becoming **extinct**.

*The species marked with an asterisk (*) were all unknown a decade or so ago (and may be missing from many textbooks on the subject). There are likely to be many as yet 'undiscovered' species in the fossil record between 7 and 4 million years ago.

Archaic and Modern Humans

Rapid advances in brain size are associated with a suite of new behaviors during this period. Anatomically modern humans emerge from one of the many regional variants and rapidly spread through much of the Old World.

Erectines

Big changes in the post-cranial skeleton with body height achieving modern proportions. Marked behavioral changes are matched by increasing brain volume, with sophisticated tool manufacture and use employed to kill and process small sized game. It is still unclear whether *H. floresiensis* belonged to this group.

Paranthropines

These early hominins represent a group specialized for eating a bulky, low-grade vegetarian diet. They developed large cheek teeth, powerful chewing muscles and a generally **robust** skull (large crests for muscle attachment, heavily buttressed face).

Habilines

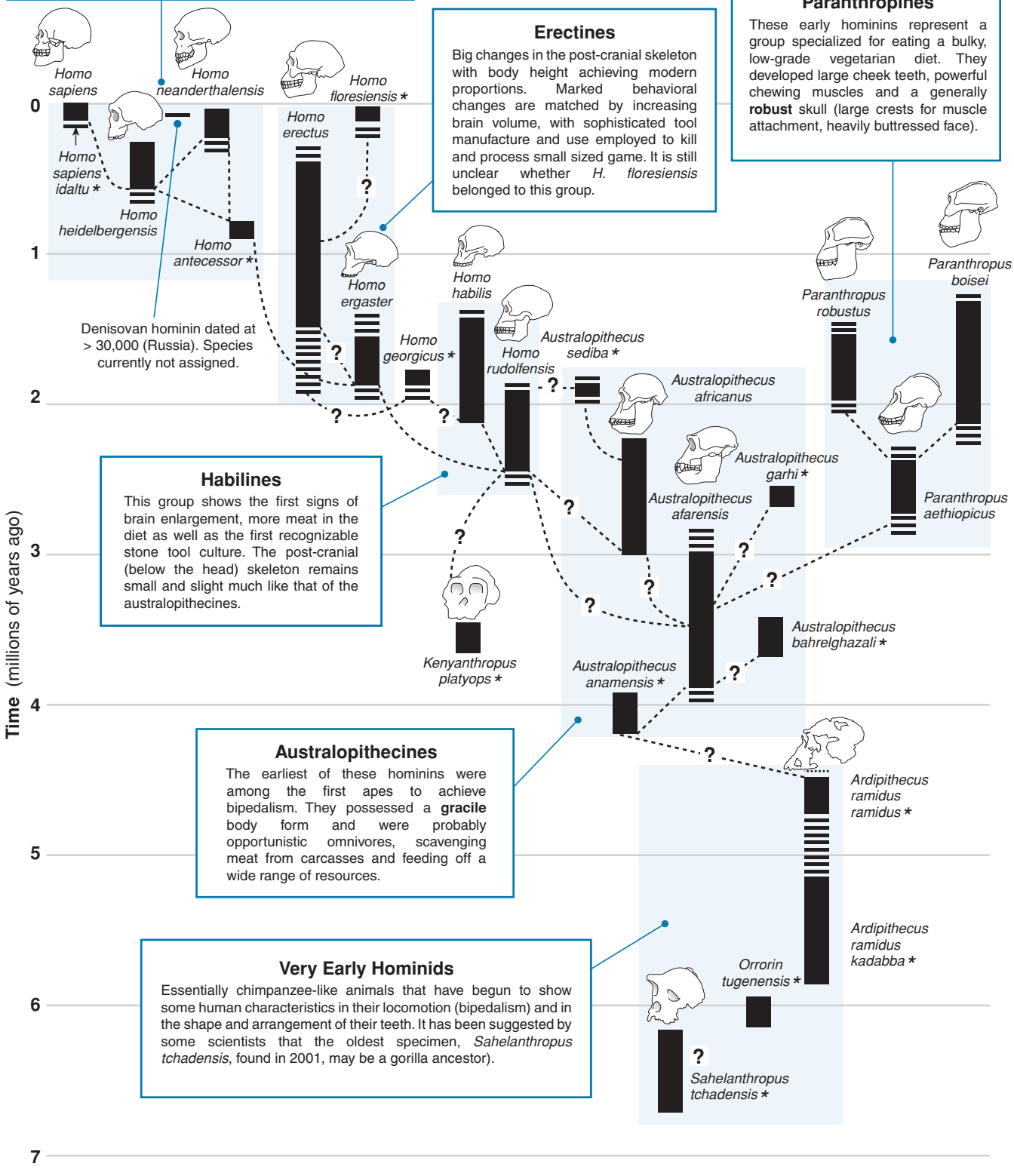
This group shows the first signs of brain enlargement, more meat in the diet as well as the first recognizable stone tool culture. The post-cranial (below the head) skeleton remains small and slight much like that of the australopithecines.

Australopithecines

The earliest of these hominins were among the first apes to achieve bipedalism. They possessed a **gracile** body form and were probably opportunistic omnivores, scavenging meat from carcasses and feeding off a wide range of resources.

Very Early Hominids

Essentially chimpanzee-like animals that have begun to show some human characteristics in their locomotion (bipedalism) and in the shape and arrangement of their teeth. It has been suggested by some scientists that the oldest specimen, *Sahelanthropus tchadensis*, found in 2001, may be a gorilla ancestor).



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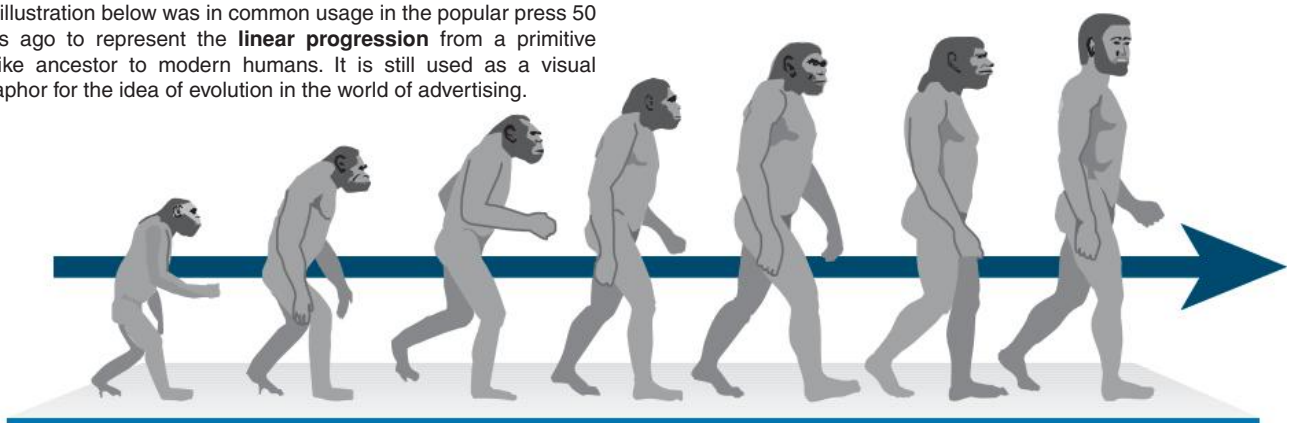
A 1960s view of human evolution

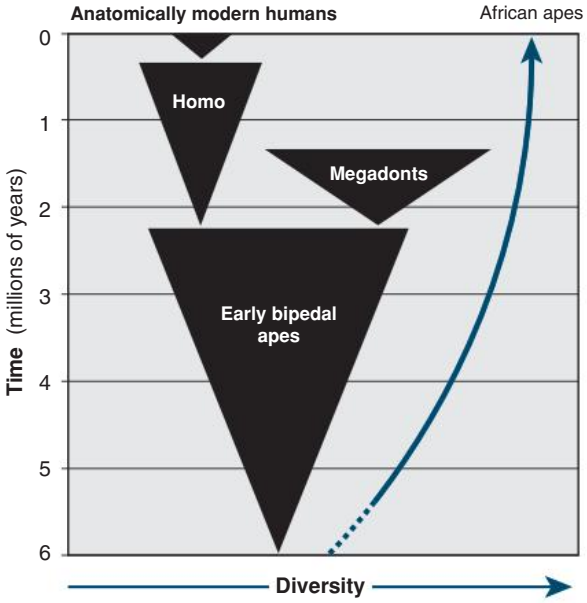
The illustration below was in common usage in the popular press 50 years ago to represent the **linear progression** from a primitive apelike ancestor to modern humans. It is still used as a visual metaphor for the idea of evolution in the world of advertising.



Evolving lineage with the accumulation of gradual genetic changes under the influence of natural selection

Predictions according to the linear progression model

- The fossil record should consistently show smooth intergradations from one species to the next.



The actual evidence observed

- Few smooth intergradations from one species to the next.
- Species tend to appear suddenly in the fossil record.
- The species linger for varying but often very extended periods of time in the fossil record.
- The species disappear as suddenly as they arrived.
- They are replaced by other species which might or might not be closely related to them.

Source: Robert Foley, (1995) ***Humans Before Humanity***, Blackwell Publishers

The current view of human evolution

The diagram on the left depicts human evolution as a series of adaptive radiations. The first radiation is that of the **early bipedal apes**, the australopithecines. The second radiation involves the genus *Paranthropus*, a group of species that exploited a coarse, low-grade vegetable food source (nuts, root tubers and seeds) resulting in **megadontic** adaptations (very large teeth). The third radiation is genus *Homo*, with the **habilines** and **erectines** developing a larger brain, diversifying and dispersing from Africa to other parts of the Old World. The last radiation does not involve any major evolutionary divergence, but reflects the dispersal of **modern humans** with considerable geographic separation.

Source: Ian Tattersall, (1995) ***The Fossil Trail***, Oxford University Press

1. Explain why the 1960s **linear progression** view of human evolution is not an acceptable scientific model:

2. Explain whether the *emerging view* (on the previous page) and the data above support the **punctuated equilibrium** or **gradualism** models of evolutionary development and the origin of new species:

3. Describe the four main **adaptive radiations** that have occurred during hominin evolution over the last 4 million years:

   (a) _____

   (b) _____

   (c) _____

   (d) _____

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Hominin Data Sheets

This exercise is designed to collate the information on the various hominin species (below) that you may have gathered from a wide range of sources (texts, videos, and class work). The eight data summary sheets can be used to describe key features and points on each species. Descriptions should be brief; in many cases, key words or brief sentences will be all that is required. After completing this activity, attempt *Hominin Skull Identification*. The following species are represented:

Genus *Ardipithecus*	Genus *Australopithecus*	Genus *Paranthropus*	Genus *Homo*
Ardipithecus ramidus	*Australopithecus africanus* *Australopithecus afarensis*	*Paranthropus robustus* *Paranthropus boisei*	*Homo habilis* (including *Homo rudolfensis)* *Homo erectus* (including *Homo ergaster)* *Archaic Homo sapiens (Homo heidelbergensis)* *Homo neanderthalensis* *Homo sapiens*

NOTE: No data sheets are provided for recent discoveries including: *Sahelanthropus tchadensis, Australopithecus anamensis, Australopithecus sediba, Australopithecus bahrelghazali, Australopithecus garhi, Orrorin tugenensis,* and *Kenyanthropus platyops*. However information on these discoveries is provided.

Below are some ideas on how you can analyze the data that you have collected. The data sheets for each hominin have some clearly defined places for answers. Use the 'Additional Notes' box for comments on culture, skeleton, habitat, etc. It is useful to make comparisons between hominins dated immediately before and after the one you are making notes about. Note that extra information is provided here: you are not required to provide detail for every species. The trends are important.

Skull Features

Where indicated, label the main distinguishing features of the skull. Note that skulls are not available for every species. Various features can be considered, but not all will apply to each skull. See the diagram below for help.

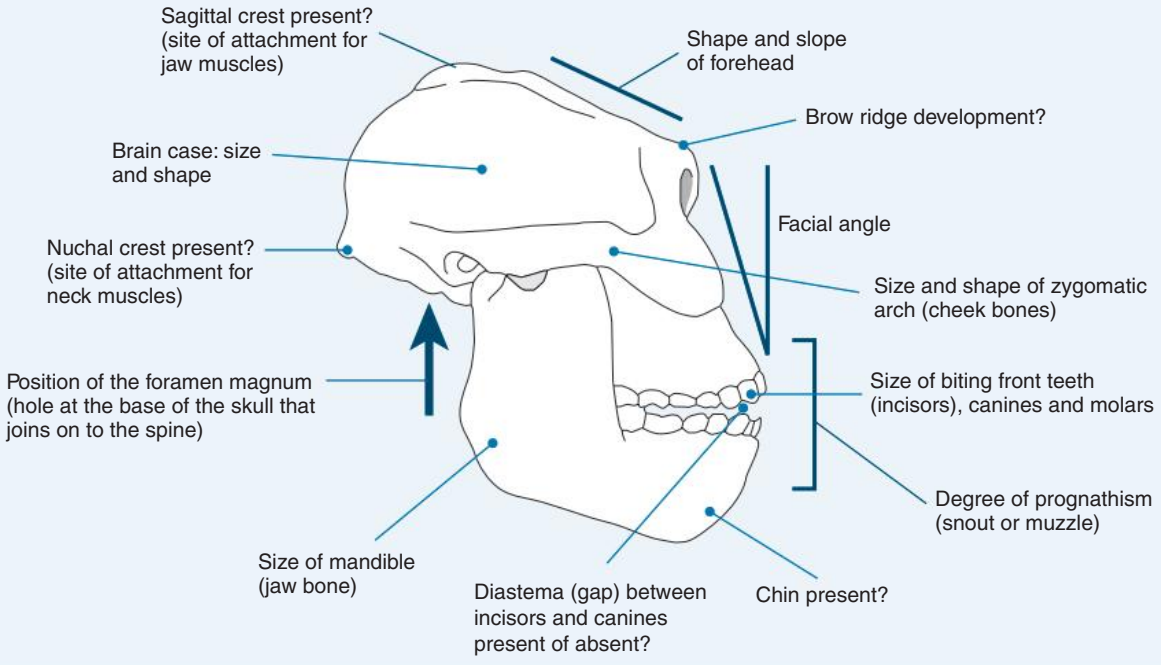
1. **Face**
   (a) Size of the face compared to the braincase.
   (b) Degree of prognathism (snout or muzzle development) of the jaw and mid face (mid-face projection).
   (c) Development of brow ridges (supraorbital tori): size, thickness, arching.
   (d) Size of cheek region.

2. **Jaws (mandible)**
   (a) Size and thickness of lower jaw.
   (b) Degree of curvature of dental arcade (tooth row).
   (c) Presence or absence of chin.

3. **Braincase**
   (a) Shape of forehead (slope, height).
   (b) Rear view: where is skull the widest, low down or high up? Shape: pentagonal, rounded, bell-shaped?
   (c) Presence of crests: Nuchal crest for neck muscles, sagittal crest for jaw muscles.
   (d) Shape of occipital region (back of skull) when viewed from the side: presence of bun?
   (e) Dorsal (top) view: where is the skull widest (rear, middle ear, etc.)?
   (f) Position of foramen magnum (opening at base of skull connected to spine).

Diet

Describe the likely food resources utilized by the hominin. This is sometimes conjecture, based on the wear patterns on the surface of the teeth. Other instances provide more direct evidence such as the fossilized or mummified remains of the food. Indicate whether the hominin is completely herbivorous, omnivore, or carnivore. In some cases a species is described as being an 'opportunist', hunter gatherer, or farmer. It has been suggested that the feeding of some early hominins may have involved opting for one of two strategies: a low grade, high volume diet; or a high grade, low volume diet. Diet is probably a major selection pressure that has strongly influenced both physical and cultural evolution.



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Geographic Distribution

List the regions (e.g. east Africa, Asia) or the countries (e.g. Kenya) where fossils of the species have been found to date. The sites are marked on the map with a triangle.

Culture

The various hominin species each have characteristic cultural features. We are restricted to describing those cultural features that have left some record in the form of fossilized remains. So although we find such things as stone tools at a certain age, this does not mean that the early hominins did not use such perishable tools such as wood, bamboo, and other organic materials that failed to preserve. Consider the following points:

(a) Stone tool technology used.
(b) Other materials used (wood, bone, ivory, clay for pottery, copper, bronze, iron, precious metals).
(c) Degree of workmanship required to produce the tool.
(d) Evidence of using fire (e.g. to cook (hearth), to hunt, for security from predators).
(e) Evidence of artistic expression (e.g. rock paintings, carvings, statues) and their significance.
(f) Evidence of abstract thought, spirituality and religion (eg. burials, cannibalism).
(g) Evidence of spoken word (voice box development), written word, higher technologies for communication.

Dentition

The teeth provide important clues about the diet of the hominin. Look for a diastema (gap between the canine and incisors).

(a) Absolute size of teeth (especially molars).
(b) Relative proportions of different tooth types: incisors, canines, molars.
(c) Amount of wear on the teeth; this indicates the quality of the diet: high grade (meat) or low grade (tough plant).

Habitat

Describe the nature of the habitat of the hominin if known. This may be African open savannah for the earlier forms but may include more varied habitats (sub-tropical forests, temperate forests, tundra, and even subarctic) for the later, more widespread hominins.

Skeleton

This section mainly deals with what is called the **post-cranial skeleton**; the skeleton apart from the skull. Various features can be investigated:

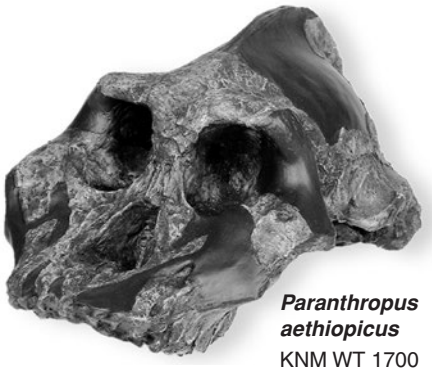
(a) Structure of the pelvis: shape, size of birth canal.
(b) Angle of the femur (thigh bone) and the knee joint.
(c) Structure of the spine: curvature and relative size of the vertebrae.
(d) Depth of rib cage.
(e) Structure of the foot; evidence for adaptations for walking and primitive features if present.
(f) General bone thickness and limb proportions.

Natural Selection Pressures

As time progressed from the earliest hominins to modern humans, there was a gradual reduction in the degree to which environmental forces acted as selection pressures in our evolution. This was largely due to our increasing ability to manipulate the environment and develop technologies to reduce environmental stresses. The trend towards increasing control of the environment and the development of learned behaviors to improve technologies is a major theme of our cultural evolution. Consider:

(a) Climatic changes (e.g. glacial periods, changes in vegetation resulting from climatic change) and the effect of these on the habitat.
(b) Diet and food resources: their effect on the development of teeth, jaw muscles, and skull architecture.
(c) Food gathering strategies: affecting such things as cooperative behavior and the development of assisting technologies.
(d) Competition with other hominin species, members of the same species (relate this to population densities).
(e) Predator avoidance: cooperative behaviors, technologies.
(f) Bipedalism: selection pressures that favoured its origin & refinement.
(g) Effect of bipedalism on other body parts and processes (e.g. consider problems associated with our walking habit).

Australopithecus afarensis



Paranthropus aethiopicus
KNM WT 1700

Homo rudolfensis
KNM ER 1470

Homo floresiensis

Photos: www.skullsunlimited.com

ISBN: 978-1-877462-99-3

The Early Hominins of Africa

Orrorin tugenensis

O.tugenensis, or 'Millenium man' was discovered in late 2000 in Kenya. It lived between 6.2 and 5.8 mya. Thirteen pieces, consisting of teeth, fragments of the arm, thigh bone, and a finger, from at least five different individuals have been found. The size and morphology of the teeth are intermediate between those of a chimpanzee and those of a human.

Ardipithecus ramidus

Discovered in 1994, this species shows evidence of bipedalism. Originally named *Australopithecus ramidus*, it was reclassified under a new genus, *Ardipithecus*. Two species of *Ardipithecus* have been identified: *Ar. ramidus* (4.4 my old) and *Ar. kadabba* (5.8 my old).

Australopithecus anamensis

Anamensis was discovered at Kanapoi, Kenya in 1994. The find consists of complete upper and lower jaws, teeth, a piece of skull, and arm and leg bones. Anamensis existed between 4.2 and 3.9 mya and had a mixture of primitive, ape-like features and advanced, human-like features. The teeth and jaws are similar to older fossil apes, but the lower leg bones show evidence of bipedalism and the upper arm bone is extremely human-like.

Kenyanthropus platyops

Named in 2001 from a 3.5 mya partial skull found in Kenya. This specimen is comparable with A. afarensis, yet quite distinct from it, demonstrating that these two hominins coexisted. The most distinctive feature of *Kenyanthropus* is the high forward cheekbones giving the face a flat appearance, similar to the later *P. boisei*. This specimen also has smaller teeth than the australopithecine, but significantly larger than those of *Orrorin*.

Australopithecus bahrelghazali

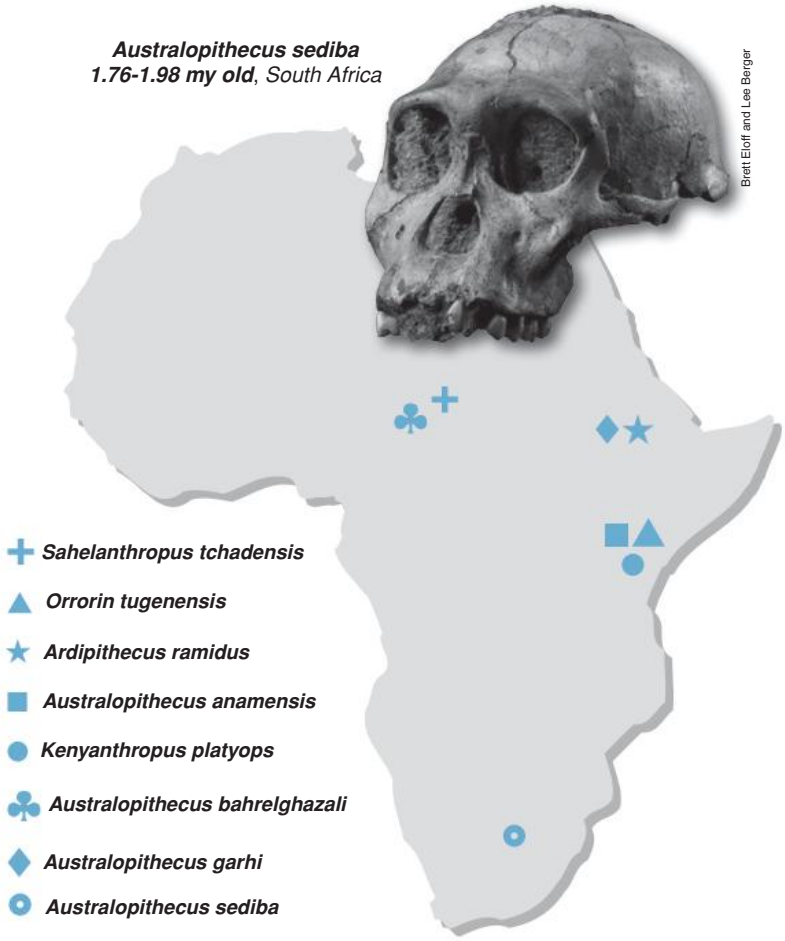
A. bahrelghazali has similar characteristics to *A. afarensis*. it was discovered in Chad in 1995, 2400 km west of the East African Rift, greatly extending the known geographic range of early hominins. The fossil find consists of a partial jawbone and teeth dated at about 3.5 to 3.0 million years ago.

Australopithecus garhi

This important discovery was made in Ethiopia. Named in 1999, this species is known from a partial skull dated at 2.5 mya. The skull differs from other species of *Australopithecus* in its extremely large teeth, and in having a primitive skull shape. Other fossils found nearby and thought to be the same species show a mix of human and ape-like proportions.

Sahelanthropus tchadensis

In 2001, the 6-7 my old remains of a nearly complete skull with gorilla-like features was unearthed in Chad. It was nicknamed 'Toumai' and assigned to a new genus, ***Sahelanthropus tchadensis***, but scientists debate whether the skull's features place it in the human family tree, or whether it represents the remains of a 'proto-gorilla' (an early gorilla ancestor).

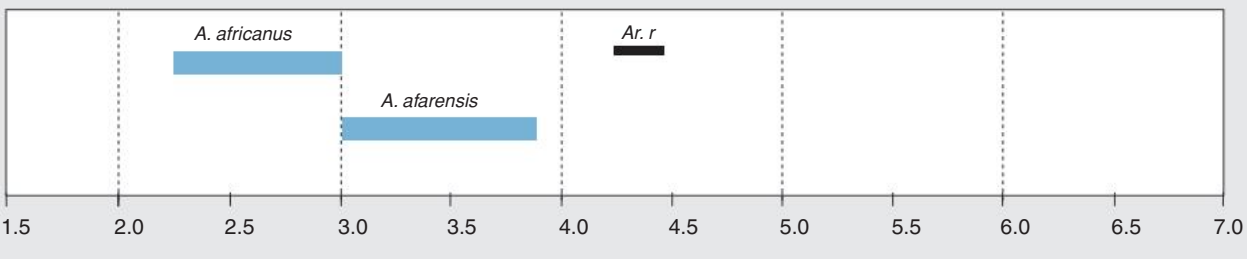


Australopithecus sediba

Australopithecus sediba was first discovered in 2008 at Malapa, South Africa. Two specimens have been found, a juvenile male and an adult female. The fossils have been dated at ~1.98 mya. They are significant because they contain a mixture of primitive and derived characteristics that may help link the genus *Australopithecus* with the genus *Homo*.

1. Using the information given in the data sheets, complete the timeline of early hominin evolution to show the relative positions of each hominin. *Ardipithecus ramidus* has been done for you.

Timeline showing early hominin evolution from 1.5 to 7 million years ago



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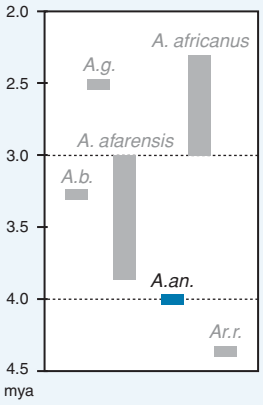
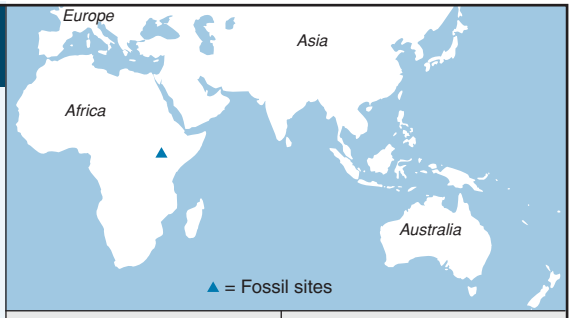
Australopithecus anamensis

Anamensis was discovered at Kanapoi, Kenya in 1994. The find consists of complete upper and lower jaws, teeth from several individuals, a piece of skull, arm bones and a leg bone. *Anamensis* existed between 4.2 and 3.9 mya and had a mixture of primitive, ape-like features and advanced, human-like features. The teeth and jaws are similar to older fossil apes. The lower leg bones, however, show strong evidence of bipedalism and the upper arm bone is extremely human-like.

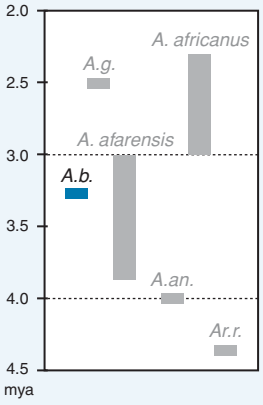


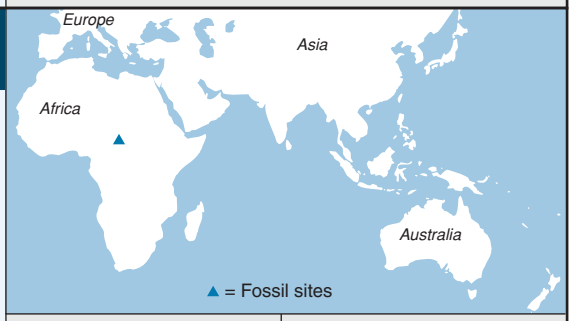


Years:	mya	Brain size:	cc
Height:	m	Weight:	kg
Geographic distribution:			

Australopithecus bahrelghazali

An important discovery, with characteristics similar to *Australopithicus afarensis*. A. *bahrelghazali* was discovered in Chad in 1995, some 2400 km west of the East African Rift, greatly extending the known geographic range of early hominins. The fossil find consists of a partial jawbone and teeth dated at about 3.5 to 3.0 million years ago.

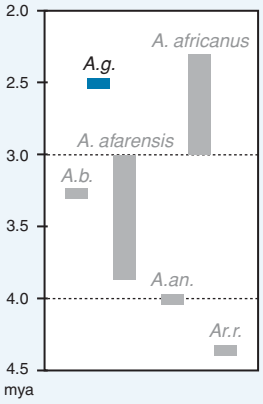


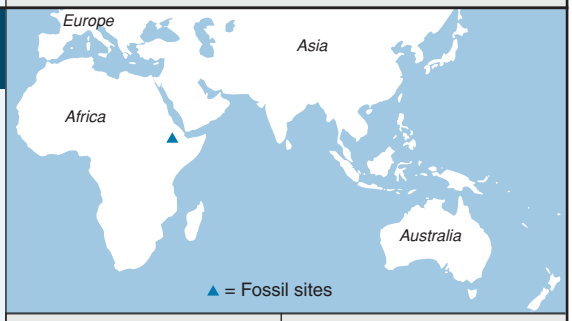


Years:	mya	Brain size:	cc
Height:	m	Weight:	kg
Geographic distribution:			

Australopithecus garhi

This important find, made in Ethiopia and named in 1999, is known from a partial skull. This skull, dated at about 2.5 mya, differs from other species of *Australopithecus* in its combination of features: the primitive skull shape and extremely large size of the teeth (especially molars). The remains of two other hominins, probably less than 1.5m tall, were found nearby. They are also dated at 2.5 mya and may be from the same species. When arm bones and leg bones are compared, they show a mix of human and ape-like proportions (humerus to femur ratio is human-like, while upper arm to lower arm ratio is ape-like).

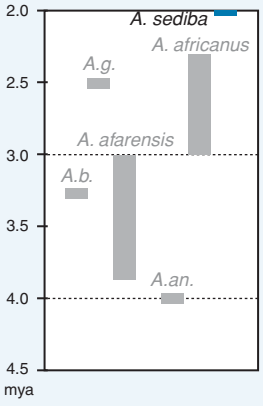


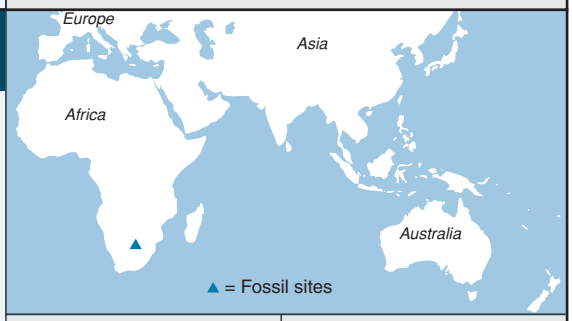


Years:	mya	Brain size:	cc
Height:	m	Weight:	kg
Geographic distribution:			

Australopithecus sediba

Australopithecus sediba was discovered in cave deposits at the Malapa site in South Africa. Features seen in the brain, feet, hands, and pelvis of *A. sediba* suggest this species was on the direct evolutionary line to *Homo*. However, it also exhibits australopithecine features such as long upper limbs and a small cranial capacity.



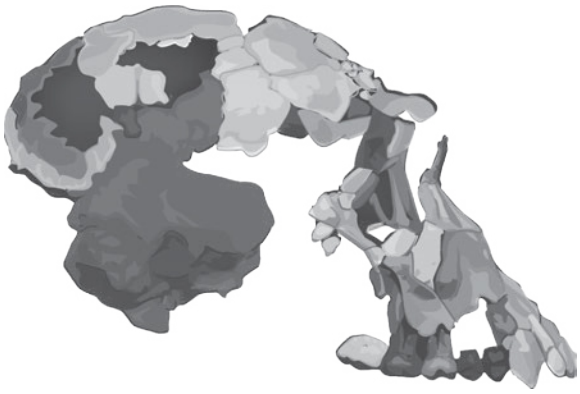


Years:	mya	Brain size:	cc
Height:	m	Weight:	kg
Geographic distribution:			

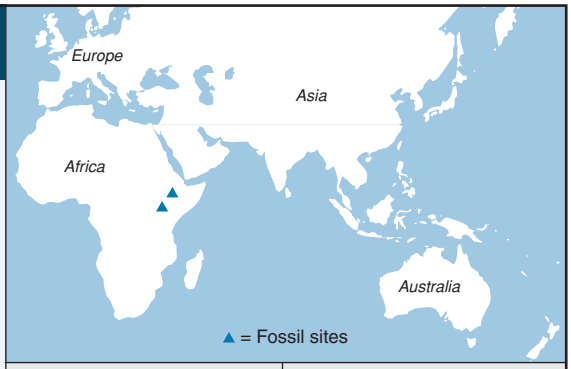
ISBN: 978-1-877462-99-3

Ardipithecus ramidus

Ardipithecus existed from 5.8 to 4.4 million years ago. It stood 1.2 m high and weighed around 50 kg. The brain case was small, at around 350 cc, and the jaw had reduced canine teeth. Fossils of the pelvis show it was capable of being bipedal but it still had an opposable toe and spent time climbing. The hand was characterized by a short palm and a flexible wrist. *Ar. ramidus* was probably an omnivore and fruit eater.



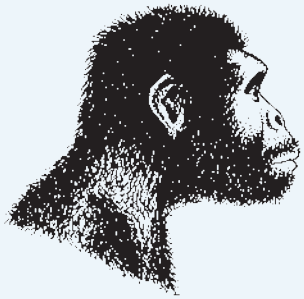
Redrawn from C. Owen Lovejoy *et. al*, Science, vol 326, 2009



Years:	mya	Brain size:	cc
Height:	m	Weight:	kg
Diet:			
Geographic distribution:			
Additional notes:			

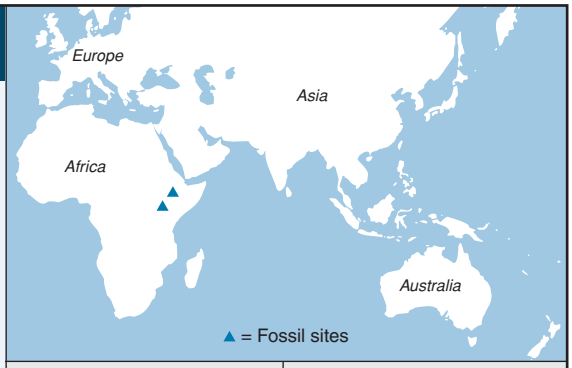
Australopithecus afarensis

Small, gracile, small-brained, and bipedal, *Afarensis* existed between 3.9 and 3.0 mya. The skull is similar to that of a chimpanzee, except for more human-like teeth. Brain size varied between 375-550 cc. The humanlike pelvis and leg bones confirm they were bipedal. Height ranges from 1.0 to 1.5 m (sexual dimorphism). Some researchers claim such differences in height suggest two separate species, not sexual dimorphism. Nicknames: Lucy, The First Family, Laetoli footprints.



Artist's reconstruction

Composite reconstruction

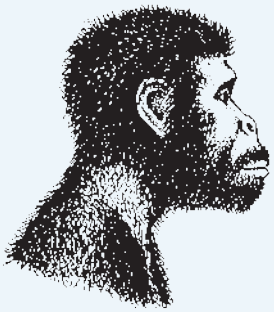


Years:	mya	Brain size:	cc
Height:	m	Weight:	kg
Diet:			
Geographic distribution:			
Additional notes:			

ISBN: 978-1-877462-99-3

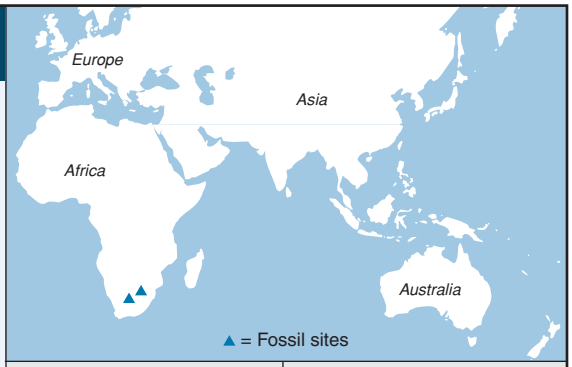
Australopithecus africanus

Africanus existed between 3.0 and 2.0 mya. Similar to *afarensis*, it was also small, gracile, and bipedal, but slightly larger in size. Brain size may also have been slightly larger, ranging from 420 to 500 cc. Generally considered to be specific to South Africa. Differs from the early australopithecines in east Africa by having larger back teeth and smaller canines. The jaw shape is fully human-like. Nicknames: Taung baby, Mrs Ples.



Artist's reconstruction

Sts 5 skull from Sterkfontein South Africa



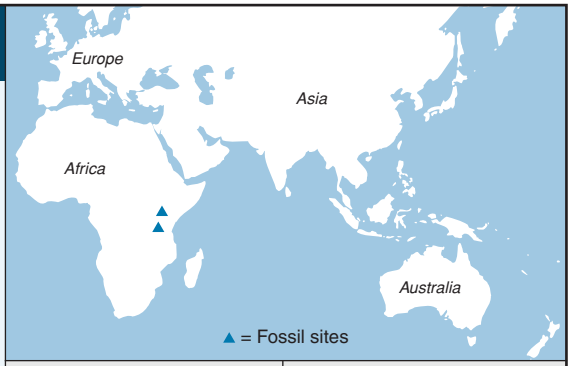
Years:	mya	Brain size:	cc
Height:	m	Weight:	kg
Diet:			
Geographic distribution:			
Additional notes:			

Paranthropus boisei

One of a group of robust species of early hominin. Existing between 2.1 and 1.1 mya, it had a brain size ranging from 500 to 545 cc. Known for its very massive jaws, large molars, and attachments on the skull associated with chewing muscle. Probably fed on a tough diet of low grade foods: tubers, grains, and other plant material. This species is also referred to by some researchers as *Australopithecus boisei*. Nicknames: Zinjanthropus, Nutcracker Man.

Artist's reconstruction

OH 5 found at Olduvai Gorge in Tanzania



Years:	mya	Brain size:	cc
Height:	m	Weight:	kg
Diet:			
Geographic distribution:			
Additional notes:			

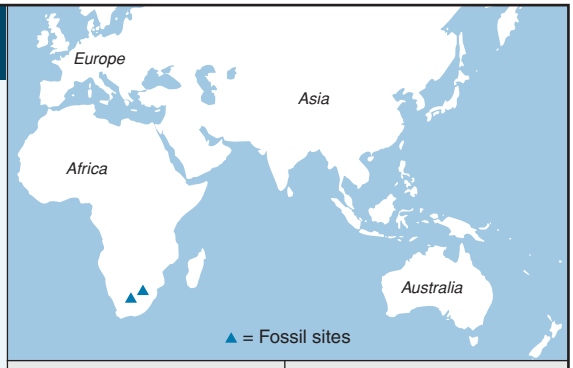
ISBN: 978-1-877462-99-3

Paranthropus robustus

Robustus existed between 2.0 and 1.5 mya and had a brain size of about 530 cc. It had a similar body to that of *africanus*, but a larger and more robust skull and teeth. The massive face was flat or dished, with large brow ridges and no forehead. Massive grinding teeth set in a large jaw suggest that it probably fed on a diet of tough, coarse plant food that needed a lot of chewing. May have used bones as digging tools. Some researchers classify this species as *Australopithecus robustus.*

Artist's reconstruction

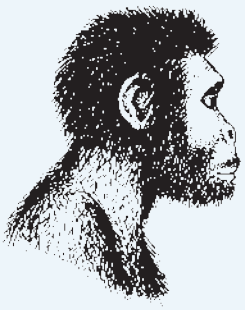
SK 48 from Swartkrans in South Africa



Years:	mya	Brain size:	cc
Height:	m	Weight:	kg
Diet:			
Geographic distribution:			
Additional notes:			

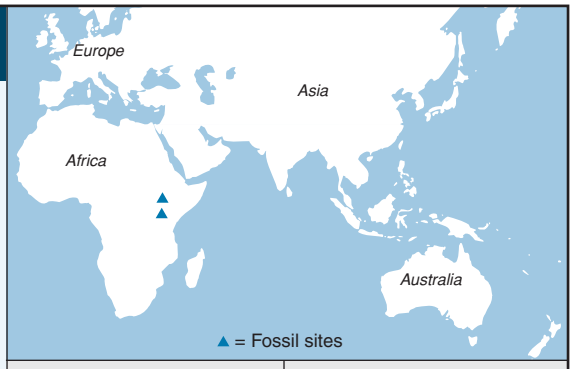
Homo habilis

Habilis existed between 2.4 and 1.5 mya. Although similar to australopithecines in many ways (e.g. height of males is 1.3 m), their brain size was considerably larger (500 to 800 cc). Some researchers argue that this species is too variable in its present classification. Recent classification split it into two species: *Homo habilis* (**ER-1813**, shown below) and the more robust *Homo rudolfensis* (**ER-1470**). One *habilis* brain cast shows a bulge of the Broca's area, suggesting rudimentary speech.



Artist's reconstruction

KNM-ER 1813 skull from Koobi Fora region to the east of Lake Turkana, Kenya



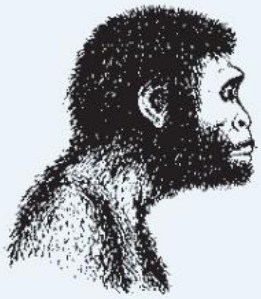
Years:	mya	Brain size:	cc
Height:	m	Weight:	kg
Diet:			
Geographic distribution:			
Additional notes:			

ISBN: 978-1-877462-99-3

Homo ergaster

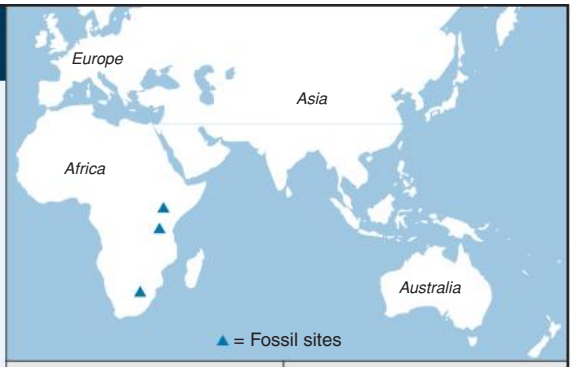
Larger brained than previous *Homo* species, with volumes of 850 to 1000 cc. Previously considered to be part of *Homo erectus*, but now thought to be a separate species. *Homo ergaster* refers to what used to be called early African forms of *Homo erectus*, existing 1.8 to 1.4 mya. Earliest hominin with human-like body proportions. An nearly complete skeleton of a 9 year old boy was 1.6 m tall (estimated 1.85 m as an adult).

Nickname: Turkana Boy.



Artist's reconstruction

KMN-ER 3733 skull from Koobi Fora region to the east of Lake Turkana, Kenya



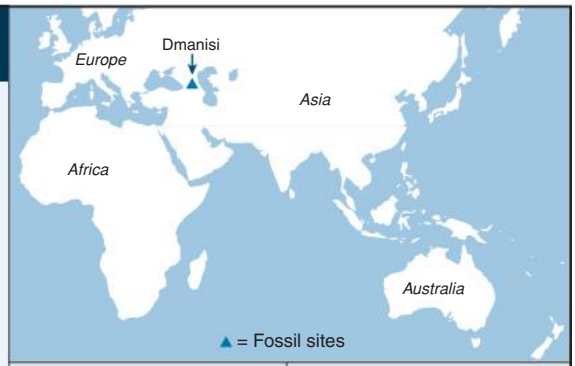
Years:	mya	Brain size:	cc
Height:	m	Weight:	kg
Diet:			
Geographic distribution:			
Additional notes:			

Homo georgicus

Fossils found in Dmanisi, Georgia in 2002 were originally classified as *H. ergaster*, but size differences have since lead to the new classification *Homo georgicus*. The fossils, which include four skulls and several jaw bones have been dated at 1.8 mya. The small size (1.5 m tall) and cranial capacity (600-780 cc) of the fossils place *H. georgicus* as a descendent of *H. habilis* and predecessor of *H. erectus*. They may have been the earliest hominin to venture out of Africa, some 800,000 years before *H. erectus*. This finding challenges the theories that hominins required a large brain and advanced tool making skills to be able to migrate out of Africa.

Nicknames: Dmanisi man.

D2700 (skull), and **D2735** (lower jaw) of *Homo georgicus* from Dmanisi, Georgia



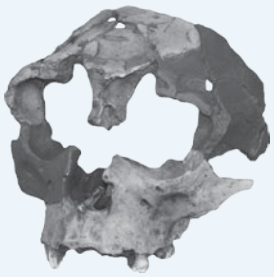
Years:	mya	Brain size:	cc
Height:	m	Weight:	kg
Diet:			
Geographic distribution:			
Additional notes:			

H. georgicus exhibited strong sexual dimorphism; the males were considerably larger than the females. This is quite a primitive trait, and not observed to the same degree in later more modern hominins such as Homo neanderthalensis.

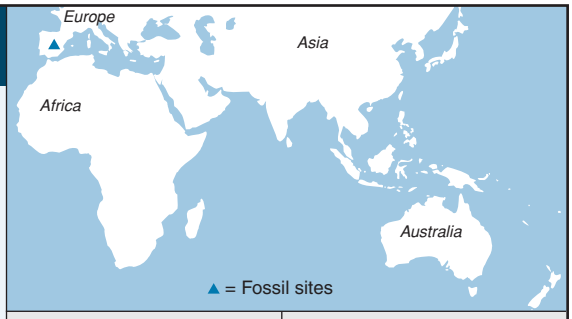
ISBN: 978-1-877462-99-3

Homo antecessor

Homo antecessor, a highly controversial species, existed between 780,000 and 625,000 years ago. Discoveries at the Gran Dolina site in the Sierra de Atapuerca, Spain, make these the earliest known European hominin specimens. Fossils consist of nearly 80 postcranial, cranial, facial, and mandibular bones as well as teeth of at least six individuals. *H. antecessor* ('pioneer') shows a mixture of primitive and modern traits, with an especially modern-looking midface.



Homo antecessor from Gran Dolina, Sima de los Huesos in the Sierra de Atapuerca, Spain

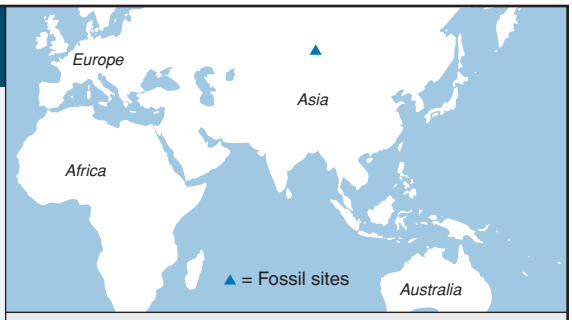


Years: mya	Brain size: cc
Height: m	Weight: kg
Geographic distribution:	

Denisovan fossils

Fossil fragments (tooth, finger bone, and toe bone) belonging to a previously unknown species of *Homo* were found in the Denisova cave in Altai mountains, Siberia, Russia. Carbon dating estimates their age at about 40,000 years. The Denisova hominin existed at the same time as modern humans and Neanderthals. The Denisova hominin has yet to be classified as a new species.

Nicknames: Denisovan fossils, Denisovan hominins, or X-women.



Additional notes:

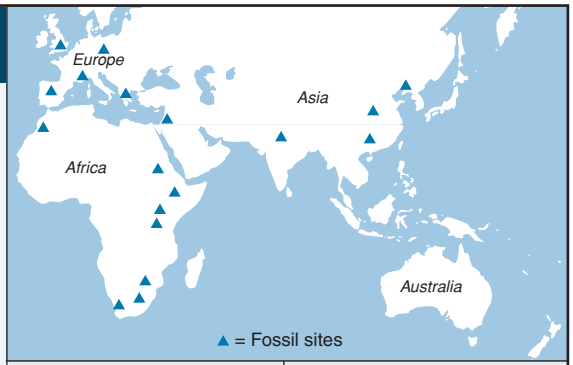
Too few fossil fragments have been found for scientists to put together a physical description of the Denisova hominin.

Archaic Homo sapiens

About 300,000 years ago transitional **archaic** forms appear in increasing variation and numbers. Possessing both modern and *Homo erectus*-like features, they were probably 'experimental prototypes' responding to diverse regional selection pressures. They had brain sizes ranging from 1100 to 1400 cc. Some researchers refer to this variable collection of early (archaic) *Homo sapiens* as a separate species: *Homo heidelbergensis*.

Nicknames: Rhodesia Man, Steinheim Man, Swanscombe Man, Heidelberg Man.

Artist's reconstruction



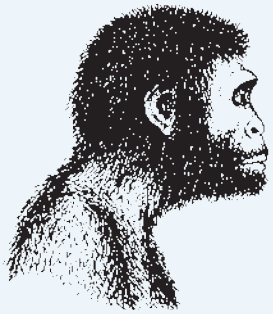
Years:	Brain size: cc
Height: m	Weight: kg
Diet:	
Geographic distribution:	
Additional notes:	

Homo sapiens rhodesiensis or 'Rhodesia Man', from Broken Hill Mine, Kabwe in Zambia

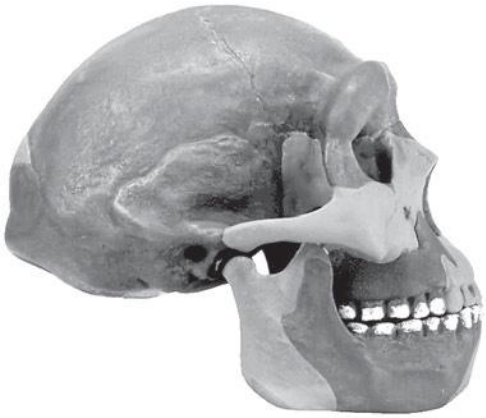
ISBN: 978-1-877462-99-3

Homo erectus

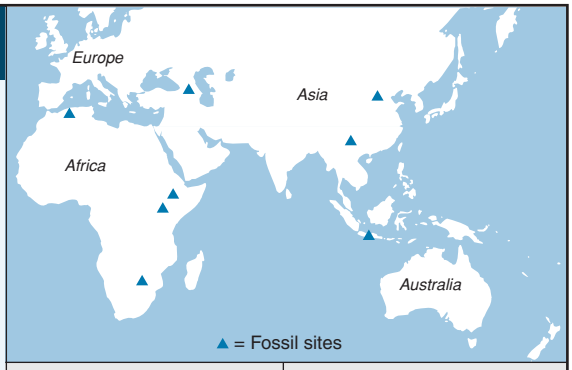
Homo erectus is reserved for the later Asian forms (shown here), with dates ranging from 1 million to 300,000 years ago. At one time thought to be the first humans to venture out of Africa (but see *georgicus*). They differ from *ergaster* by having skulls that were strongly buttressed with ridges of bone, skull walls greatly thickened, and larger brain volumes (range: 1000 to 1250 cc). These simple hunter-gatherers used stone tools and fire. Nicknames: Java Man, Peking Man, Solo Man.



Artist's reconstruction



Homo erectus pekinenis or 'Peking Man' from Zhoukoudian Cave, near Peking in China

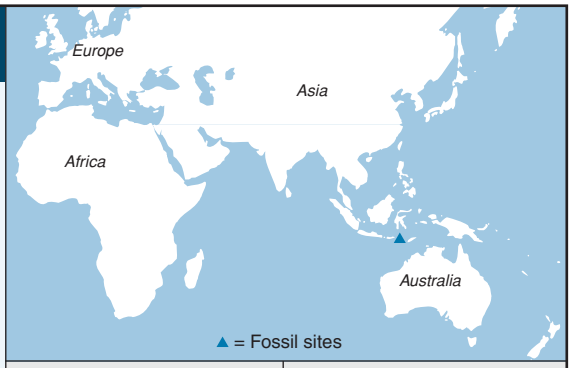


Years:	Brain size: cc
Height: m	Weight: kg
Diet:	
Geographic distribution:	
Additional notes:	

Homo floresiensis

A nearly complete skeleton (**LB1**), with a mix of primitive and derived features, was discovered on the Island of Flores, Indonesia, and named *Homo floresiensis*. The specimen, was small, 1.06 m tall, and weighed only 25kg. It also had a very small brain capacity (only 380 cc). Subsequent *floresiensis* fossils have been found in conjunction with tools and remnants of fire indicating that the species had advanced behaviors. The fossils have been dated at 38,000-13,000 years, indicating this species existed at the same time as moderns until recently.
Nicknames: Hobbit, man of Flores.

LB1 skull from Liang Bua Cave, Flores Island, Indonesia



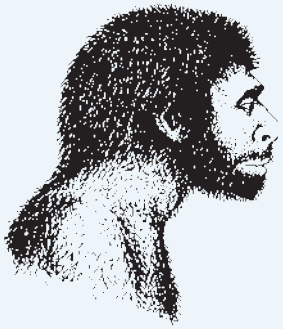
Years: mya	Brain size: cc
Height: m	Weight: kg
Diet:	
Geographic distribution:	
Additional notes:	

Some anthropologists argue that Homo floresiensis is a microcephalic, or malnourished version of modern H. sapiens. However, variations in its teeth, lack of chin, and low twist of the forearm bones lend support for a new species.

ISBN: 978-1-877462-99-3

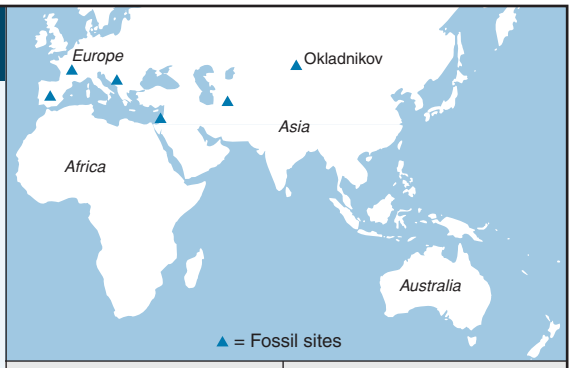
Homo neanderthalensis

Neanderthals existed between 230,000 and 28,000 years ago. Average brain size was 1450 cc and they had short, squat, cold-adapted bodies with thick, heavy bones (male height ~1.7 m). Recent evidence from the Neanderthal Genome Project suggests that the ancestral populations of Neanderthals and modern humans separated between 270,000 and 440,000 years ago, but there was probably some gene flow between non-African humans and Neanderthals as recently as 100,000 to 50,000 years ago.



Artist's reconstruction

La Ferrassie Skull, Le Bugue, Dordogne Valley in France



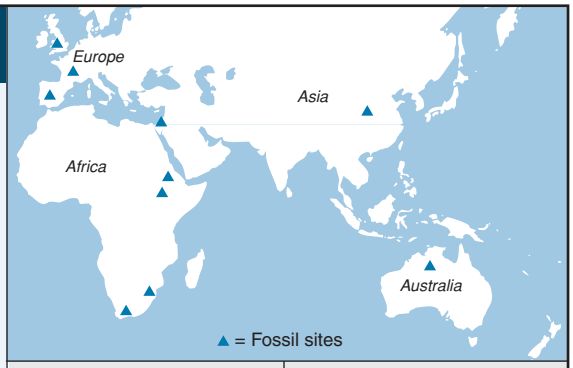
Years:	Brain size: cc
Height: m	Weight: kg
Diet:	
Geographic distribution:	
Additional notes:	

Homo sapiens

The first anatomically modern humans appear about 160,000 years ago in southern African and the Middle East. The average brain volume was 1350 cc and the skeleton was very gracile. They underwent a sudden cultural revolution about 40,000 years ago, with the appearance of Cro-Magnon culture. Using a wider range of materials, their tool kits became markedly more sophisticated. They were skilled hunters, tool-makers and artists (cave art and music).

Artist's reconstruction

'Cro-Magnon Man', from Cro-Magnon, Dordogne Valley in France

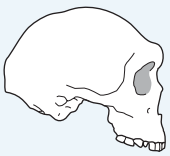


Years:	Brain size: cc
Height: m	Weight: kg
Diet:	
Geographic distribution:	
Additional notes:	

ISBN: 978-1-877462-99-3

Hominin Skull Identification

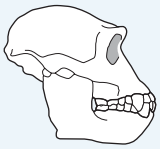
Attempt this activity once you have completed the *Hominin Data Sheets*. Give the **name** of the species for each of the hominin skull shapes below. With reference to the following list, describe the **key features** in its identification. Features include the overall shape of the skull, the presence of brow ridges, the facial angle, the volume of the brain case relative to the rest of the skull, the presence of a snout, the robustness of the jaw, size of teeth, and the presence of a sagittal crest. Species presented (not in order) are: *Homo sapiens, H. neanderthalensis,* archaic *H. sapiens, H. erectus, H. habilis, Paranthropus robustus, P. boisei, A. afarensis, A. africanus.*



(a) Species: _____

Features: _____

_____



(b) Species: _____

Features: _____

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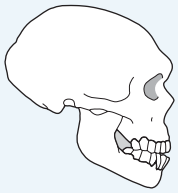

(c) Species: _____

Features: _____

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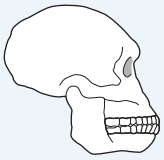

(d) Species: _____

Features: _____

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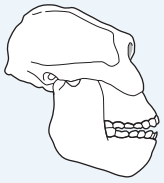

(e) Species: _____

Features: _____

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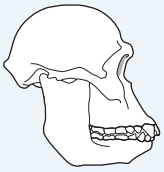
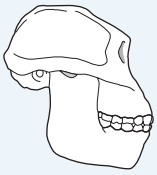


(f) Species: _____

Features: _____

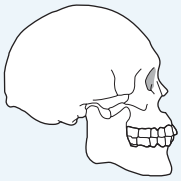
_____



(g) Species: _____

Features: _____

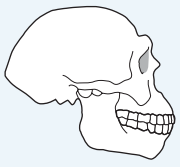
_____



(h) Species: _____

Features: _____

_____



(i) Species: _____

Features: _____

_____

Related activities: *Distinguishing Features of Hominins, Hominin Data Sheets*

ISBN: 978-1-877462-99-3

The Origin of Modern Humans

There is great debate over the origins of anatomically modern humans, i.e. the first emergence of *Homo sapiens*. The two main contesting theories are the **multiregional hypothesis** and the **replacement hypothesis**. A third model, the assimilation model (not shown) is a compromise between the two. The moderns lack some of the features characteristic of earlier, archaic forms, such as the protruding snout and heavy brow ridges. The modern skulls have an essentially flat face, are globular (rather than elongated), and have a more nearly vertical forehead. The face is narrower and smaller, and the jaw has a protruding chin. The rest of the skeleton is less robust.

Multiregional Hypothesis

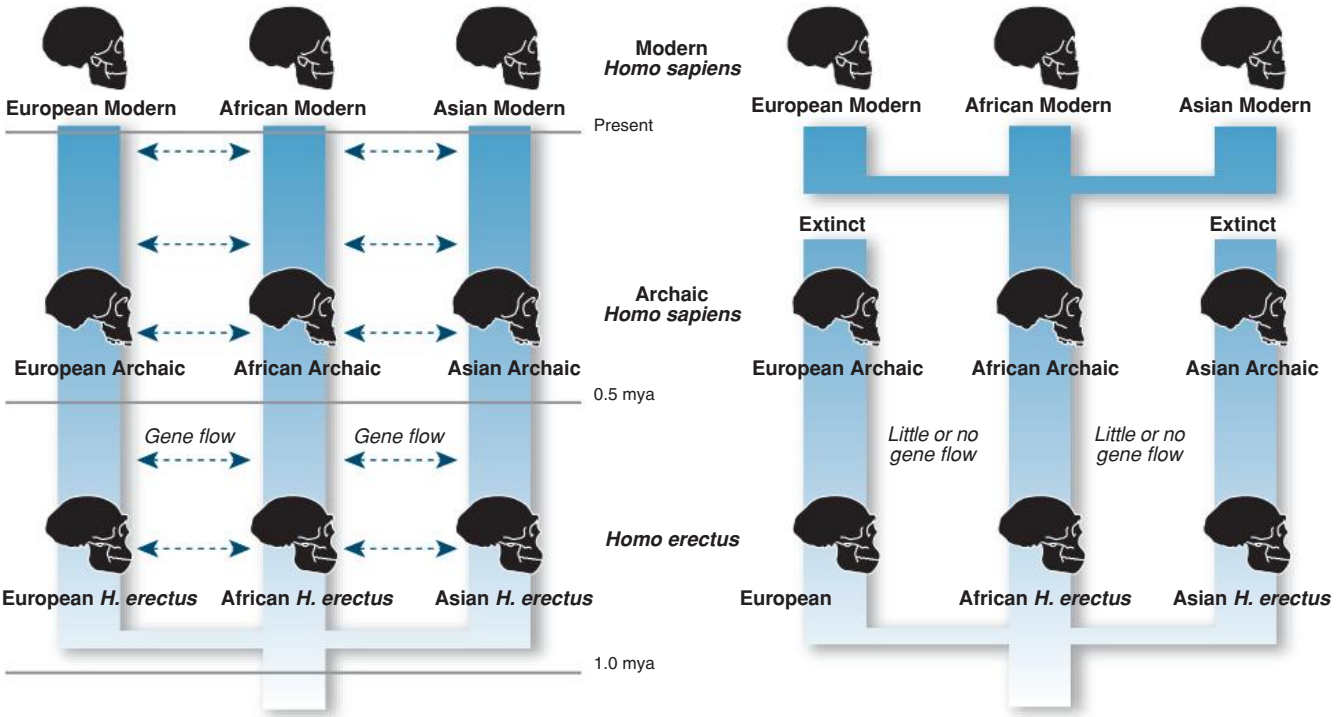
Advocates: Milford Wolpoff, University of Michigan
Alan Thorne, Australian National University

'Multiregional evolution' traces all modern populations back at least 1 million years to when early humans (*Homo erectus*) first left Africa. The hypothesis is based largely on the fossil evidence and the anatomical characteristics of modern populations. It states that modern *Homo sapiens* emerged gradually throughout the world, with populations remaining in genetic contact as they dispersed. This gene flow between neighboring populations ensured that the general 'modern human blueprint' was adopted by all. This limited gene flow still allowed for slight anatomical differences to be retained or develop in the regional populations. Wolpoff and Thorne who are advocates of this theory maintain that the mitochondrial DNA data can be interpreted in a way that supports the multi-regional model.

Replacement Hypothesis

Advocates: Christopher Stringer, Natural History Museum in London
The late Allan C. Wilson

Also known as the *Out of Africa Hypothesis* and *Eve Hypothesis*. This model keeps *Homo sapiens* as a separate species and states that modern humans evolved from archaics in only one location, Africa, and then spread, replacing the archaic populations when they came in contact. The extinction of regional archaic populations occurred because the modern humans were better adapted. In support of this theory, the late Allan Wilson and colleagues carried out genetic studies on modern endemic human populations. They concluded that the evolutionary record of mitochondrial DNA could be traced back to a single female who lived in Africa some 200,000 years ago. This woman, real or hypothetical, has been dubbed 'Eve'. By implication, this theory maintains that all modern descendants contain mtDNA that can be traced directly back to Eve.



Predictions made by this model

1. Fossils that show the change from one stage to the next in all geographic regions (transitional forms).
2. Modern traits should appear in the fossil record somewhat simultaneously all over the Old World range of Archaic *Homo sapiens*.
3. Today's modern "racial" traits characteristic of a particular region can be traced back to ancient forms in that region.
4. The human species today should have a high degree of genetic diversity since it is an old species with distinct populations that have had a lot of time to accumulate genetic differences.
5. The amount of genetic variation within each modern human group is about the same since they have all been evolving together.

Predictions made by this model

1. Transitional forms would be found in only one place (in this case Africa) which is the area of origin for modern humans.
2. Modern traits should appear first in one location (Africa) and then later elsewhere as the modern population spread to other parts of the Old World.
3. Modern and archaic populations should overlap in time outside the area that moderns originated (the process of replacement would not be instantaneous).
4. Humans today should have relatively little genetic diversity since the species is young.
5. Today's modern populations should differ in the amount of genetic variation, the most diversity being found in the region where moderns first evolved (this would have been the oldest group and therefore the one that had the most time for genetic variation to accumulate).

Source: Michael A. Park, Biological Anthropology, Mayfield Publishing, 1996

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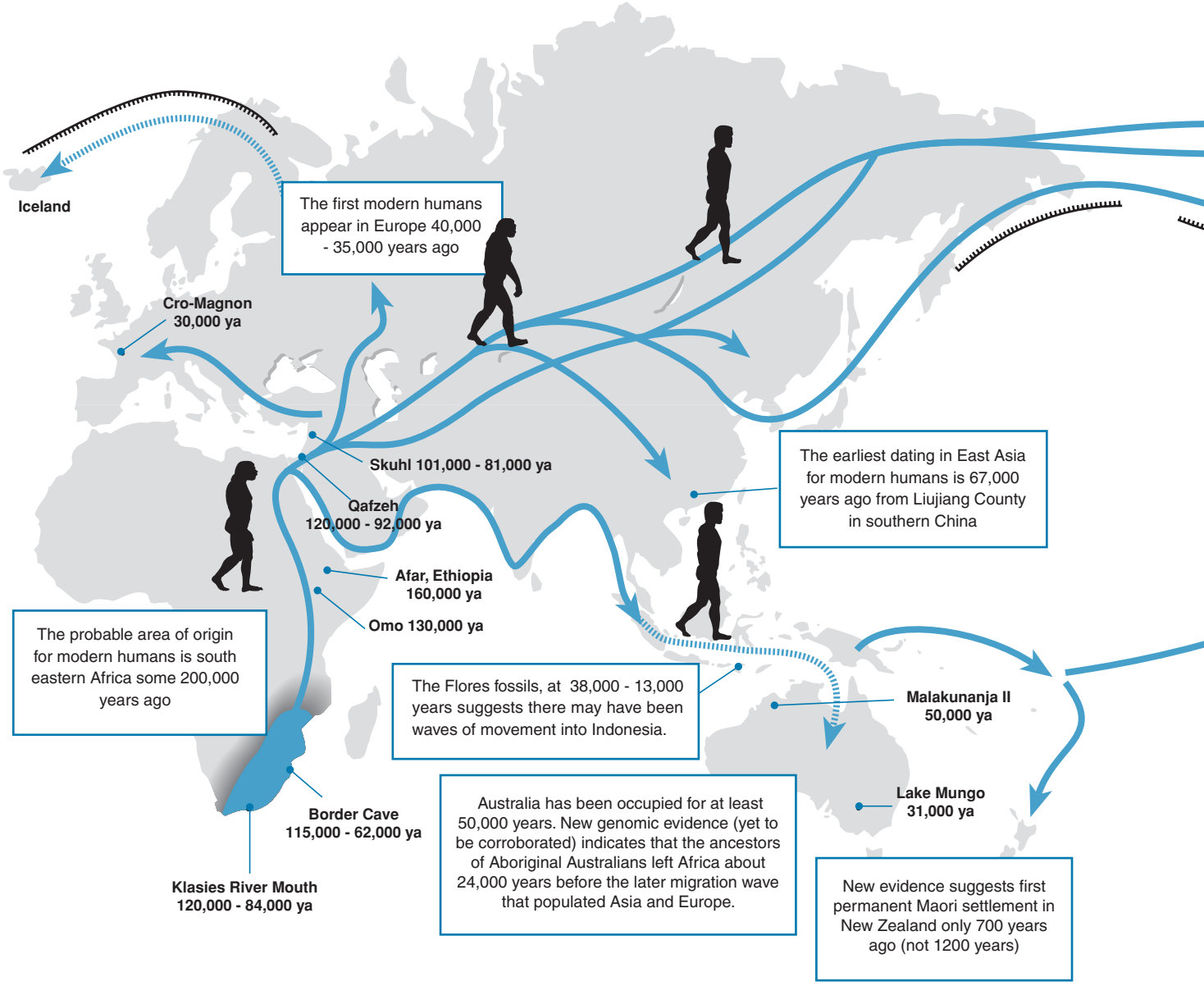
Periodicals: *New look at human evolution*

Weblinks: *Human Migration Hypotheses*

The map below shows a suggested probable origin and dispersal of modern humans throughout the world. An African origin is almost certain, with south eastern Africa being the most likely region. The dispersal was affected at crucial stages by the presence or absence of 'land bridges' formed during the drop in sea level that occurs with the onset of ice ages. Recent evidence suggests that island-hopping and coastal migration may also have been important, e.g. for the movement of people into Indonesia. The late development of boating and rafting technology slowed dispersal into Australia and the Pacific. New Zealand was one of the last places on Earth to be populated. (On the map, **ya** = years ago.)



1. State at what date the two models suggest that anatomically modern humans shared a common ancestry:

   (a) Replacement model: _____ years ago (b) Multiregional model: _____ years ago

2. In 1992, paleoanthropologists recovered the remains of two *Homo erectus* skulls in China, which have modern faces but a cranium typical of *Homo erectus*. Identify which of the two models this evidence supports and explain your choice:

   _____

   _____

3. Mitochondrial DNA was used to compare the genetic relatedness of modern human endemic populations (i.e. native populations from around the world). Explain why it was used instead of DNA from the nucleus:

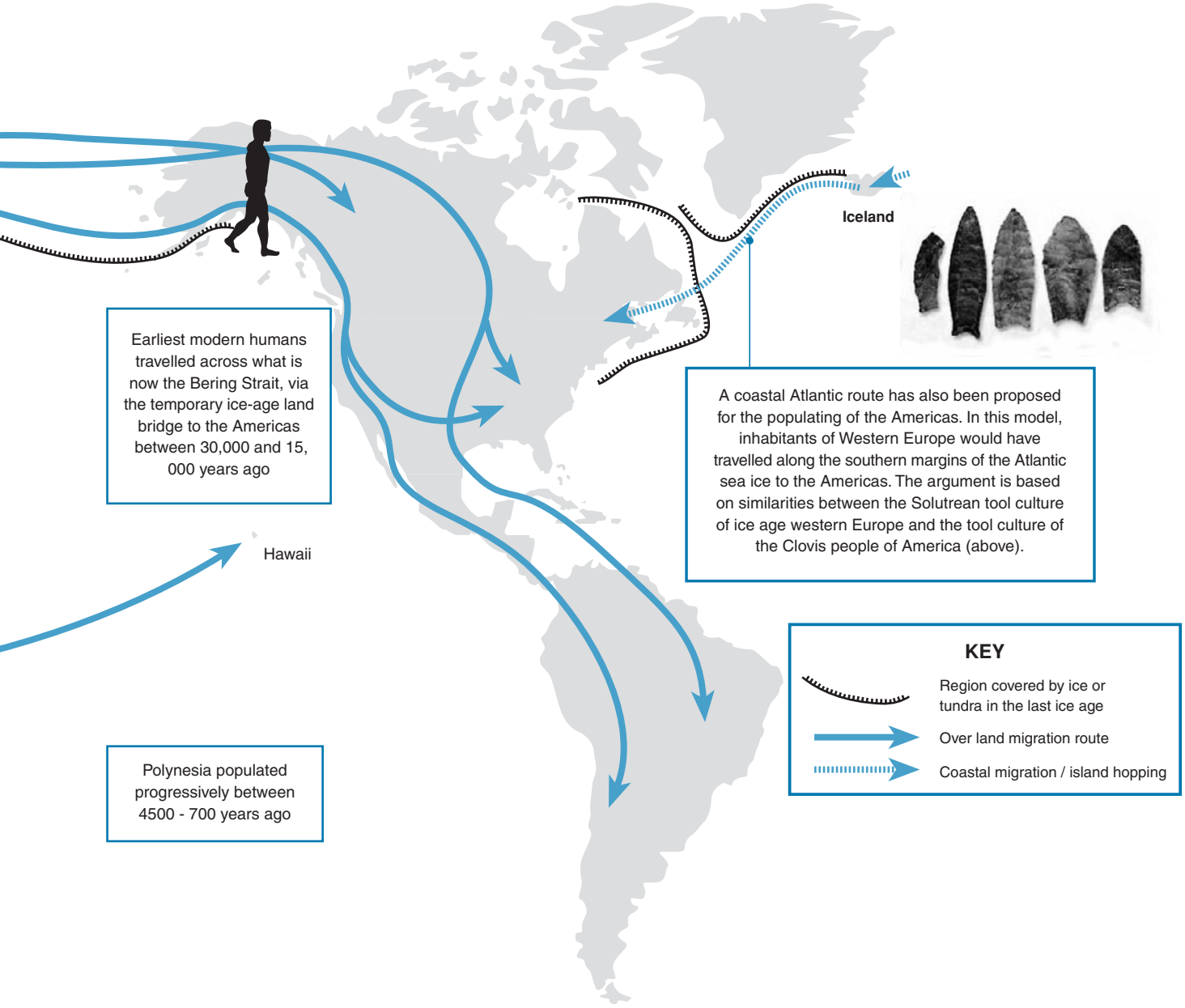
   _____

   _____

4. What is the significance of the **gene flow** between early populations of humans in the multiregional model?

   _____

ISBN: 978-1-877462-99-3



5. In the out of Africa model, modern humans move out of Africa to populate the rest of the world.

   (a) Describe the fate of the other human populations already inhabiting these regions, according to this theory:

   _____

   _____

   (b) Identify one example of such a population: _____

   _____

6. Discuss the implications of an early (135,000 ya) arrival of modern humans into Australia: _____

   _____

   _____

   _____

   _____

ISBN: 978-1-877462-99-3

The Importance of Ardi

In 1994, the first fossils of *Ardipithecus ramidus* were discovered in the Middle Awash region of northeastern Ethiopia. After many years of excavation, a partial skeleton was unearthed and, after many more years of intense study, the skeleton of *Ar. ramidus* is beginning to change our understanding of hominin evolution. Until recently, it had been theorized that our earliest ancestors moved about very much like the chimpanzees of today. However the evidence from the *Ar. ramidus* skeleton shows that this is not the case and that bipedalism developed in quite a different way to what was once thought. Moreover, a dextrous hand developed early and is also an ancient trait.

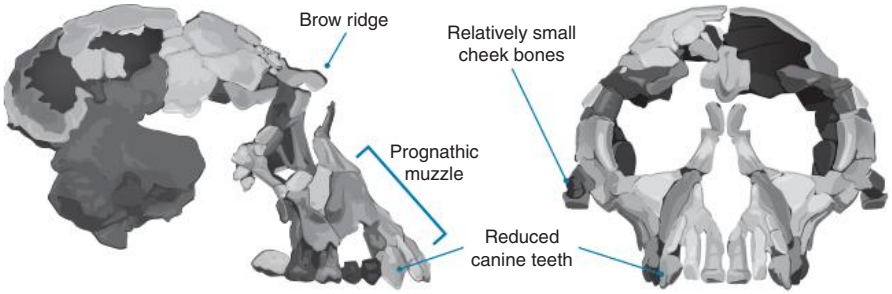
Skull: The skull of *Ar. ramidus* shares certain features with *Australopithecus*, including a reduction in the size of the canine teeth in both male and females. This implies a reduction in aggression between males. The orientation of the base of the skull on which the brain stem rests suggests that the parts of the brain involved in visual and spatial perception were already beginning to develop.

Hand: Analysis of the hand of *Ar. ramidus* shows that it is similar to our own, and that human hands are therefore close to the primitive form and not as greatly modified for tool use as was previously thought. *Ar. ramidus* had a flexible wrist and the opposable thumb was well developed. By contrast, chimpanzees move on the ground by knuckle walking, a motion that requires strengthening of the wrist and knuckle bones and lengthening of the palm, making the hand less flexible and not as dextrous.

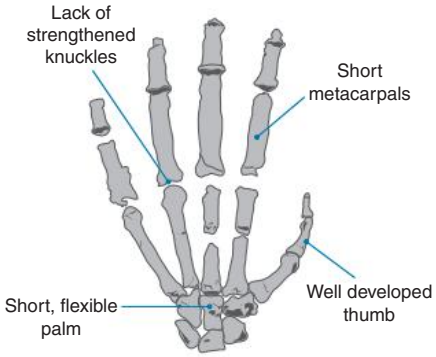
Pelvis: The pelvis of *Ar. ramidus* indicates that the modern pelvis, evolved for bipedal locomotion, began its evolution in the trees. Although several features of the upper pelvis strongly indicate bipedalism, features of the lower pelvis show that muscles associated with tree climbing were still well developed.

Foot: The foot of *Ar. ramidus* is a generalized one, with some human-like features, such as a rigid foot, as well as some modern ape-like features, such as an opposable big toe. These features indicate that *Ar. ramidus* spent considerable time climbing in trees.

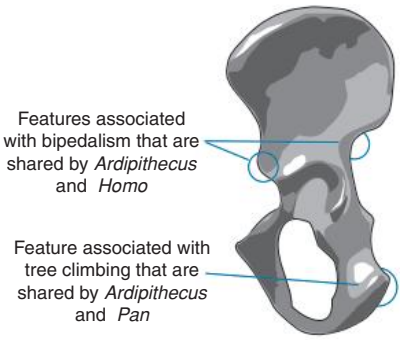
Images redrawn from C. Owen Lovejoy, et al Science, vol 326, 2009



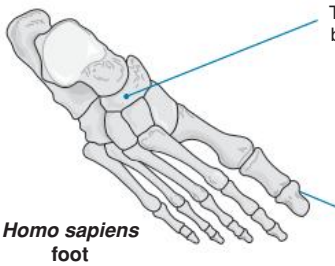
***Ardipithecus ramidus* skull features**



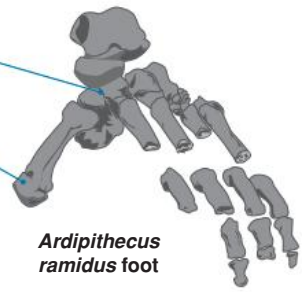
The primitive features of the ***Ardipithecus* hand** that are shared with *Homo*.



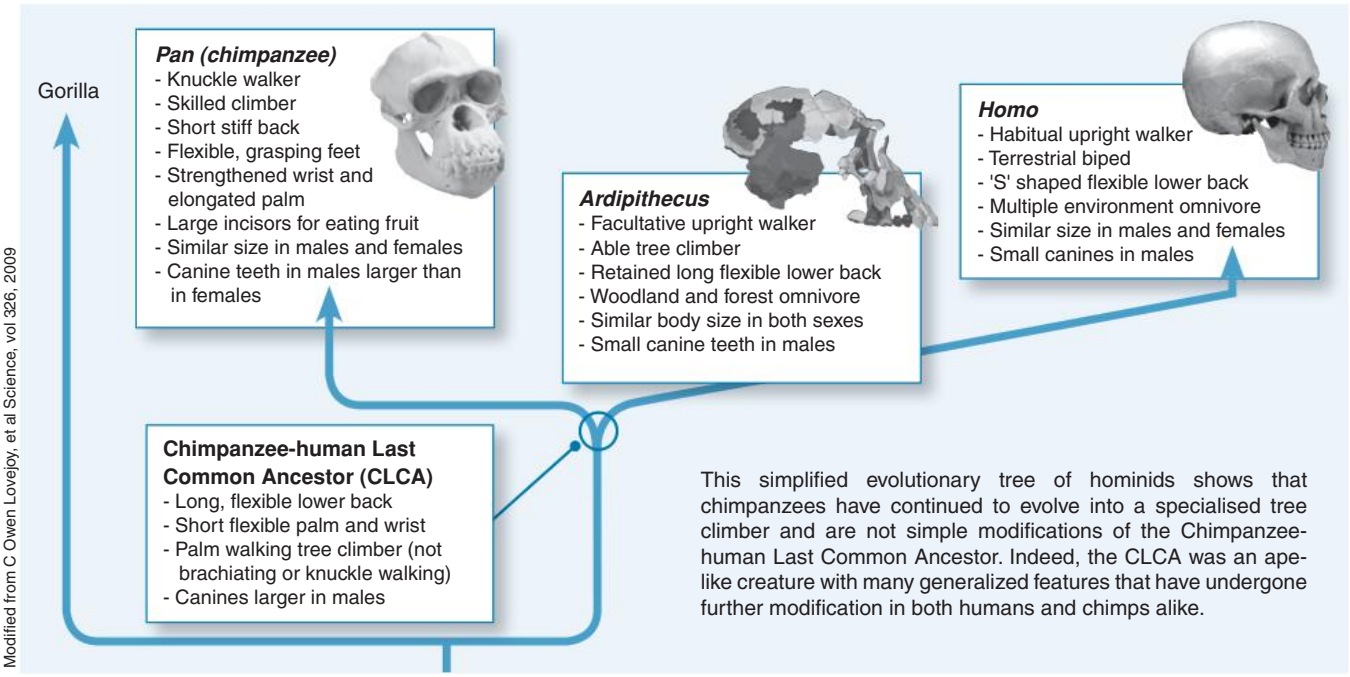
***Ardipithecus ramidus* pelvis**



***Homo sapiens* foot**



***Ardipithecus ramidus* foot**



This simplified evolutionary tree of hominids shows that chimpanzees have continued to evolve into a specialised tree climber and are not simple modifications of the Chimpanzee-human Last Common Ancestor. Indeed, the CLCA was an ape-like creature with many generalized features that have undergone further modification in both humans and chimps alike.

Modified from C Owen Lovejoy, et al Science, vol 326, 2009

Related activities: *Distinguishing Features of Hominins*
Weblinks: *World's Oldest Human-Linked Skeleton Found*

Periodicals:
Ardipithecus ramidus

ISBN: 978-1-877462-99-3

Photo: Tony Northrup

Female chimpanzees advertise signs of being reproductively available with swollen genitalia. In human females, fertility is not advertised. Instead, signs of ovulation are hidden, a phenomenon called **ovulatory crypsis**.

In primates, **canine teeth** are commonly used to display dominance. In hominins, a reduction in aggression between males led progressively to the size of the canine teeth being reduced.

The model above shows the possible selection pressures that led to the reduction in aggression between males, and the development of the male-male and male-female cooperation that is characteristic of the genus *Homo*.

Modified from C. Owen Lovejoy, *et al.* Science, vol 326, 2009

It is now appears that instead of bipedalism developing in response to diminishing woodland habitat, many aspects of it developed in a wooded environment and were subsequently modified. The reduction in the size of the canine teeth in males suggests less aggressive competition between males for females and more cooperation, possibly in food gathering. Grasping hands for holding branches were now used for carrying food from place to place. It is now hypothesized that these features shifted human evolution in the direction of mate selection based on the ability of the male to care and provide food for the female (**provisioning**). A less aggressive and more cooperative nature would have allowed males to gather more food, while bipedal walking combined with grasping hands allowed the transport of that food back to the female and the nest site. Combined with an omnivorous diet, this may have selected for a larger, more spatially aware brain that could identify ways to gather more food and hence be valuable to the female.

1. Describe the evidence for reduced aggression between *Ar. ramidus* males: _____

2. Explain why the human hand might now be viewed as the primitive type: _____

3. Discuss the evidence for bipedalism developing in a primarily arboreal (tree-dwelling) ancestor rather than in a knuckle walking, terrestrial ancestor:

4. Discuss how the interactions of bipedality, reduction in canine size, and ovulatory crypsis may have led to the rise of *Homo*:

ISBN: 978-1-877462-99-3

Bipedalism and Nakedness

The first major step in the development of humans as a distinct group from apes was their ability to adopt the habitually upright stance we call **bipedalism**. Closely linked to this shift in the mode of locomotion was the reduction in body hair (we are the only 'naked ape'). A number of selection pressures for hair reduction are described in the left column below. Early studies suggested that bipedalism and hair reduction were both evolutionary responses to the changing climate of East Africa about 7-3 million years ago. However, recent (2009) analysis of the 4.4 million year old *Ardipithecus* fossils indicates that these very early hominins were still primarily forest dwellers, so any current hypotheses must account for the emergence of bipedalism in a forested environment. The *Ardipithecus* finds indicate that bipedalism was strongly associated with provisioning, and was later reinforced by a move into less forested habitats as savannah became established throughout Africa during the later Miocene.

Hair Reduction

Retention of head hair
Hair on the head (and to a lesser extent the shoulders) has been retained to reflect and radiate heat before it reaches the skin of the exposed part of the body.

Parasite control
A reduction in body hair would have made the control of parasites such as fleas, ticks and lice much easier. This became particularly important when early hominins began to use a 'home base' rather than continually wandering. Parasites, such as fleas, need to complete their life cycle at a single location so that hatching eggs can reinfect their host.

Lice Ticks Fleas

Thermoregulation
About 3 mya, the vegetation patterns in East Africa began to favor open grasslands, with fewer forested areas. This environment would have provided fewer opportunities for shelter from the hot sun, creating a selection pressure for the refinement of several thermoregulatory mechanisms. Shorter, finer hairs (not hair loss) in early hominins would have allowed greater heat loss via radiation from the skin surface. Well developed sweat glands in humans enable heat loss at an astounding 700 watts m^2 of skin (a capacity not approached by any other mammal).

Bipedalism

Seeing over the grass
An upright posture may have helped early hominins to see predators or locate carcasses at a distance.

Carrying offspring
Walking upright enabled early hominins to carry their offspring, facilitating movement as a family group.

Provisioning
The ability to carry food while walking appears to have been a major selective pressure in the initial development of bipedlism. Potential mates would have favoured males with the ability to provide energy-rich foods. The capacity to carry food away from a kill site or growing site to a position of safety would have had great survival advantage.

Efficient locomotion
Once bipedalism was established, changing habitats would have reinforced its further development. Bipedal motion provided an efficient means of moving across the growing expanses of savannah.

Holding tools and weapons
Tool use was probably a consequence of bipedalism, rather than a cause. Upright walking appears to have been established well before the development of hunting in early hominids.

Thermoregulation
Upright walking exposes 60% less surface area to the sun at midday and there is greater air flow across the body when it is lifted higher off the ground.

1. Discuss the selection pressures that are likely to have been important in the initial development of bipedalism, given that the current evidence indicates it arose in a forested environment:

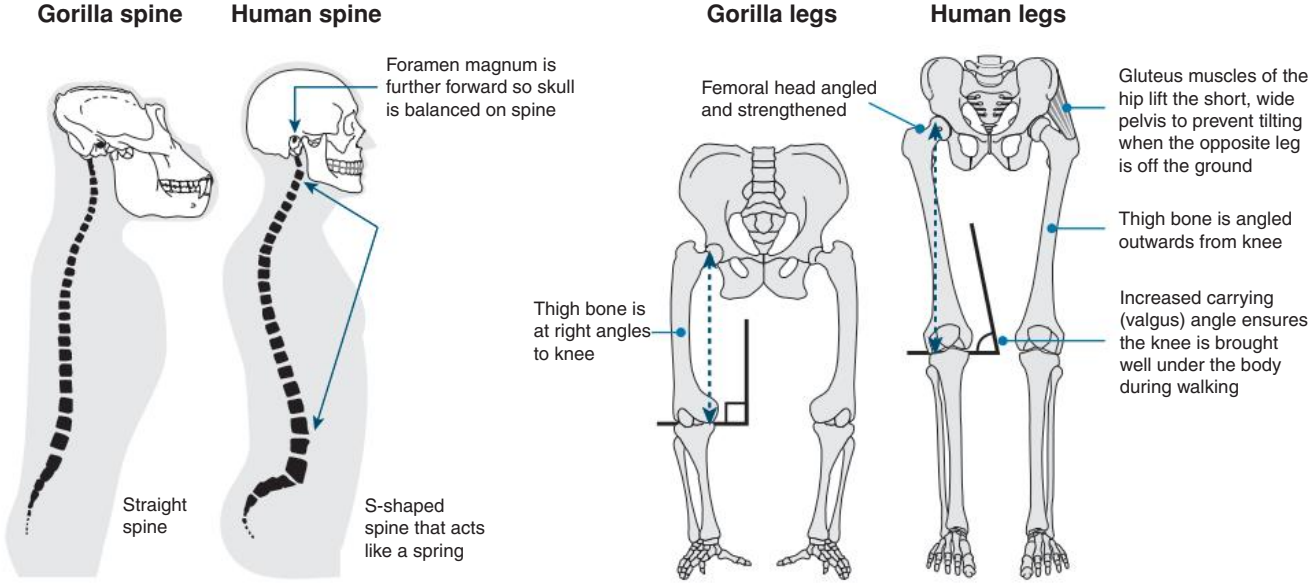
***Related activities**: The Importance of Ardi*
***Weblinks**: World's Oldest Human-Linked Skeleton Found*

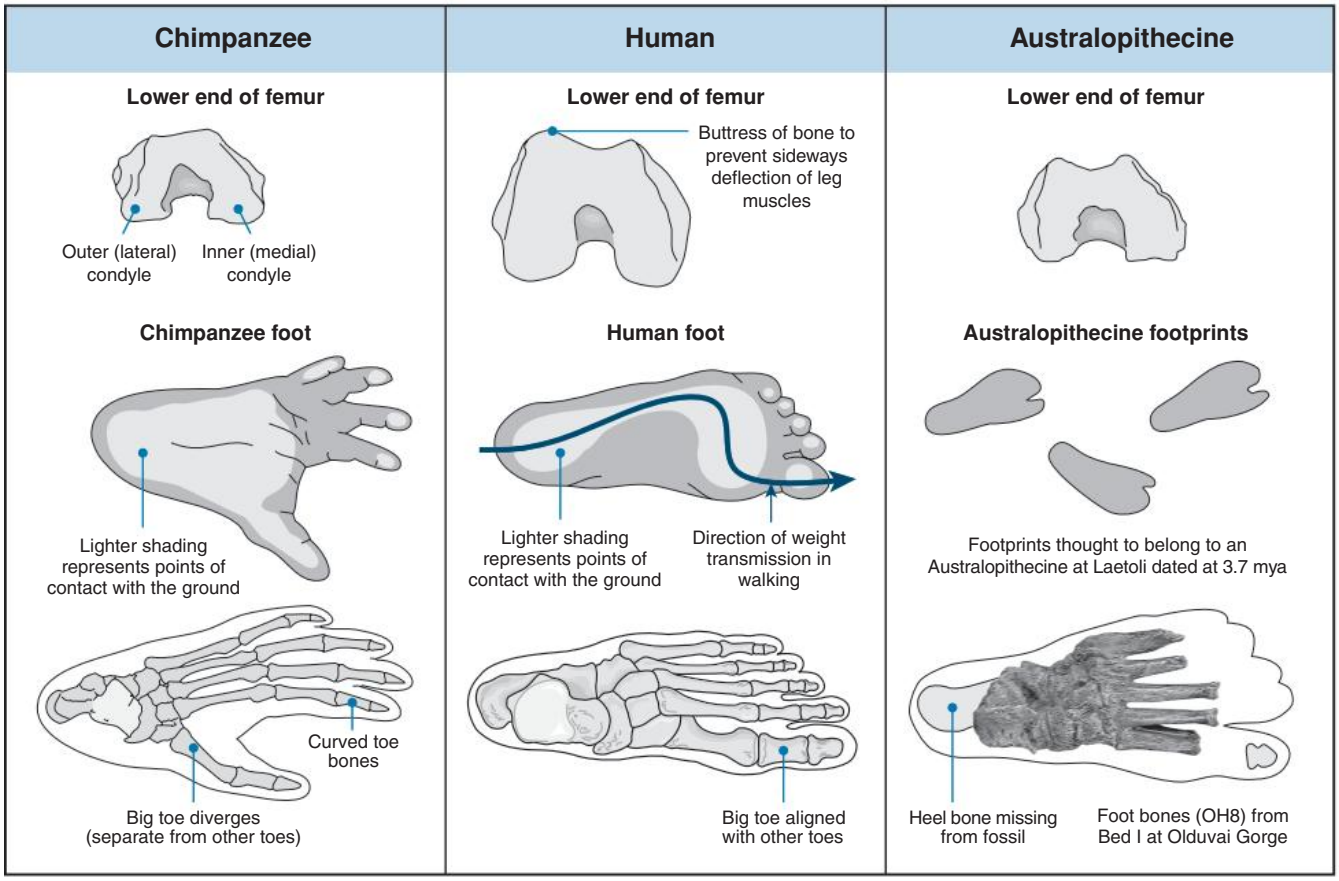
Periodicals:
Birth of bipedalism

ISBN: 978-1-877462-99-3

Adaptations for Bipedalism

Important modifications in the skeleton are associated with the move to bipedal locomotion in early hominins. The skeleton on the following page is an example of an early bipedal hominin. It is a reconstruction of '**Lucy**' (*Australopithecus afarensis*) dated at about 3 million years ago. While Lucy still possessed some ape-like characteristics, such as curved toes, she was a fully-bipedal hominin with all the modern adaptations associated with modern human walking. Lucy was a small individual, only 1.1 metres tall, about the height of a 5-6 year old child. Although there is no doubt that Lucy was habitually bipedal, a number of skeletal features suggest that tree climbing was still an important part of this hominin's niche. Such activities may have been associated with escape from predators, obtaining a secure sleeping place, and foraging for foods found in trees. The features that point to a link with **arboreal** (tree-dwelling) locomotion are indicated on the left of the diagram. *A. afarensis* forms an important link between the quadrupedal locomotion of apes and bipedalism in hominins.





1. Referring to the diagram above, describe whether each of the **australopithecine fossils** compare more closely to the *chimpanzee* or *human* examples (i.e. to which do they bear the closest resemblance):

   (a) Lower end of femur: _____

   (b) Footprints: _____

   (c) Foot skeleton: _____

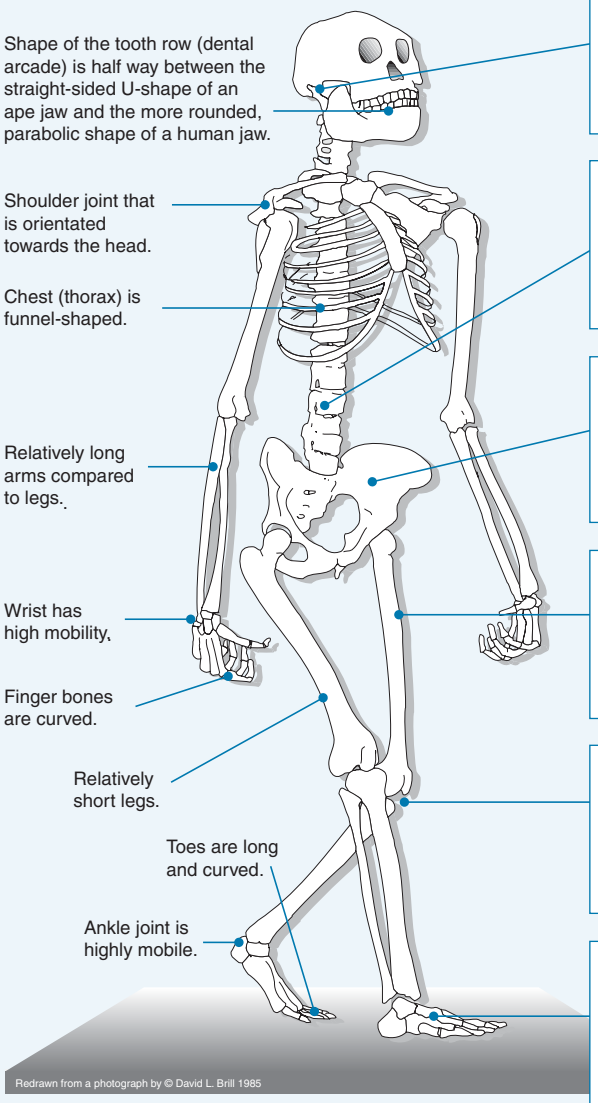
ISBN: 978-1-877462-99-3

Periodicals: *New look at human evolution*

Related activities: *Bipedalism and Nakedness*

Weblinks: *Compare the Skeletons, Lucy's Legacy*

Lucy's* ape-like characteristics



*Lucy is the name given to a specimen of ***Australopithecus afarensis***

(a) Position of foramen magnum (where the spine enters the skull):

(b) Spine shape:

(c) Pelvis shape and gluteus muscles:

(d) Femur shape and length:

(e) Knee joint:

(f) Shape of foot and arrangement of toe bones:

2. In the boxes, (a) to (f) above, describe the modifications required for habitual bipedal locomotion (walking).

3. Describe six possible selection pressures that may have encouraged the development of bipedalism in early hominids:

   (a) _____ (d) _____

   (b) _____ (e) _____

   (c) _____ (f) _____

4. Imagine you are on an expedition to a well known hominin fossil site in east Africa. Describe a part of a hominin fossil skeleton that you would wish to find that would be ideal in clearly indicating **bipedalism**:

   _____

5. Describe two selection pressures that may have encouraged the retention of tree-climbing ability in *A. afarensis*:

   (a) _____

   (b) _____

6. Discuss the significance of the **valgus** (carrying) **angle** in hominin bipedal locomotion: _____

   _____

   _____

   _____

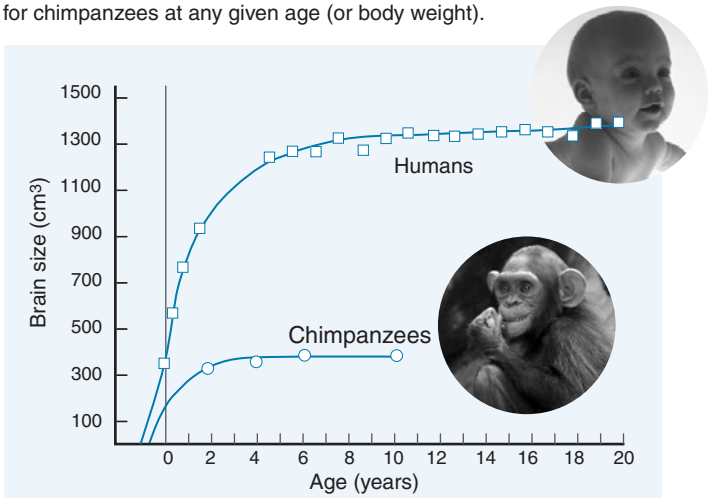
ISBN: 978-1-877462-99-3

The Development of Intelligence

The human brain is an extraordinary organ and is responsible for our unique human behavioral qualities. Although it makes up just 2% of our body weight, it demands about 20% of the body's metabolic energy at rest. This makes the brain an expensive organ to maintain. The selection pressures for increased brain size must have been considerable for additional energy to be made available. The normal human adult brain averages around 1330 cc, but ranges in size between 1000 and 2000 cc. The modern brain contains as many as 10,000 million nerve cells, each of which has thousands of synaptic connections with other nerve cells. But intelligence is not just a function of **brain size**. There are large mammals, such as elephants and whales, with brain volumes greater than ourselves and yet they are not considered to be as intelligent. It appears that what is more important is the **relative brain size** (brain size relative to body size). Modern humans have a brain volume three times larger than that predicted for an average monkey or ape with our body size. Another important factor is the way in which the brain is organized. Apart from the highly developed cerebrum, two areas of the brain associated with communication have also become highly developed in modern humans: **Broca's area**, concerned with speech, and **Wernicke's area**, concerned with comprehension of language.

Growth in Brain size in Humans and Chimpanzees

In most primates, including chimpanzees, brain growth, relative to body size, slows markedly after birth while body growth continues. In human infants, the slowing of brain growth does not occur until more than a year after birth, which results in larger brain masses for humans than for chimpanzees at any given age (or body weight).



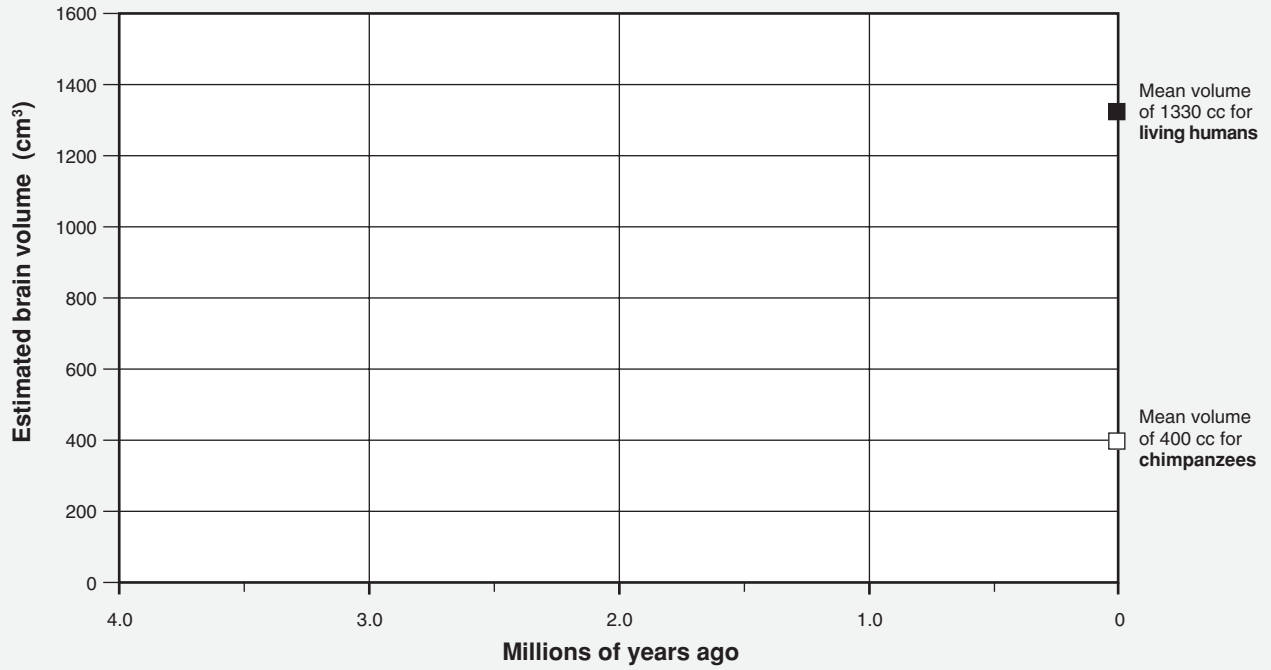
Brain Volume for Hominin Species

This table provides a generalized summary of the changes in estimated brain volume recorded from the fossil remains of hominins. The dates for each species are generally the middle of their time range for long-lived species or at the beginning of their time range for short-lived species.

Hominin species	Years ago (mya)	Average brain Volume (cm³)
Australopithecus afarensis	3.5	440
Australopithecus africanus	2.5	450
Paranthropus robustus	2.0	520
Paranthropus boisei	1.5	515
Homo rudolfensis	2.0	700
Homo habilis	1.8	575
Homo ergaster	1.8	800
Homo erectus	0.5	1100
Homo heidelbergensis	0.2	1250
Homo neanderthalensis	0.05	1550
Homo floresiensis	0.095*	380
Early *Homo sapiens*	0.08	1450

* *H. floresiensis* may have lived as recently as 13 000 ya

Changes in hominin brain volume over time



1. Plot the data in the table on the estimated *Brain Volume for Hominin Species* (above) onto the graph provided.

2. There were two 'bursts' (sudden increases) of brain expansion during human evolution. **Indicate on the graph** you have plotted where you think these two events occurred.

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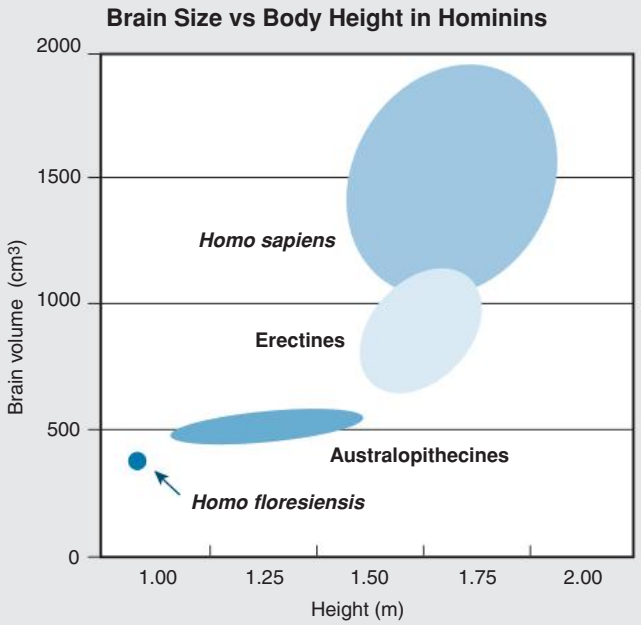
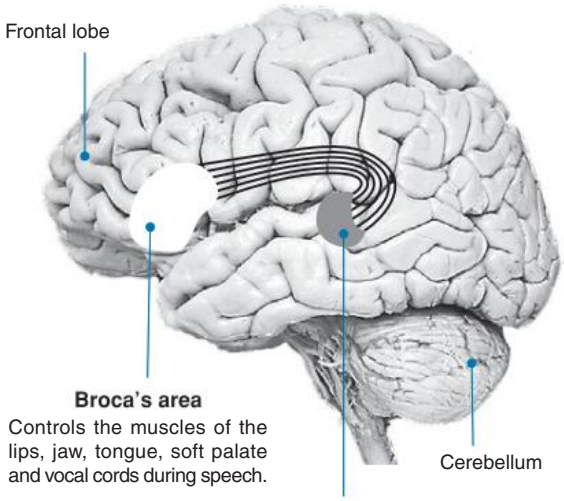
Periodicals: *New look at human evolution*

Related activities: *Social Development, Cultural Evolution*



Brain size can be correlated with body height in hominins. Three distinct clusters emerge, indicating three phases of evolutionary development. *Homo floresiensis*, found on the Indonesian island of Flores, clearly falls outside these clusters. Its brain size to body size ratio is similar to that of the *Australopithecines*, but key aspects of its morphology, such as its small canine teeth and organization of the brain, identify it as *Homo*. In addition, the Flores finds were associated with relatively advanced stone tools.



Modern Human Brain

The human brain is very large for a primate of our size, but this may not be as important as its internal organization. The most important specialization of the human brain is the capacity for language: a result of the development of **Wernicke's** and **Broca's areas**. Specific differences associated with the left and right hemispheres of the brain are associated with these specializations.

3. Why is brain volume alone not a reliable indicator of intelligence? _____

4. Explain the significance of the high energy requirement of a relatively large brain: _____

5. Comment on the significance of the brain/body size growth curve in humans compared with other primates:

6. (a) With respect to stature and brain size, comment on the position of *Homo floresiensis* with respect to other hominins:

   (b) Comment on the significance of the Flores finds: _____

7. Describe a likely **selection pressure** for brain development in early humans: _____

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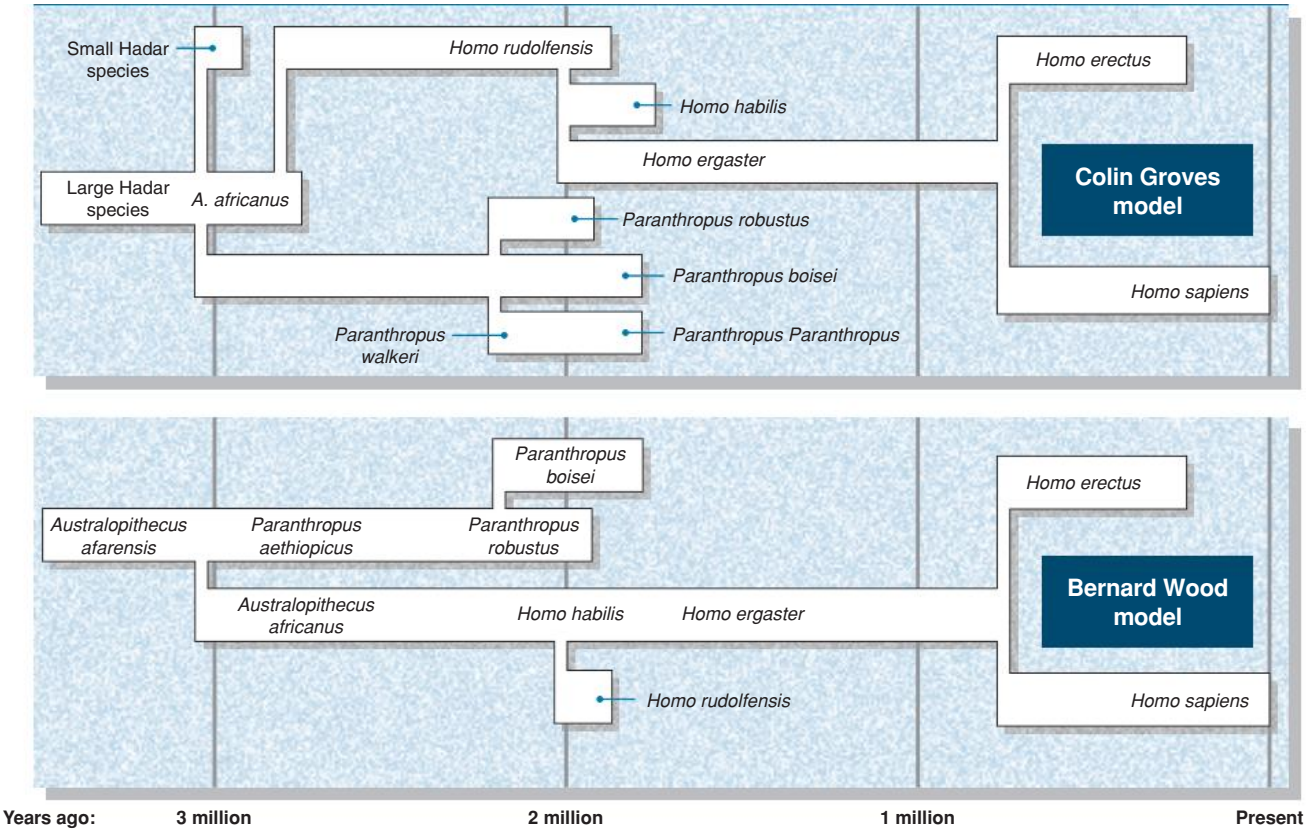
Human Evolutionary Models

Producing a family tree (**phylogeny)** of human evolution, is a very difficult and complicated task. New fossil evidence is regularly being uncovered, and the findings can sometimes significantly alter currently held views of human evolution. To complicate the situation, anthropologists often disagree on the interpretation of fossil evidence. Different researchers may propose very different evolutionary models based upon the same fossil evidence, and it can sometimes be difficult to know which is the most correct. There are many reasons why anthropologists disagree about hominin evolution. Sometimes new fossil evidence is very limited, making it difficult to conclusively assign a fossil to a new or existing species. It can also be difficult to recognize which fossils merely represent males and females of the same species. Some anthropologists place more importance on some anatomical features than others, and this can lead to further differences in opinion. The evolutionary models below represent two evolutionary models commonly debated in the 1990s. They demonstrate how differences in fossil interpretation can lead to very different scenarios.



Note: The **small** and **large Hadar species** refer to *Australopithecus afarensis*, which has been split into two species by some anthropologists.

1. Explain how anthropologists can arrive at different models for a hominin phylogeny despite analyzing the same fossil data:

2. How could DNA analysis help to consolidate the different hypotheses of human evolution into one model?

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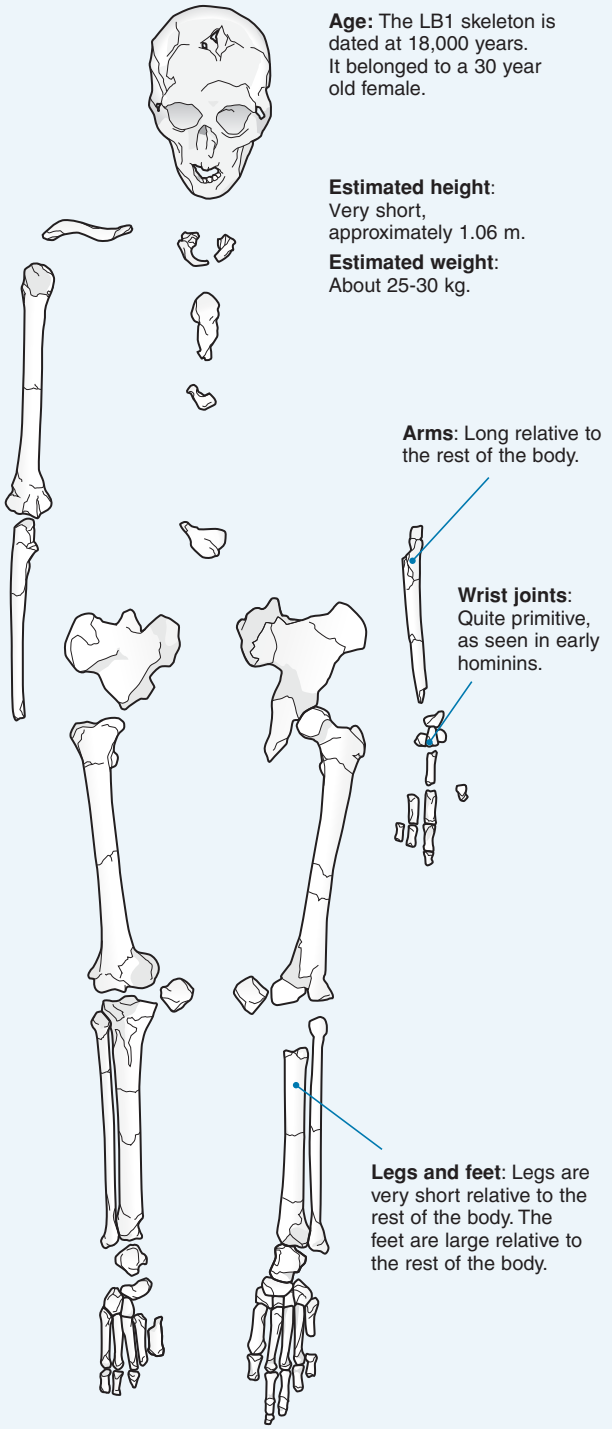
***Related activities**: A Controversy in Human Evolution, Analyzing Ancient DNA*

A Controversy in Human Evolution

In 2003, hominin fossils, including an almost complete skeleton, were discovered on the island of Flores, Indonesia. The fossils were astounding for their recent date (18,000 years) and mix of primitive and derived features. This new species, *Homo floresiensis*, was not only contemporary with moderns, it was very small in stature and fully bipedal. Although its brain was very small, its organization was advanced and stone tools associated with the skeleton indicated well established hunting technology.

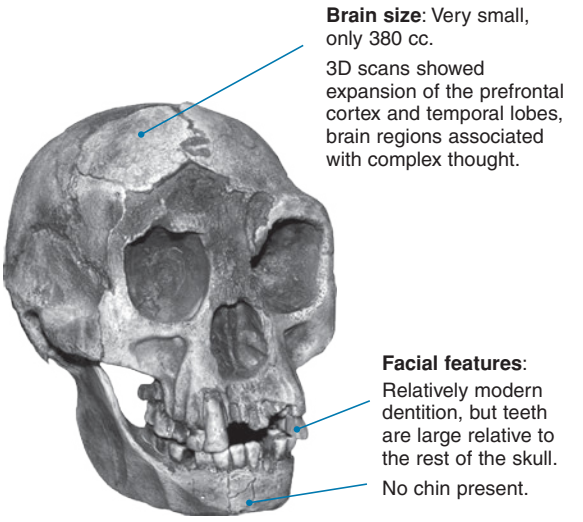
In contrast to these features, aspects of the skeleton (e.g. the wrist bones) showed primitive features found only in apes and early hominins. *H. floresiensis* probably lived between 38,000 and 13,000 years ago, but the species may date back as far as 95,000 years ago. Its discovery caused widespread controversy in the scientific community, and several opposing hypotheses were put forward to explain its place in human evolution. You will analyze the information for these hypotheses in this activity.



Artist's reconstruction of the LB1 skeleton, after William Junger, Stony Brook University

Rosino

Above: The fossils were discovered in Liang Bua, a limestone Cave on Flores Island, Indonesia. The cave contains 12 m of stratified deposits. The remains of modern humans, as well as Homo floresiensis, have been found in the cave.



Avandergeer

A cast of the *Homo floresiensis* fossil LB1 (above, left) compared a microcephalic present day skull (above, right).

***Related activities**: Models of Human Evolution*

***Weblinks**: Hobbits on Flores*

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Hypothesis	Key Features	Comments
*Homo floresiensis*is is a new species of *Homo*	The fossils are those of a new hominin species, *H. floresiensis* (*H.f*), and evolved on Flores from an unknown small-bodied and small-brained hominin which had earlier migrated from Africa. This ancestral hominin was perhaps a Dmanisi hominin.	A study of the bones and joints of the arm, shoulder, and lower limbs concluded that *Homo floresiensis*is was more similar to early humans and apes than modern humans. Small brain size coupled with more advanced brain organization indicate possible parallel evolution of sapiens-like features.
The features of *Homo floresiensis* are the result of island dwarfism	An isolated population of *H. erectus* migrated to Flores and underwent island dwarfism, a phenomenon whereby large animals become smaller in size because of limited resources.	Extinct pygmy elephants on Flores showed this adaptation.
The features of *Homo floresiensis* are the result of disease (pathology)	*H. floresiensis* is a diseased variant of *H. sapiens*. Pathologies proposed to produce the features observed in *H. floresiensis* include: Microcephaly, a neurodevelopmental disorder with various causes, which causes abnormally small brain size	Comparisons of cranial endocasts of 9 microcephalic and 10 normal human brains indicated *Homo floresiensis*is brains to be highly developed in the frontal and temporal regions and bear no resemblance to microcephalic brains. Statistical analysis of skull shapes of healthy modern humans, microcephalic humans, and several ancient human species, as well as *Homo floresiensis*is showed that the three grouped separately, with *Homo floresiensis*is among the ancient humans, providing evidence for it being a separate species.
	Congenital hypothyroidism, which can be caused by factors, including iodine deficiency, which is an endemic public health problem in parts of Indonesia.	Congenital hypothyroidism is endemic in parts of Indonesia but a comparison of the Flores bones with the bones of people affected with hypothyroidism showed no overlap in features. The carpals belonging to LB1 resembled ape carpals and were comparable to carpal bones of *Australopithecus*. It is improbable the shape could be the result of disease.

1. After reviewing the information provided about the *Homo floresiensisis* fossils, choose **one** hypothesis from the table above which you think provides the mostly likely explanation for the physical appearance of *Homo floresiensisis*. Explain why you have chosen your hypothesis, and justify your position using examples.

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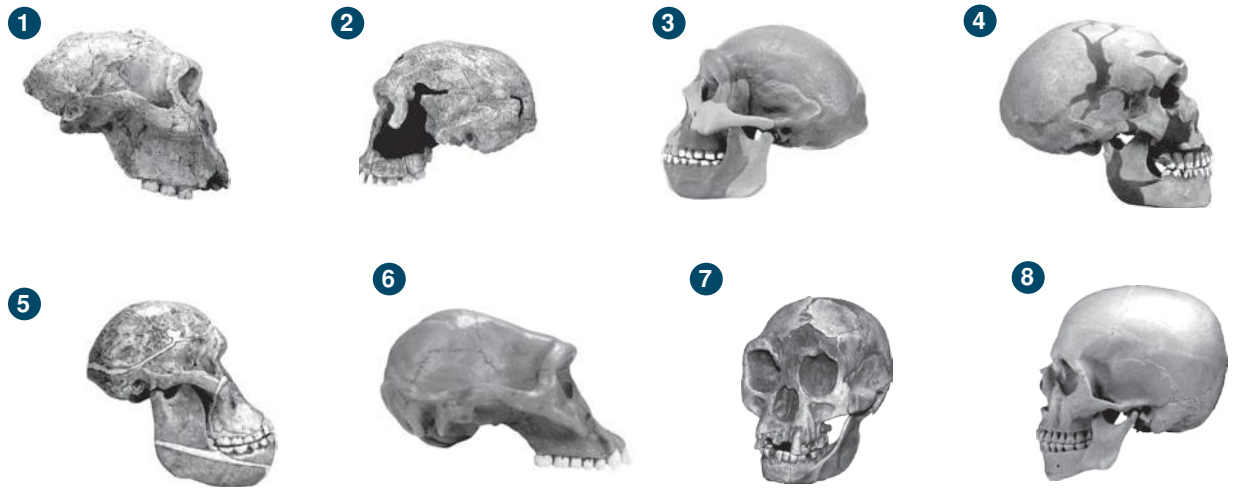
Comprehension and Vocabulary

1. Draw lines to match up the hominid name with its meaning, then match the name to the correct skull number (1-8 below).

Name:	Meaning:	Skull number:
Australopithecus afarensis	Man from the Neander Valley.	_____
Australopithecus africanus	Beside man	_____
Paranthropus	Handy man	_____
Homo neanderthalensis	Southern Ape from Afar, Ethiopia	_____
Homo sapiens	Southern Ape from Africa	_____
Homo habilis	Man from the island of Flores or Flores man	_____
Homo erectus	Upright man	_____
Homo floresiensis	Knowing, or wise man	_____



2. Draw lines to link the statements in the three columns below to form complete sentences and so form a coherent paragraph. The first column is in order, the centre and right columns are not. The centre column provides appropriate joining words to link the first and second parts of the sentence.

The evolutionary trend in the physical features of hominins has been towards a more upright, bipedal stance, larger brain case...	have	... low, sloping foreheads.
The early hominins had prognathic faces...	and	... resulted in bipedalism being habitual in *H. sapiens*.
Fossils such as *Australopithecus afarensis* show the teeth and jaw shape were ape-like...	with	... large canines and parallel or V-shaped dental arcades.
Homo sapiens instead have a parabolic dental arcade...	and	... the forehead became increasingly high.
Prognathism diminished in genus *Homo*...	as	... small canines and molars.
The volume of the brain case also increased, the brain case of *H. hablis* being around 500 cc...	while	... higher forehead, flatter face, and smaller teeth and jaws.
Bipedalism originated early on in hominin evolution...	and	... modern *H. sapiens* have a braincase volume of around 1400 cc.
Adaptations to the spine, pelvis, legs, knees and feet...	with	... shown by such fossils as *Ardipithecus ramidus*.

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3. Test your vocabulary for this chapter by matching each term to its correct definition.

anthropoid	**A** Area of the brain that allows the processing and comprehension of speech patterns.
arboreal	**B** An older taxonomic term, still often used. It includes the tarsiers and all the simian (higher) primates.
Ardipithecus	**C** Modern humans. Appeared around 160,000 years ago. Features include a large domed skull and upright forehead.
Australopithecus	**D** Hominin that lived some 2 million years ago. The first humans to use stone tools (Oldowan) and show possible development of the Broca's area.
Au. afarensis	**E** Genus of robustly built, vegetarian hominins, also know as robust australopithecines.
Au.africanus	**F** The outward projection of the face; in human evolution it usually refers to the degree to which the mid-face and upper jaw projects forward of the brain case
bipedalism	**G** Genus of gracile, small-brained hominins from east Africa. Became extinct about 2 mya.
Broca's area	**H** Hominin that lived between 1 and 0.3 million years ago in Asia. One of the first human species to have left Africa.
Homo	**I** Hypothesis that modern humans evolved from several different groups of *Homo erectus* in several regions of the world, with gene flow occurring between regional groups.
H. erectus	**J** Hypothesis that states that humans moved out of Africa and displaced other *Homo* species living in the rest of the world. Also called *Out of Africa*.
H. habilis	**K** Hominin that lived around 2 million years ago in eastern Africa. Known for its robust skeleton and skull that had large teeth and cheek bones.
H. neanderthalensis	**L** Members of the superfamily of primates, which includes the gibbons, orangutans, gorillas, chimpanzees and humans.
H. sapiens	**M** Tree-living, adapted for living in trees.
hominid	**N** The habit and action of walking upright on two feet.
hominins	**O** Hominin that lived around 2 million years ago in southern Africa. Like *P. boisei* it had a robust skeleton and large teeth and cheek bones.
hominoids	**P** Genus of large brained hominin characterized by tool manufacture and culture.
multiregional hypothesis	**Q** *Homo* species that may have split from the lineage leading to *H. sapiens* around 600,000 years ago. Skeleton was more robust than modern humans and the skull was slightly larger.
Paranthropus	**R** Area of the brain that allows for the production of speech sounds by controlling the jaw, tongue, lips, and vocal cords.
P. boisei	**S** Hominin that lived between 3 and 2 million years ago in southern Africa. Slightly larger than *Au. afarensis* and possessed larger molars and smaller canines.
P. robustus	**T** Very early hominin genus. Very important for recent hypothesis on the development of bipedalism as an adaptation to provisioning.
prognathism	**U** Members of the tribe of Homininae comprising humans and chimpanzees, and their ancestors.
replacement hypothesis	**V** A taxonomic family of primates, which incudes the humans and great apes.
valgus angle	**W** The carrying angle of the femur to the knee, which in humans and their ancestors brings the knee under the centre of gravity.
Wernicke's area	**X** Hominin that lived between 3.9 and 3 million years ago in Eastern Africa. Possessed many human like features such as the pelvis and leg and foot bones.

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Cultural **Evolution**

Key terms

Acheulian (tool)
Art (development of)
Bronze Age
cave painting
Copper Age (= Chalcolithic)
cultural evolution
Mesolithic (Middle Stone Age)
Mousterian (tool)
Neoolithic (New Stone Age)
Oldowan (tool)
Paleolithic (Old Stone Age)
selection pressure
spirituality
Upper Paleolithic (tool)

Key concepts

- Cultural evolution describes the development of a culture into progressively more complex forms.
- Early cultural evolution was associated with specific Paleolithic tool cultures.
- Modern humans face new selection pressures that arise from our modern culture and technology.

Objectives

☐ 1. Use the **KEY TERMS** to help you understand and complete these objectives.

Cultural Evolution

pages 71-84, 87-88

☐ 2. Define **cultural evolution** and describe its relative importance in human evolution.

☐ 3. Identify and discuss general trends in hominin cultural development, including tool use, spiritual practices, and the development of abstract thought.

☐ 4. Describe the features of the various Paleolithic (or Old Stone Age) tool cultures, including the hominin species associated with each. Identify the advancements in tool technology made at each stage:

(a) **Oldowan** (pebble) tool culture
(b) **Acheulian** tool culture
(c) **Mousterian** tool culture
(d) **Upper Paleolithic** tool culture

☐ 5. Describe the development of the successive cultures listed below. Identify the advancements in tool technology made at each stage and the particular features characteristic of each.

(a) **Mesolithic** (or Middle Stone Age)
(b) **Neolithic** (or New Stone Age)
(c) **Copper** or **Chalcolithic** (Copper-Stone) Age
(d) **Bronze Age** culture

☐ 6. Discuss how the evolution of more complex behaviors (the use of tools, fire, clothing, beliefs, and spirituality) were aided by a growing capacity for learning and communication. Provide examples of the evidence for increasingly sophisticated cultural development towards the end of the Upper Paleolithic period.

Future Evolution of Humans

pages 85-86

☐ 7. Discuss the likely **selection pressures** currently acting on the human gene pool. Discuss likely future trends in human biological and cultural evolution, giving reasons for your ideas.

☐ 8. Analyze the possible effects on human evolution of increased population mobility, modern medicine, and genetic engineering. Explain how the development of these behaviors has been aided by a growing capacity for learning and communication.

Periodicals:
Listings for this chapter are on page 91

Weblinks:
www.thebiozone.com/weblink/HE-2993.html

Presentation Media
Human Evolution:
Cultural Evolution

Cultural Evolution

Natural selection acting on the expression of genes brought about considerable transformations in the anatomy of early humans. In addition, it was possible for ideas and behaviors that were learned to be passed on to offspring. This non-genetic means of adaptation, called **cultural evolution**, further enhanced the success of early humans.

Resulting physical features

The physical features that evolved in response to selection pressures in a changing environment included:

Head balanced on the top of the spine, instead of being held up by large neck muscles. Large brain with a capacity for learning, planning and passing on ideas. Keen eyesight, capable of judging distances with eyes located high above the ground. Reduced dependence on other senses. Light but strong jaw, with teeth suitable for varied foods. Spine allowed upright stance without tiring, freeing hands, and giving good all round vision. Hands able to grasp and manipulate objects in a sensitive way. Legs allowed energy-efficient walking and running on two legs. Flexible ankle, but rigid and arched foot, allowed efficient locomotion on hard ground.

Environmental forces

Over many millions of years, the evolution of human ancestors has been directed by the forces of natural selection. Environmental forces such as climatic change causing alterations in habitat and food supply, as well as fierce predators, acted on the gene pool.

Climatic change

The climate became drier and the forests which were the homes of the earlier primates gradually disappeared. This not only reduced shelter but also meant that traditional food sources became scarce or disappeared. New food resources had to be found.

Fierce predators

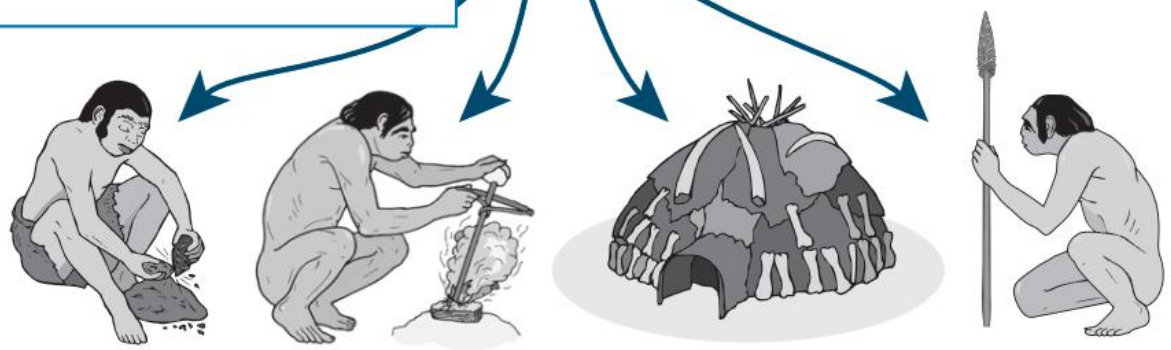
Many large, fierce predators made a ground dwelling lifestyle dangerous. Early humans would have to protect themselves from attack using smart behavioral solutions

Adopted niche

An opportunist/scavenger that was able to live reasonably successfully on the ground. Able to exploit a number of varied habitats, early humans utilized a range of food resources.

Cultural forces

The unique combination of brain and specialized physical features enabled early humans to begin to direct the course of their own evolution. They began to control their environment and to use it to alter their way of life. At first they did this in small ways, with few widespread effects on other living things. Early humans became efficient hunters living in organized groups. Their genes had been almost unchanged, but they lived more comfortably, with a better survival rate, and more time and opportunity to plan ahead.



Tool making

Tools made by chipping stones, or shaping bones or wood were used in a wide variety of ways. In some cases, the use of tools replaced the need to develop physical features.

Fire making

Fire is a powerful tool. It provided a means of keeping warm in cold periods, deterring predators from a camp site, and driving animals during a hunt. It was also used to cook, allowing difficult to digest food to be eaten more easily.

Shelter and clothing

The earliest shelters were probably natural ones, such as caves, overhangs and large trees. Creating artificial shelters allowed flexibility in where they were located. Clothing enhanced their ability to withstand cold.

Cooperative hunting

Working in organized groups requiring considerable coordination, early humans were able to tackle large game that would be impossible for a solitary hunter.

1. Explain what is meant by **cultural evolution**: _____

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Related activities: *Social Development, Paleolithic Tool Cultures, Art and Spirituality*

Development of Agriculture

People learned to cultivate and tend food plants, especially grains, and to domesticate animals. In the Middle East, about 10,000 years ago they learned to grow wheat, while in Mexico, about 2500 years ago they began to grow maize.

Maize (Central America)

Rice (Asia)

Wheat (Middle East)

Donkey

Bactrian camel

Goat

Sheep

Development of Stable Settlements

Communities of successful grain cultivators became established. People lived in relatively large, permanent settlements. People developed qualities such as patience, industry, and a sense of property, preparing the way for further cultural evolution.

Development of Cities

As communities became larger, trade and commerce began to develop. Large cities grew up where markets and trading systems developed. These were places where people could develop special skills such as pottery and metal work. It also resulted in rivalry, and in some cases war, between states.

The move from opportunist scavenger to hunter-gatherer was a major stage in mankind's cultural evolution. It was taken in a series of small steps, over a very long time (perhaps a million years). A few human societies, such as the Australian aborigines last century, were still at this stage until very recently.

2. Describe two probable effects of a drying climate on the selection pressures directing the evolution of early hominins:

_____

_____

_____

_____

3. Explain how each of the cultural developments listed below enhanced the survival ability of early humans:

(a) Manufacture of bone and stone tools: _____

_____

(b) Shelters and clothing: _____

_____

(c) Use of fire: _____

_____

(d) Cooperative hunting: _____

_____

(e) Development of agriculture: _____

_____

(f) Communication: _____

_____

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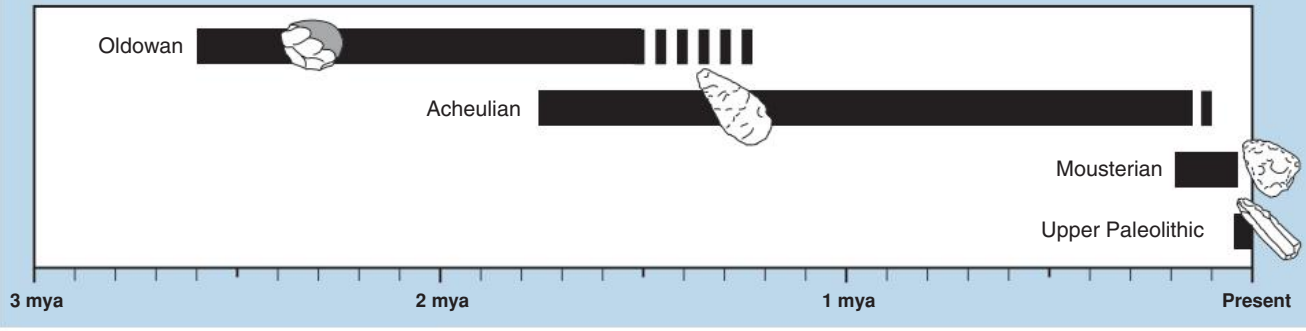
Paleolithic Tool Cultures

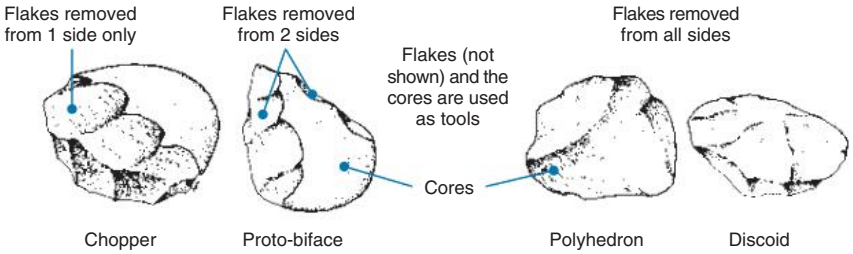
The **Paleolithic** (**Old Stone Age**) refers to a time period in early human cultural development. It spans the emergence of the first recognizable stone tools about 2.6 million years ago in eastern Africa, until the development of sophisticated tool kits in the Mesolithic (Middle Stone Age) about 10,000 years ago. These tool cultures are known mostly by their stone implements. This does not mean that the associated hominins did not use other materials (such as wood), just that they did not preserve well.

Timeline of Stone Tool Technologies



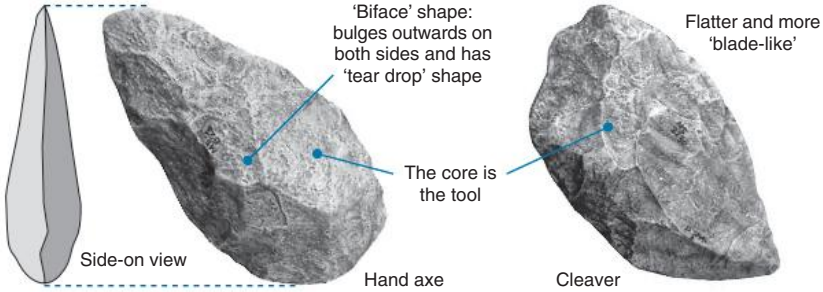
Oldowan (pebble) tool culture

Probably made by *Homo habilis*, these tools were simple river-worn pebbles that were crudely fashioned with a minimum of flakes being removed. These tools typically had flakes knocked from several angles to produce a core with a cutting edge (e.g. chopper, discoid, polyhedron). Although the cores may have been used as tools, it is known that the sharp flakes were also useful in cutting.



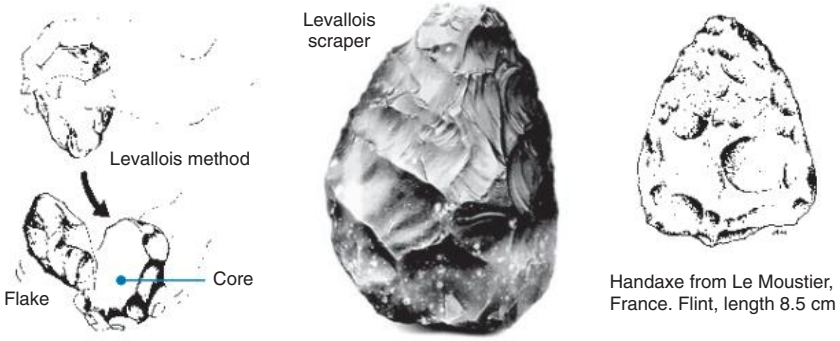
Acheulian tool culture

The product of *Homo erectus* and archaic *Homo sapiens*, these tools were typically 'tear drop' in shape and were carefully crafted with a slight bulge on each broad surface (called a bi-face). They ranged greatly in their size and are often referred to as hand axes although it is not clearly understood how they were used. They differ markedly from the earlier pebble tools in that there appears to be a standard design and each tool is manufactured using a great many more blows to remove flakes.



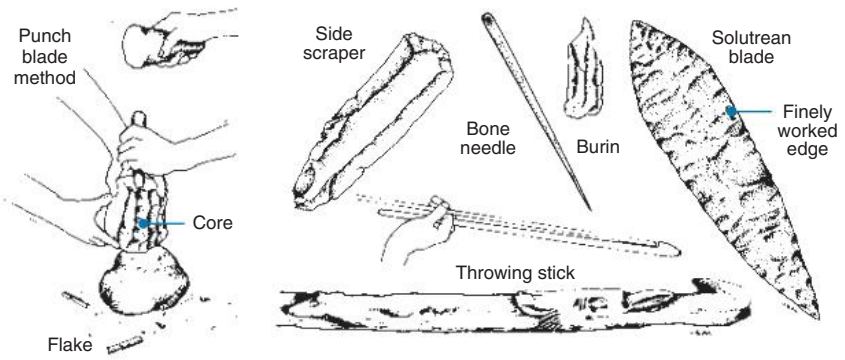
Mousterian tool culture

The **Neanderthals** developed a more refined tool culture than the earlier Acheulian. Flint finally became a sought after material to produce stone tools. The advantage of this rock was the very predictable way in which it would chip when struck with another hard object. Much finer workmanship was possible. A particular tool making technique from this period is known as the **Levallois method**. It involves the preparation of a core and striking off a large oval flake which is then retouched on one surface only (see the photograph on the right; the retouched surface is visible).



Upper Paleolithic tool culture

There was a rather sudden increase in the sophistication of tool making about 35,000 to 40,000 years ago. Both the **modern** *Homo sapiens* and the last of the Neanderthals produced flint tools of much finer workmanship using a technique called **punch blade**. Long, thin flakes are removed and shaped into a large number of different tool types. European sub-cultures (traditions) include the **Magdelanian**, **Solutrean** and **Aurignacian**. Other material such as bone, ivory and antler became increasingly utilized to produce very fine tools such as needles.



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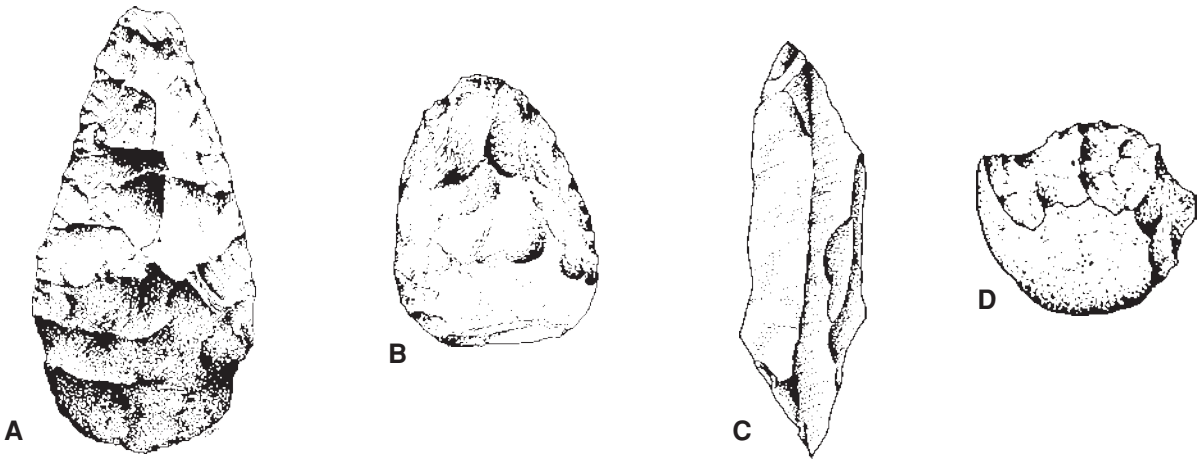
***Related activities**: Paleolithic Tool Use*
***Weblinks**: Paleolithic Tool Technologies*



1. Name the culture associated with each of the tools above (A-D) and describe the features that help identify them:

   (a) Tool **A** culture: _____

   _____

   (b) Tool **B** culture: _____

   _____

   (c) Tool **C** culture: _____

   _____

   (d) Tool **D** culture: _____

   _____

2. Identify the **hominin species** associated with, and the approximate time period for, each of the tool cultures below:

   (a) Oldowan: _____

   (b) Acheulian: _____

   (c) Mousterian: _____

   (d) Upper Paleolithic: _____

3. Describe the general trends in the design of the stone tool from **Oldowan** to **Upper Paleolithic** cultures:

   _____

   _____

4. The tools that are recovered from early human prehistoric sites are almost invariably stone, bone or ivory. Explain why tools made from other materials are almost never recovered from these sites:

   _____

   _____

5. Name the materials used to make tools in the **Upper Paleolithic** culture that were seldom used in earlier cultures:

   _____

6. Explain why the makers of the **Oldowan** tools were not able to produce designs that were as sophisticated as those of the Upper Paleolithic:

   _____

   _____

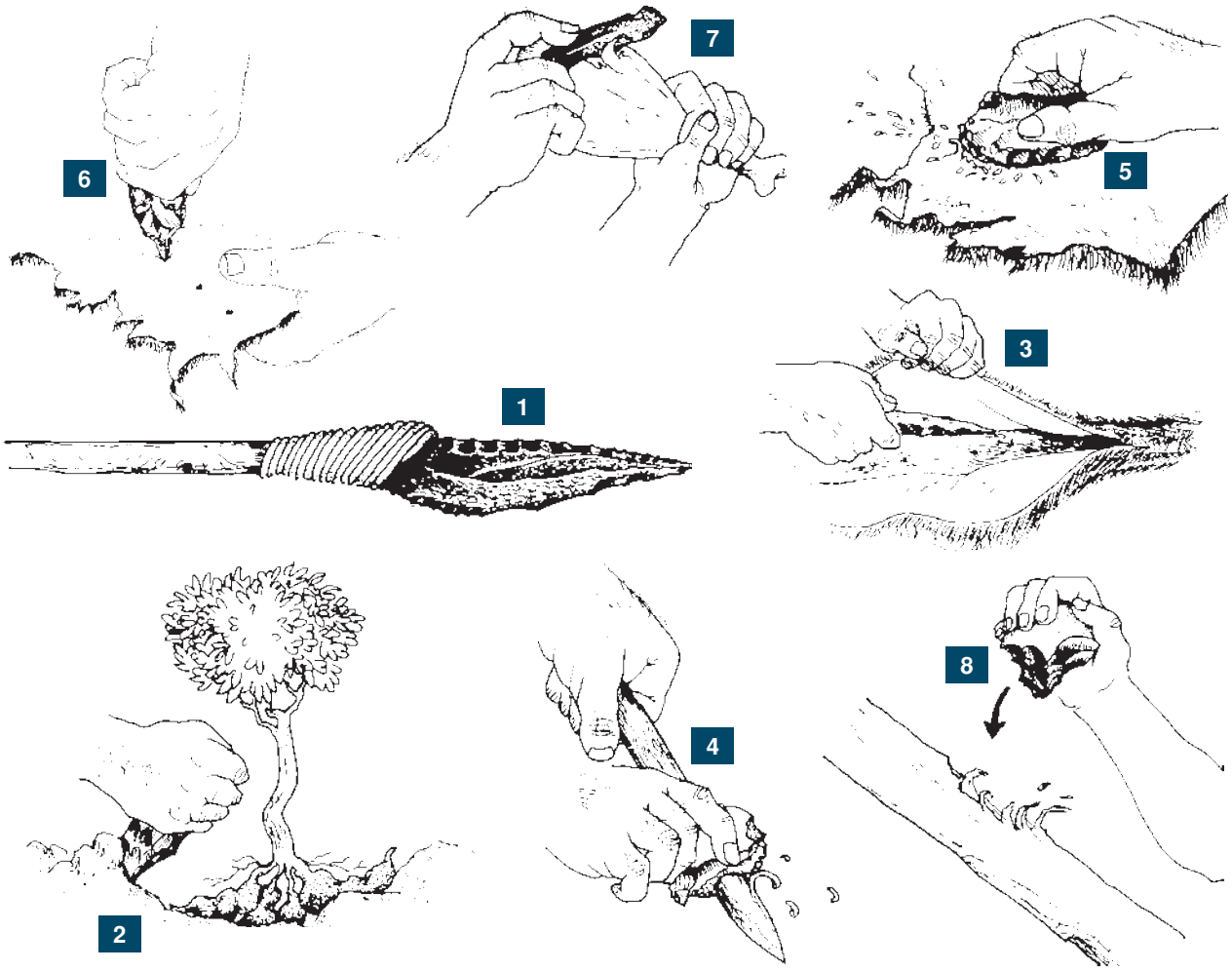
   _____

   _____

ISBN: 978-1-877462-99-3

Paleolithic Tool Use

It is impossible to tell with certainty what a tool recovered from an archaeological site was used for. By studying how similar tools have been used by recent 'stone age' societies, it is possible to infer their likely function. People using only stone-based technology were still in existence well into the first half of this century. Hunter-gatherer people existed in places like the Kalahari desert in south west Africa, the Australian outback, and some of the more remote areas of South East Asia and South America. Anthropologists studying these primitive cultures gathered valuable insights into how our ancestors may have lived.



1. Match each of the diagrams above with the **description** of their function in the table below (place 1-8 in number column):

	No.	Name of Tool	Description
(a)			This tool was probably used to scrape the fat and sinew from the underside of a freshly killed animal, in preparation for curing.
(b)			The curved, sharp edge of this tool would probably have been used to shave wood chips from spear heads.
(c)			Later forms of this tool were probably used to skin and dismember carcasses.
(d)			A simple tool used as an axe, probably to cut into wood or possibly to dismember a carcass.
(e)			Early forms of this tool may have been used as a pick-like tool to expose root tubers growing under plants.
(f)			Used as a knife, this tool had only one side with a sharp cutting edge so that pressure could be applied to the blunt edge.
(g)			Hafted to a pole with greased sinew or plant fibre, this flint tool would have provided an effective cutting edge for the spear.
(h)			The sharp narrow point of this tool makes it an effective drill when twisted back and forth. In this way, holes could be made in materials such as hides, wood and ivory.

2. Assign each tool with their **correct** name from the list below and place the correct name in the table above:
Side scraper, borer, denticulate tool, spear point, chopper, backed flake, early hand-axe, late hand-axe

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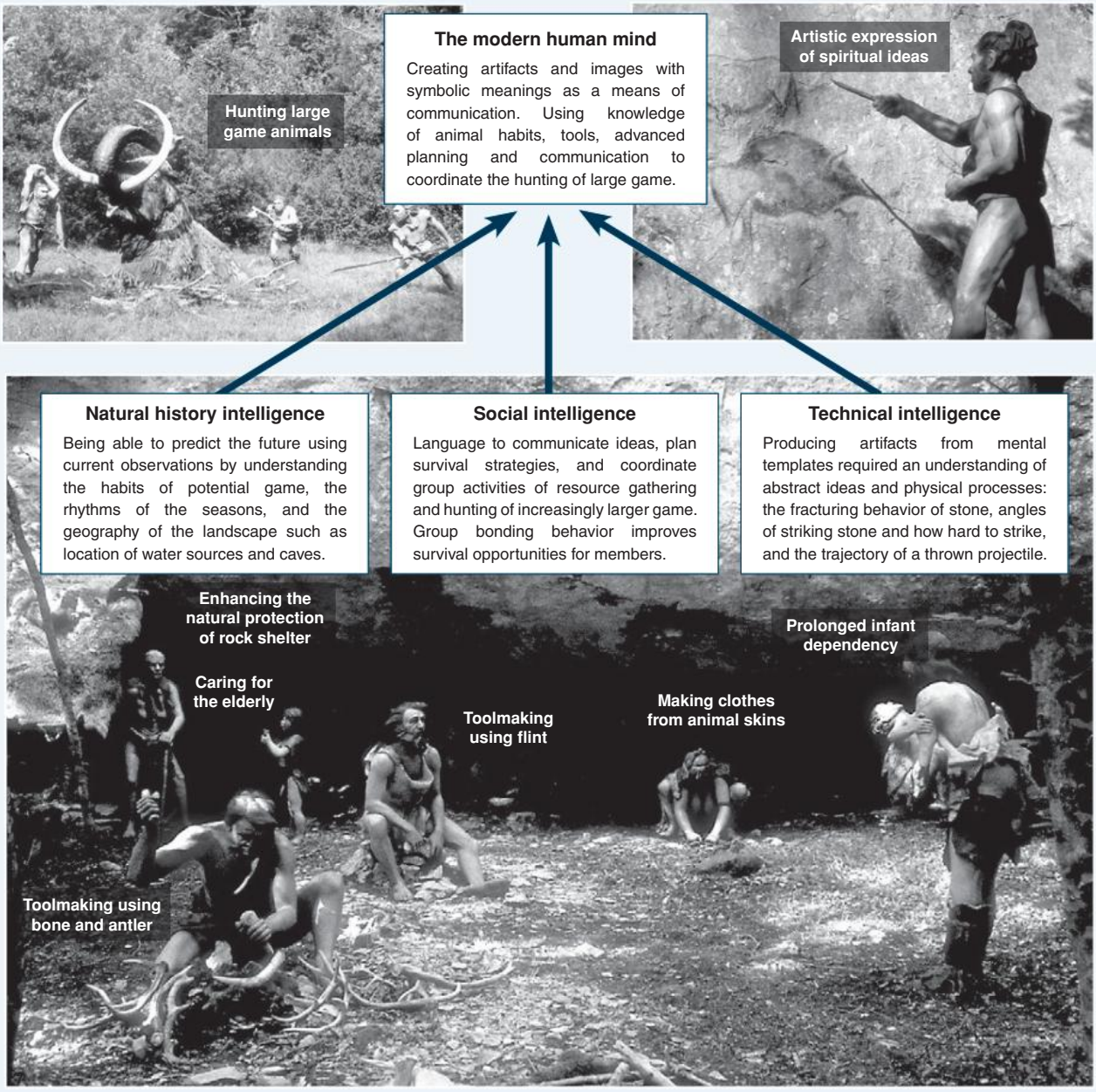
Social Development

The evolutionary development of the brain in hominins was associated with increasing social complexity and the development of what we know as culture. Culture can be thought of as the accumulation of knowledge, rules, standards, skills, and mental abilities that humans utilise in order to survive. Obtaining and preparing food, coping with climatic conditions, trying to understand the world, and cooperating with others are normal, daily activities that require cultural solutions. The modern human mind is the cumulative product of responses to these various selection pressures.



These reconstructions were photographed at Préhisto-Parc near Les Eyzies, in southern France. **Top left**: A group of Neanderthals hunting a woolly mammoth by using a concealed pit. **Top right:** A Cro-Magnon artist at work. **Bottom**: A Cro-Magnon family group at a rock shelter campsite. PHOTOS: RA

1. Explain how each of the following areas of human intelligence may have improved the success of early humans:

   (a) Natural history intelligence: _____

   _____

   (b) Social intelligence: _____

   _____

   _____

   (c) Technical intelligence: _____

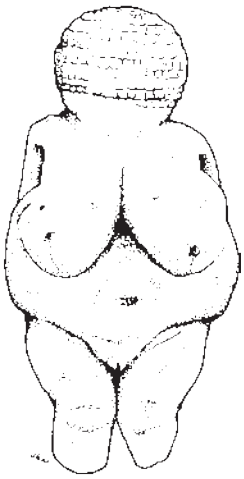
   _____

***Related activities**: The Development of Intelligence, Cultural Evolution*

ISBN: 978-1-877462-99-3

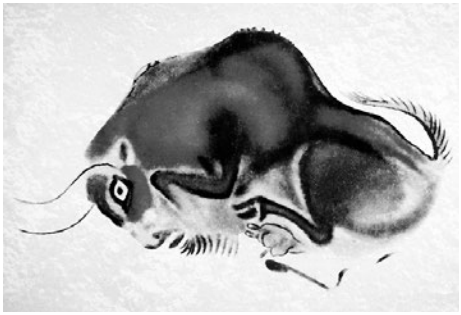
Art and Spirituality

Until recently, it was believed that art and spiritual beliefs first developed with the arrival of modern humans, particularly in Europe. A cultural explosion took place in the form of prehistoric art and new kinds of tools attributed to modern humans about 35,000 years ago. The beginning of this period, the **Aurignacian**, marks a dramatic development occurring simultaneously over large parts of western and eastern Europe. There is growing evidence that Neanderthals were more sophisticated than previously thought. Not only did they bury their dead, but they **appear** to have adorned their bodies, used necklaces, and made and used flutes. The stimulus for the new cultural development, in the Aurignacian at least, was probably a need to represent, in a concrete and lasting way, ideas about the unknown, such as death, hunting success, and fertility. A wide range of materials were used in this display of early human thought. Ivory, bone, clay, and stone were used to create sculptures, and the walls of rock shelters and caves were adorned with drawings, paintings, and bass-relief (sculptures that stand out from the rock wall).

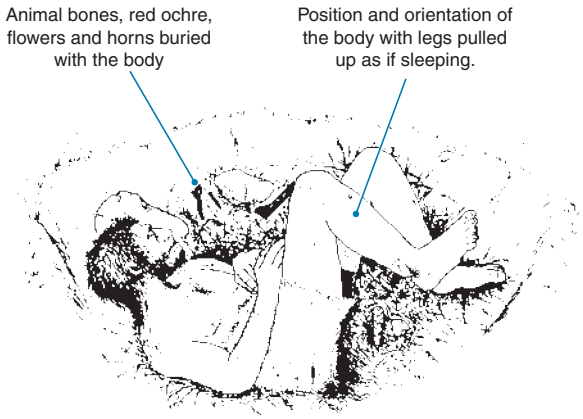


Sculpture: One of the earliest prehistoric works of art is the Venus of Willendorf (left), from Austria (10 cm high). The small figurine, carved from limestone about 30,000 years ago, has exaggerated breasts, buttocks, and body fat; these were thought to be desirable traits among women to enhance fertility and survival in periods of deprivation.

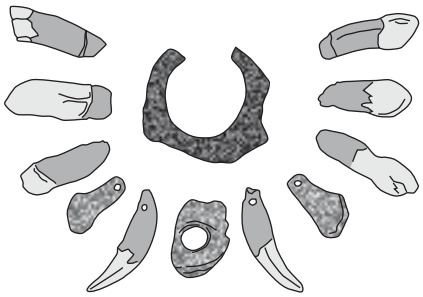
Music: Made of bird-bone, this 25,000 year old flute (above) is one of the earliest instruments providing evidence of music. A similar flutelike piece of cave bear bone has been found at a Neanderthal hunting camp in Slovenia. The bone, dated at between 43,000 and 82,000 years ago, suggests that Neanderthals may have made music.



Rock art: Many examples of rock art are found in southern France and northern Spain. However, rock art was not restricted to Europe; the earliest examples may come from Australia. The pigments (charcoal, manganese oxide, and ochre) were applied to grease smeared on the rock surface.



Neanderthal burials: The Neanderthals of Europe and Southwest Asia buried their dead in a way that showed signs of ritualization. The grave is usually characterized by certain items found buried with the body. The position and orientation of the body are consistently the same. Some experts have questioned the validity of these so-called burials and claim the finds are the result of coincidences and later disturbances.



Neanderthal necklace: The necklace above was recovered from a late Neanderthal site. Was the necklace made by the Neanderthal, or was it traded or stolen from modern humans? Whatever the answer, it suggests that Neanderthals appreciated such objects.

Spirituality and ritualism: Painted about 15,000 years ago on a cave wall at Trois Féres, in the Pyrenees Mountains, this creature (above right) may have been a sorcerer dressed in animal skins. Rituals involving spiritual re-enactment may have been conducted to ensure successful hunting.

1. (a) Identify three items that may have been found with the body in a Neanderthal grave: _____

   _____

   (b) Describe the usual position and orientation of skeletons found at Neanderthal burial sites: _____

   _____

   (c) Describe a cultural significance of burying the dead in this manner: _____

   _____

   _____

2. Describe two recent findings that support a view that Neanderthals were more sophisticated than previously thought:

   (a) _____

   (b) _____

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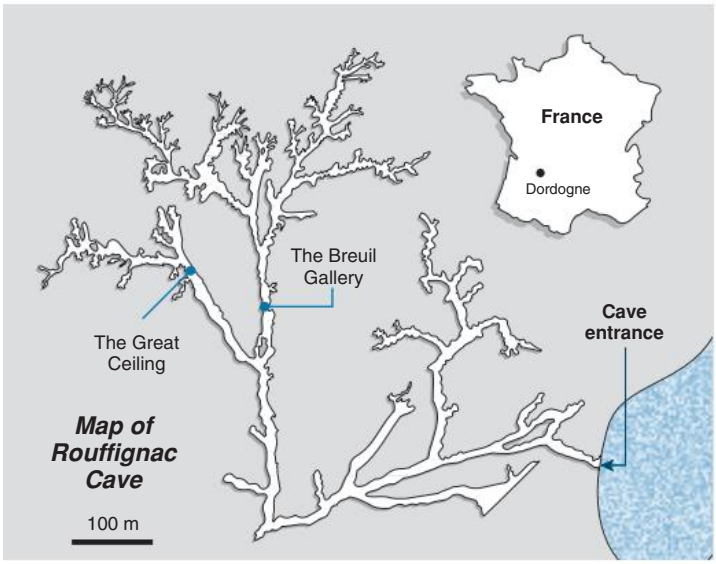
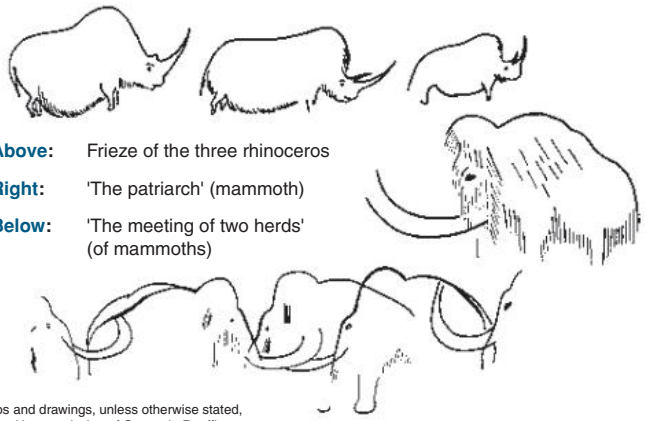


Rouffignac cave, in the Dordogne Valley, France, is a huge cavern with 10 km of galleries. It is remarkable for its large number of prehistoric paintings dating from 13,000 years ago. The first drawings are about 750 m from the entrance and continue deep underground to the end of the galleries. It contains over 250 engravings and cave paintings, of which over 150 paintings are of the mammoth. Below and right are some typical examples of these drawings. Earlier rock engravings have been dated in Australia at >60,000 years;but this date is disputed by some.



Above: Frieze of the three rhinoceros

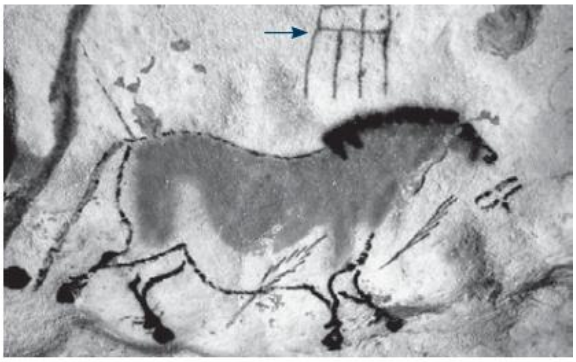
Right: 'The patriarch' (mammoth)

Below: 'The meeting of two herds' (of mammoths)

All photos and drawings, unless otherwise stated, reproduced by permission of Grotte de Rouffignac

Detail of the head of a rhinoceros from the Great Frise in the **Breuil Gallery**, Rouffignac Cave. Like the mammoth, the woolly rhinoceros was common to Europe before becoming extinct 12,000 years ago.

The **Great Ceiling** is the heart of the sanctuary at Rouffignac. The collection of drawings depicts a mammoth and ibex. It was common for drawings to be made over the top of one another.



Corel

This painting of a horse is one of many splendid images painted on the ceiling of the famous Lascaux cave in the Dordogne, France. Note the abstract markings (arrowed) for which there is no explanation.

3. Describe the relationship the early humans had with the mammoth and woolly rhinoceros: _____

4. Describe a probable purpose for the drawings and paintings appearing in the cave art: _____

5. Describe the likely function of the 'Venus' statues in Paleolithic life (see the *Venus of Willendorf* on the previous page):

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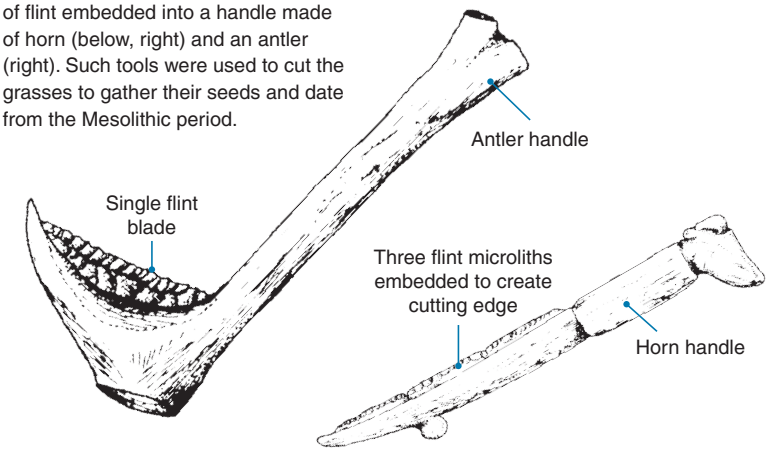
Mesolithic Culture

The **Mesolithic** (or Middle Stone Age) period occurred in Europe between 12,000 and 3000 years ago, as the last glacial period ended. The tools produced at the time were small bladed geometric stone tools (**microliths**), and were often fitted into a handle of wood or bone. People of the Mesolithic period demonstrated a wide variety of hunting, fishing, and food gathering techniques, which may have arisen because of the changing ecological conditions and a climate that would have been more conducive to increased productivity. The Mesolithic occurred during the current, Holocene epoch, which is relatively warm compared to the previous epoch, the Pleistocene. The warmer Holocene climate resulted in the retreat of glaciers, the growth of forests in Europe and deserts in North Africa, and the disappearance of the animals hunted during the glacial period.

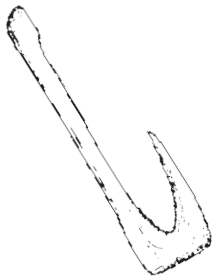
Tools of the Mesolithic Period

Sickles: These two sickles are made of flint embedded into a handle made of horn (below, right) and an antler (right). Such tools were used to cut the grasses to gather their seeds and date from the Mesolithic period.



Didier Descouens

Harpoon: This flat harpoon is made of bone, and dates between 12,000 and 9500 years ago. It was found in France.



Bone fish hook: This fish hook dates from the Mesolithic period and was found in Sweden.

Didier Descouens

Microlith: Made of flint or chert (a sedimentary rock). Microliths formed the points of hunting weapons such as spears. This microlith was found in the Tourasse cave, France.

1. The **Mesolithic culture** replaced the Upper Paleolithic culture. When did the Mesolithic culture begin?

2. (a) Describe the key features that characterize the Mesolithic culture:

   (b) How did the Mesolithic culture differ from the Upper Paleolithic culture?

3. Explain the significance of the warmer climate experienced during the Mesolithic period:

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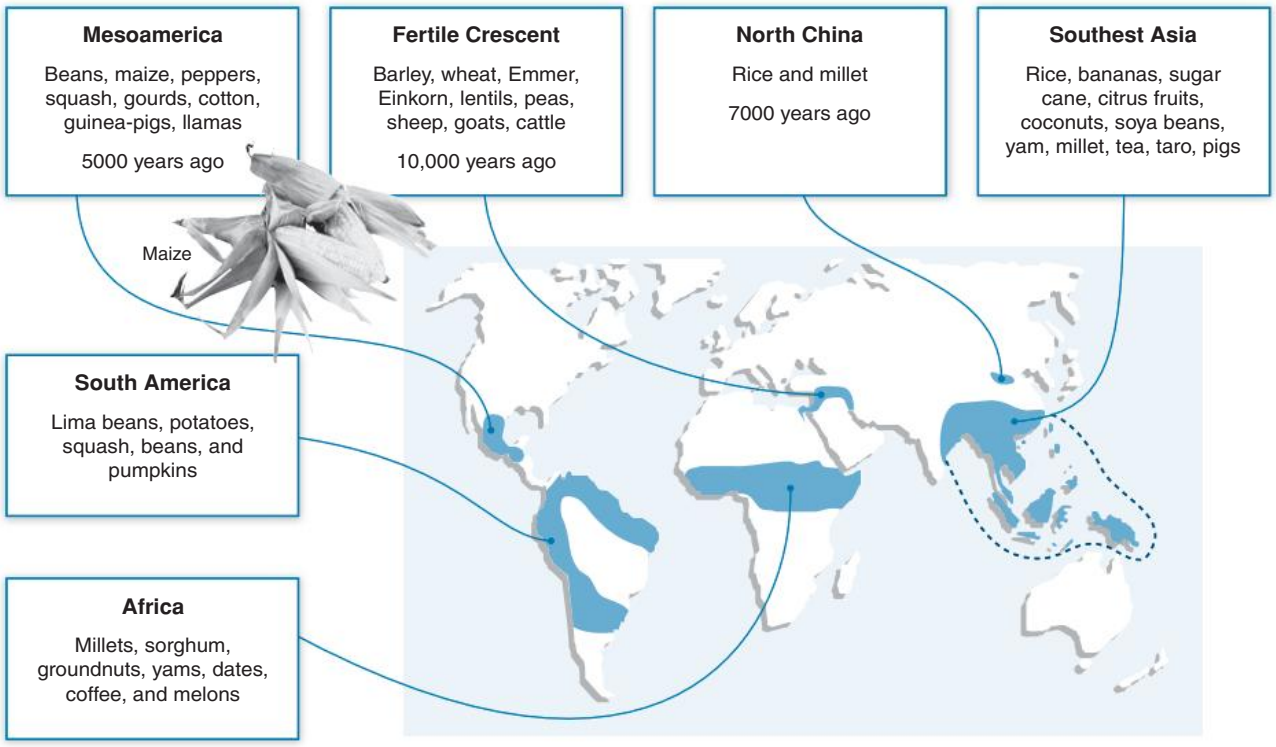
***Related activities**: Paleolithic Tool Cultures, Summary of Recent Cultural Evolution*

Neolithic Culture

The date of the **Neolithic** (or New Stone Age) culture varies with geographic location. In the middle East it dates from about 10,000 years ago, and in Europe from 4000 to 2000 years ago. The period is characterized by advancements in farming and animal domestication practices, the development of crafts (e.g. pottery and weaving), the use of polished stone and flint tools, and the development of permanent settlements. The production of food, through farming, allowed a shift away from the hunter-gatherer economy of the Mesolithic to a food producing culture. Not all individuals had to be involved in food gathering activities, and some people developed specialized craft skills (e.g. potters). As permanent settlements developed, ideas and knowledge could be more easily transferred between people, resulting in a rapid expansion of cultural evolution during this period.

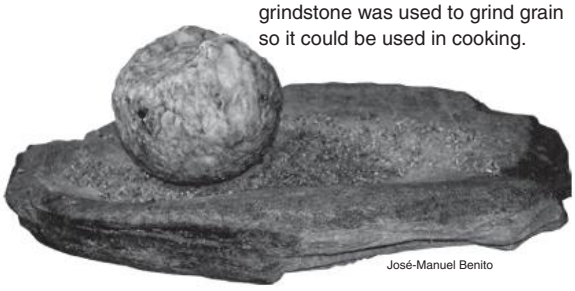
The Origin of Agriculture



Domesticated animal	Wild ancestor	Region of origin	Date (years ago)
Dog	Wolf	many places?	13,000
Goat	Bezoar goat	Iraq	10,000
Sheep	Asiatic mouflon	Iran, Iraq, Levant	10,000
Cattle	Aurochs	Southwest Asia	10,000
Pig	Boar	Anatolia	9000
Domestic fowl	Red jungle fowl	Indus Valley	4000
Horse	Wild horse	Southern Ukraine	6000
Arabian camel	Wild camel	Southern Arabia	5000
Bactrian camel	Wild camel	Iran	4500
Llama	Guanaco	Andean plateau	6000
Water buffalo	Indian wild buffalo	Indus Valley	4500
Ass	Wild ass	Northeast Africa	5500

Each domesticated animal was bred from the wild ancestor. The date indicates the earliest record of the domesticated form.

Grindstone: This Neolithic grindstone was used to grind grain so it could be used in cooking.



José-Manuel Benito

Sandstein

Neolithic people produced a wide range of purpose-specific tools to harvest, store, and prepare food. The photo, above, displays food and cooking items retrieved from a Neolithic site in Europe. The containers are made of antlers and wood.

***Related activities**: Cultural Evolution, Summary of Recent Cultural Evolution*

ISBN: 978-1-877462-99-3

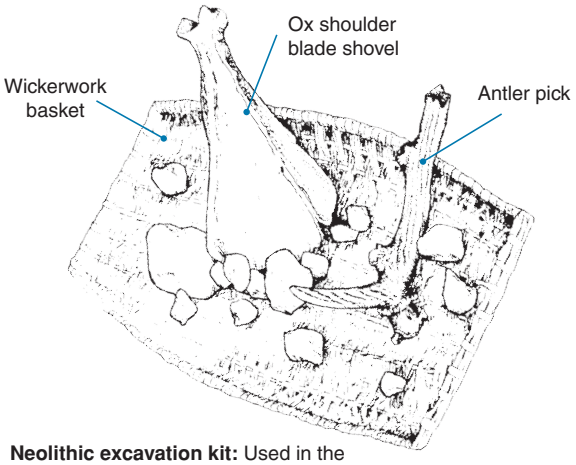
The Development of Permanent Settlements

Dr J.F Burka: http://en.wikipedia.org/wiki/File:Orkney_Skara_Brae.jpg

Neolithic village at Skara Brae, Scotland.

The development of agricultural practices significantly changed the lifestyle of Neolithic people. The hunter-gatherer lifestyle gave way to food production using agricultural techniques. The need to tend to crops and animals resulted in a shift away from a nomadic lifestyle to living in permanent settlements.

Skara Brae, Scotland, is the location of Europe's most complete stone-built Neolithic village (above). It consisted of ten houses, and was occupied between 3180 and 2500 years ago. The people of Skara Brae raised cattle and sheep, and may have cultivated barley. The presence of fish bones and shells amongst the ruins suggest their diet was supplemented with seafood from the nearby ocean.



Neolithic excavation kit: Used in the construction of massive earthworks in Britain (such as Avebury Stone Circle). The pick made from an antler was used to loosen chalk, while the ox shoulder blade was used to shovel the soft rock into a wickerwork basket.

Arrow head: Made of flint, this finely worked Neolithic arrow head was recovered from the Algerian Sahara desert and is about 6000 years old.

1. The **Neolithic culture** replaced the Mesolithic culture. When did the Neolithic culture begin

   (a) In the middle East? _____

   (b) In Europe? _____

2. Describe the key cultural developments that characterize the Neolithic culture: _____

3. Why was the shift of Neolithic people from hunter-gatherers to farmers an important step in cultural evolution?

4. How did the establishment of permanent settlements influence cultural evolution during the Neolithic period?

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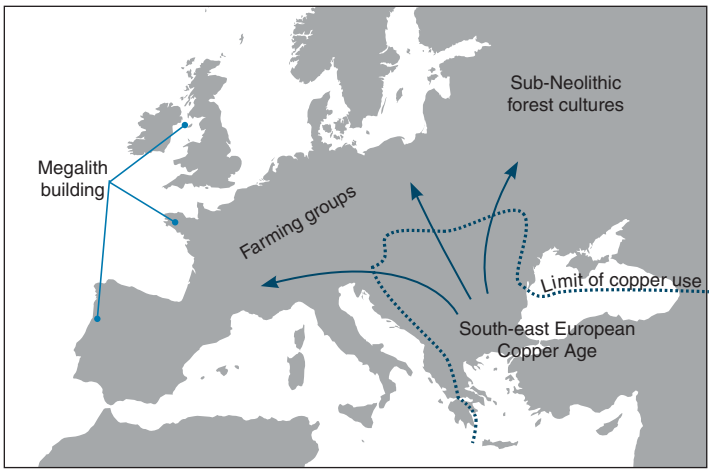
Copper Age Culture

The **Copper Age** appeared as early as 7000 years ago. It is also referred to as the **Chalcolithic** (Copper-Stone) Age because stone technology was still heavily in use at the same time. The scarcity of copper meant that initially only precious objects, such as pins and beads, were made by cold hammering native copper into shape. Later, metalsmiths learned to extract copper by heating copper ore and pouring it into molds. Many Copper tools and weapons could be produced this way. The copper Age is often considered to be an early phase of the Bronze Age, where tin was added to copper to produce bronze.

Copper Age Cultures in Europe between 6500-5500 years ago



The Copper Age was a transitional phase between the use of stone and the use of bronze. It some areas it lasted many centuries, in others it appeared and was replaced by other technologies very quickly. Copper was first used in Eastern Europe and Central Asia, around 7000 years ago. At this time Western Europe was still using Neolithic, and in some places Mesolithic, technologies. The use of copper slowly spread west reaching Britain around 4450 years ago.

Copper axe from the Copper Age
Photo: Jojojoe CC 3.0

The Copper Age produced little in terms of material change, i.e. objects were created that were similar or identical to stone implements. However, copper's scarcity made copper objects highly prized commodities, and owning them was associated with social prestige. This association created social competition in life and in burial and led to important changes in social and economic structure.

Otzi - The Man in the Ice

In 1991, a frozen body of a male was discovered in the Ötztal Alps on the Italian-Austrian border. **Otzi** (named after the mountains he was found in) lived 5300 years ago, and provided researchers with many details about the culture of people living during the Copper Age.

Otzi's clothes were designed for cold weather and his shoes were very sophisticated, made from three different components. He carried a copper axe and its presence probably meant he had high social status.

Ozti appears to have died violently, perhaps from a blow to the head. There are deep cuts on his hands, and an arrowhead lodged in his back. Some researchers speculate he may have died defending his property or animals, or possibly in a battle between rival groups.

Otzi's Equipment

The following items were associated with Otzi:

- Dagger and scabbard
- Two birch-bark containers
- Bow-stave
- Copper axe
- Back pannier
- Ibex bones
- Retoucher
- Belt and pouch
- Birch fungi
- Tassel with stone bead
- Sloe (fruit)
- Net
- Quiver and contents

Otzi's clothes consisted of:

- Hat
- An upper garment
- Grass cloak
- Loincloth, leggings, and shoes

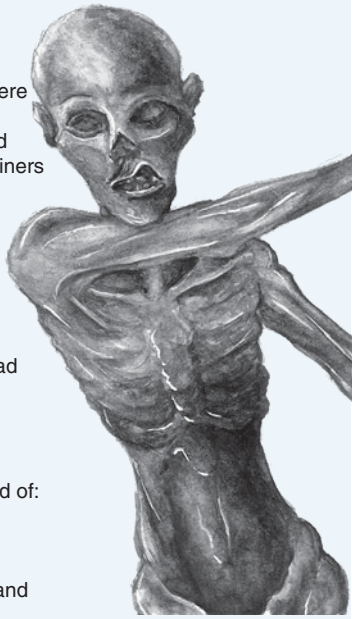


Image drawn and painted by F. Hicks

Artist's reconstruction of Otzi

1. (a) Approximately when did the **Copper Age** begin? _____

   (b) Describe some key features which define the Copper Age: _____

2. Why were both stone tools and copper tools manufactured and used during the Copper Age? _____

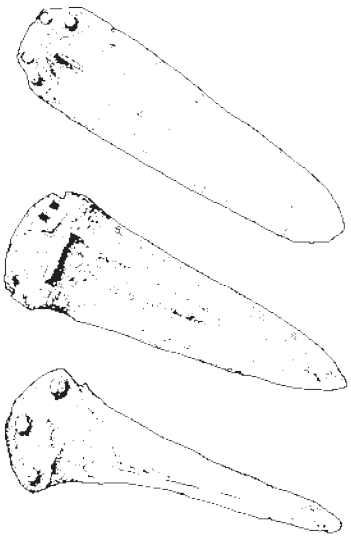
3. How do you think an individual's social status may have been affected if they owned copper objects?

***Related activities**: Bronze Age Culture, Summary of Recent Cultural Evolution*

ISBN: 978-1-877462-99-3

Bronze Age Culture

The **Bronze Age** followed on from the Copper Age. It is defined by the manufacture of objects from true bronze (an alloy of tin and copper). Bronze implements first appeared about 5000 years ago but, because tin deposits were hard to find, its use did not become widespread until 4000 years ago when more tin deposits were discovered. Bronze Age technology was quite sophisticated. Tin first had to be mined and smelted before it was added to molten copper to produce bronze. During the Bronze Age, the availability and use of metal goods increased and the use of stone implements decreased. Many geographical regions lacked tin deposits, so trade networks in either tin or finished bronze goods developed to meet demands. About 3000 years ago, the forging of iron brought the Bronze Age to an end.

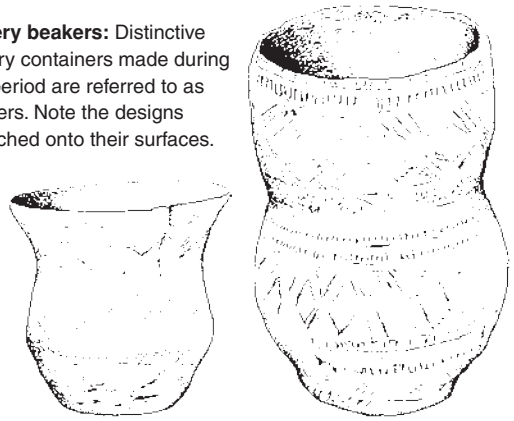


Copper and bronze daggers: These blades date from early Bronze Age sites around Stonehenge and Avebury in southern England. They would have had wooden or bone handles attached.

Axe head: This stone axe head would have been hafted to a wooden handle.

Jet button: Jet is a hard black variety of lignite and can be given a brilliant polish. It was commonly used for items of jewelry such as this button.

Pottery beakers: Distinctive pottery containers made during this period are referred to as beakers. Note the designs scratched onto their surfaces.



Flint knife: Although copper and bronze became increasingly used to make tools and weapons, they were still used in conjunction with traditional materials such as flint.

1. When did the **Bronze Age** begin and end? _____

_____

2. What is the composition of "true bronze": _____

_____

3. Why were so few bronze tools made before 4000 years ago? _____

_____

_____

4. Explain why the technology associated with the Bronze Age is regarded as quite sophisticated: _____

_____

_____

_____

5 (a) Why did trade networks for trading tin develop in the Bronze Age? _____

_____

_____

(b) What might have been some other benefits of these trade networks? _____

_____

_____

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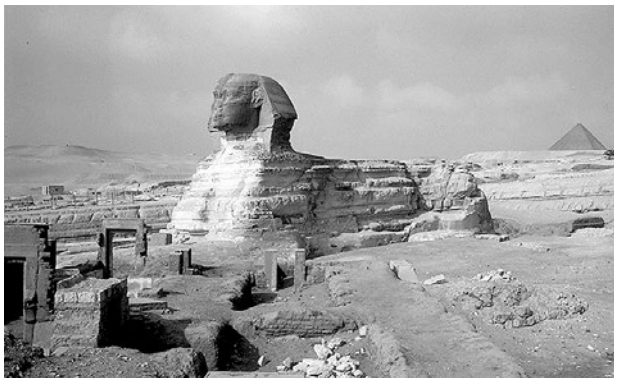
Summary of Recent Cultural Evolution

Year BC	Cultural Period
	Mesolithic
9000	Jericho settled as first town Sheep domesticated in Middle East Tools fashioned from native copper in use (Anatolia)
	Neolithic
8200	Goat domesticated in Iran
8000	Pottery made in Japan
7500	Humans cultivate the first crops (wheat and barley) in the Middle East
7200	Sheep, pigs, cattle (domesticated) near Greece
6900	Domesticated dog at Sarab (Iran)
5500	Open mould copper casting at Turkey Copper used as trade in Mediterranean area
	Copper Age
5000	Farming supersedes hunting in most of Europe Corn grown in Mexico Vaulted graves in Brittany
4350	Horse herding in the Ukraine
4000	European metallurgy. (Copper axe casting in Rumania.) Sail boats used in Europe Large cities developed
3500	Writing appears. Many trade routes evident Egyptian merchant ships ply Mediterranean
3120	Beginning of Dynasty 1 Egypt
3100	Goldsmiths active in Bulgaria
	Bronze Age
3000	Tin bronze implements found at royal cemetery 'Ur'
2800	Calendar devised in Egypt
2613	Beginning of Dynasty IV in Egypt. The Pyramid Era
2300	Very large cities in existence - Ebla - 260,000 people Trade flourishes via the Persian Gulf
1900	Pharaoh Sesostris II builds the Fayum reservoir
1780s	Reign of Hammurabi in Mesopatamia during which many of the major law codes controlling Near East trade were introduced
1,595	End of first Dynasty in Babylon
1500	Invention of ocean going outrigger canoes enables man to reach the islands of the South Pacific
1480	Paved roads in Crete
	Iron Age
1000	Iron in use in Middle East
1350	Alphabet devised in Syria
1300	Turin Royal Papyrus - records the first dynasties in Egypt
1000	Reindeer domesticated in Northern Europe
900	Phoenicans develop modern alphabet
800	Celts spread iron through Europe Nomads build a society based on the horse in Russia
720	Homer composes Iliad and Odyssey
700	Rome founded Civilization flourishes and expands
0	Christian era begins

DA

The stone circle of Avebury is one of the most famous of the many Neolithic stone circles in Britain. Built in stages during the late Neolithic period 2500-2000 BC, its purpose is unknown, but was probably a place of worship. The 150,000 t of chalk excavated during its construction indicates its importance.



Egyptian culture bloomed during the 4th dynasty (2500 BC). This was a wealthy, stable period that ushered in the civilization's first great age, the Old Kingdom. The Giza pyramids and the sphinx (above), which bears the face of king Khafre, are unparalleled feats of architecture of the era.

DA

A reconstruction of a European Iron Age (c. 500 BC) dwelling: a round house, located at the Butser Hill Experimental Iron Age Farm in Southern England. The building would have been constructed from wicker-work (woven branches) with a thatched 8 m high roof.

The Mayas of central America were the only truly literate civilization of the Americas, dating back to 300 BC. Large architectural complexes formed the centres of cities with up to 50,000 inhabitants. Plazas surrounded by stone pyramids were crowned by palaces and temples for human sacrifice.

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Present and Future Human Evolution

The culture and technology of modern humans has resulted in an environment that is vastly different to that experienced by our human ancestors. It is common to link our modern lifestyles with increased rates of cancers and other diseases, but factors in our current environment can only act as selection pressures if they affect reproductive fitness. Environmental factors causing post-reproductive cancers, while affecting individual health, will not act as selection pressures. Some of the trends identified in the evolution of human anatomy (below) may continue, but new selection pressures may increasingly influence human evolution. In the last 200 years, rapid developments in science, technology, and medicine have helped humans to withstand and manipulate conditions that would otherwise have acted as selection pressures. Medical advancements and genetic technology have helped in lowering mortality, increasing fertility, and assisting the survival of medically compromised offspring (e.g. premature babies and the offspring of multiple births). Even the ease of global travel adds a new selection pressure, new diseases can be easily transferred across countries by people travelling by plane.

Evolutionary Trends

Brain: Increase in brain size and complexity.

Nasal form: A reduction in the width of the nose.

Face: Reduced facial projection leading to a flatter profile. There is a trend towards a smaller, more vertical face, with loss of brow ridges.

Dentition: Reduction in tooth size (particularly of the canines) and loss of the diastema.

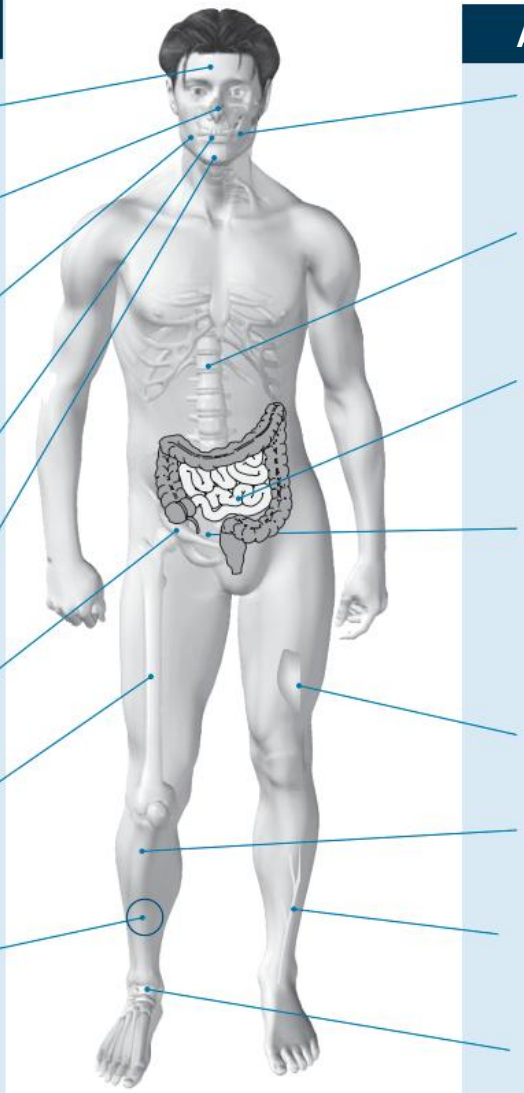
Jaw: Reduction in the size and robusticity of the jaw, with increasing loss of a prominent chin.

Pelvis: A trend towards a shorter and broader pelvis in order to accommodate the attachment of leg muscles adapted for walking.

Femur: Improvements in the adaptations of the legs (angle, stability, and strength of the femur) for upright bipedal locomotion.

Body hair: Reduction in the coarseness of body hair over much of the body surface (there has been no reduction in the number of hair follicles however).

After C.B. Stringer



Associated Problems

Teeth: Wisdom teeth become overcrowded and impacted as a result of reduced jaw size.

Slipped disc: Lower back troubles, usually the result of degenerative changes with age, are compounded by the load being carried by only two limbs.

Weakened muscles: Muscles lose mass and tone. Intestinal hernias may develop if intestines can bulge out through a weakened abdominal wall.

Birth canal (in women): Changes in pelvic shape in response to bipedalism, together with babies born with larger skulls, can cause childbirth problems if medical intervention is not possible.

Skin cancer: With the loss of shielding body hair, the skin is exposed to larger amounts of UV radiation from the sun.

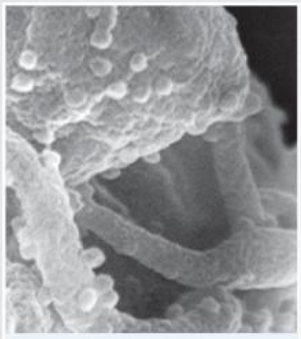
Weakened bones: Bones demineralize with age, as a result they can break more easily.

Varicose veins: An upright posture hampers venous return, allowing blood to collect in the leg veins.

Joint wear: Joint lubricants become thin through repeated use. Joints grind against each other and become damaged.

New Selection Pressures

- Pollution introduces toxins into the environment. Children are particularly vulnerable to environmental toxins. An ability to tolerate and metabolize toxins may provide an evolutionary advantage.
- Resistance to malaria and HIV/AIDS will be strongly favored in many of the world's most populous regions where there is a high prevalence of these diseases.
- Global dietary changes provide strong selection pressure for food tolerances, e.g. the gene associated with lactose tolerance has been shown to be strongly favored.



HIV virions budding from a human lymphocyte

The Consequences

The success of humans as a species has presented modern populations with a number of complex problems. The fast-paced development of new technologies has contributed to global pollution and resource depletion. Medical advances and improved living standards have increased the human life-span, particularly in developed countries, and the world now faces over-population. The ability to manipulate the genetic composition of organisms has many biological, social, and ethical implications that often divide both the scientific community and the general public.

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Periodicals:
New look at human evolution

1. Describe the evolutionary trends associated with the following human anatomical features:

   (a) Body hair: _____

   (b) Jaw: _____

   (c) Brain: _____

   (d) Pelvis: _____

   (e) Face: _____

   (f) Femur: _____

2. Describe three problems with the modern human anatomy that have developed as a result of bipedalism:

   (a) _____

   (b) _____

   (c) _____

3. Describe a problem that has resulted from the jaw becoming smaller: _____

4. Describe two problems that have arisen because of the reduction of coarseness of body hair:

   (a) _____

   (b) _____

5. Modern humans face selection pressures quite different from that of our early ancestors. Describe some of the new selection pressures that operating on the human species:

6. Describe an example of a modern technology or practice and discuss how it might influence future human populations:

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Summarizing Trends in Human Evolution

Use the information you have collected during the study of this topic to fill in the summary sheet for each of the hominins listed below. Some points to consider are listed on the right. Not all boxes can be filled in.

Skull

Consider such things as:

1. Skull shape (e.g. brow ridges).
2. Brain capacity & organization (which lobes are prominent?).
3. Face angle: snout present?
4. Tooth size, enamel, and use.
5. Attachment of skull muscles.
6. Robustness of skull.

Locomotion

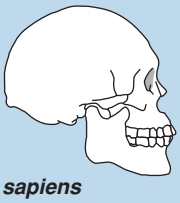
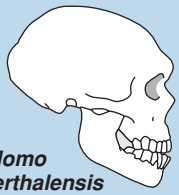
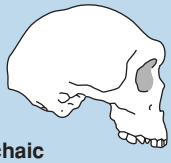
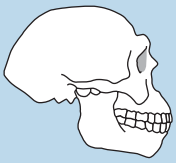
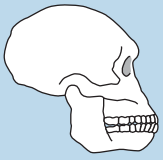
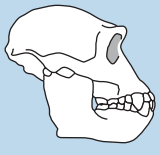
Consider such things as:

1. Bipedal or quadrupedal?
2. Position of foramen magnum.
3. Knee joint and femur shape.
4. Valgus (carrying) angle.
5. Foot structure.
6. Lower spine shape.
7. Pelvis and hip joint.

Tool use & manufacture

Consider such things as:

1. Tool technology: Oldowan, Acheulian, Mousterian, upper Paleolithic (how finely worked). Purpose of tools.
2. Other materials used: antler, wood, bone, pottery, metals.
3. Use of fire.

 ***Homo sapiens*** Duration: _____ Years ago			
 ***Homo neanderthalensis*** Duration: _____ Years ago			
 **Archaic** ***Homo sapiens*** Duration: _____ Years ago			
 ***Homo erectus*** Duration: _____ Years ago			
 ***Homo habilis*** Duration: _____ Years ago			
 ***Australopithecus afarensis*** Duration: _____ Years ago			

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Abstract thought	Diet and food resources	Distribution	Selection pressures
Consider such things as: 1. Burial of dead. 2. Collecting materials for tool manufacture, complex design. 3. Artistic expression: paintings, statues, carvings. 4. Writing and recording events.	Consider such things as: 1. Vegetarian, carnivore or opportunist omnivore? 2. Food collection: scavenger, hunter/gatherer, small or large game, domestication of plants and animals. 3. Suitability of teeth for diet.	Consider such things as: 1. Globally: Africa, Asia, Europe, Americas and the Pacific. 2. Habitat: savannah, forest, deserts, mountains, coastal. 3. Presence of other hominin species in the same place at the same time.	Consider such things as: 1. Climatic change (e.g. ice ages). 2. Diet on: teeth, jaw, muscles. 3. Competition with other species. 4. Predator avoidance. 5. Effect of bipedal locomotion on other body parts. 6. Cultural response to pressures.

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KEY TERMS: Flash Card Game

The cards below have a keyword or term printed on one side and its definition printed on the opposite side. The aim is to win as many cards as possible from the table. To play the game.....

1) Cut out the cards and lay them definition side down on the desk. You will need one set of cards between two students.
2) Taking turns, choose a card and, BEFORE you pick it up, state your own best definition of the keyword to your opponent.
3) Check the definition on the opposite side of the card. If both you and your opponent agree that your stated definition matches, then keep the card. If your definition does not match then return the card to the desk.
4) Once your turn is over, your opponent may choose a card.

Acheulian (tool)	Paleolithic	Cultural evolution
Selection Pressure	Mousterian (tool)	Copper Age (= Chalcolithic)
Mesolithic	*Homo neanderthalensis*	Oldowan (tool)
Homo erectus	Neolithic	Bronze Age

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When you've finished the game keep these cutouts and use them as flash cards!

The development of a culture from a simpler to more complex or sophisticated form.

Literally meaning “old stone” refers to the time of the stone tool cultures that lasted from 2.6 million to 10,000 years ago.

Tool culture that developed around 1.5 million years ago that saw the development of tear drop shaped, bi-faced hand axes.

A cultural period that first emerged about 7000 years ago. It is characterized by the emergence of copper tools, alongside stone tools. Sometimes regarded as an early phase of the Bronze Age.

Tool culture that developed around 200,000 years ago. Involved striking a flake off a central stone, then retouching the flake on one side to make a blade.

Those factors that influence the direction of natural selection.

Tool culture that developed around 2.5 million years ago. Also known a pebble tools, stones were crudely fashioned to form a cutting edge and were probably used by *H. habilis*.

This hominin is associated with the Mousterian tool culture.

Literally meaning "middle stone", this cultural period occurred in Europe between 12,000 and 3000 years ago, and was characterized by microlith tools.

A period in cultural evolution characterized by the manufacture and use of bronze tools.

Literally meaning “new stone”. Significant advancements in farming and animal domestication occurred at this time.

This hominin is associated with making and using Acheulian tools.

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Appendix

PERIODICAL REFERENCES

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- **The Littlest Human** pp. 48-57. *The Flores hominin (new information since).*
- **Founder Mutations** pp. 58-67. *Tracing migrations through genetic mutations.*
- **How We Came to be Human** pp. 68-73. *The role of language and art.*
- **The Morning of the Modern Mind** pp. 74-83. *The origins of human intellect.*
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- **An Ancestor to Call Our Own** pp. 4-13. *Controversial new fossils may be close to the origin of humanity.*
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- **Who Were The Neanderthals?** pp. 28-37. *Evidence that these hominins interbred with AM humans.*
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