Studying mammals: Food for thought

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Contents

Introduction

In this course, we will explore the fascinating question of who our ancestors were. I'll be looking at living species of apes in order to pick up clues about social structure and lifestyle in our ancestors and gain some understanding about why we humans behave as we do. I'll discuss tool use and culture in both ape and human societies, and look at two ancient species known only from their fossils - an australopithecine and *Homo erectus*.

This is the tenth in a series of units about studying mammals. To get the most from these units, you will need access to a copy of *The Life of Mammals* (2002) by David Attenborough, BBC Books (ISBN 0563534230), and *The Life of Mammals* (2002) on DVD, which contains the associated series of ten BBC TV programmes. OpenLearn course S182_8 *Studying mammals: life in the trees* contains samples from the DVD set. You should begin each course by watching the relevant TV programme on the DVD and reading the corresponding chapter in *The Life of Mammals*. You will be asked to rewatch specific sequences from the programme as you work through the course.

This OpenLearn course provides a sample of level 1 study in Environment & Development

Learning Outcomes

After studying this course, you should be able to:

- describe features of apes, and features that distinguish Homo from apes
- explain an evolutionary tree for hominines that shows one interpretation of the evolution of Homo from ape-like ancestors, australopithecines
- use what is known about social group structure in living species of ape to suggest social group structure in extinct species
- interpret features of apes, australopithecines, and Homo species in terms of adaptations
- understand the roots of those features that make Homo sapiens different from other mammal species.

1 The apes and their relationship to humans

As you work through this course you will come across boxes, like this one, which give you advice about the study skills that you will be developing as you progress through the course. To avoid breaking up the flow of the text, they will usually appear at the start or end of the sections.

As well as the course text, you will be using *The Life of Mammals* book (LoM) and related *The Life of Mammals* DVDs, as described in the introduction to this course. Before you go any further, watch 'Food for Thought' on the DVD and read LoM Chapter 10. Unless stated otherwise, all the page references you encounter in this course will be to LoM.

You were no doubt already familiar with apes before you watched 'Food for thought', because they are so prominent in zoos and have featured in many other TV programmes and films as beautiful and interesting animals. Sadly, apes will also be familiar to you because of the well-publicised risks most of them face of habitat loss and imminent extinction. You will recall from the TV programme and LoM Chapter 10 that there are relatively few species of ape living today. The smallest apes - frequently called the lesser apes - are 11 species of gibbons and siamangs living in the forests of Southeast Asia. The great apes, comprising (according to most experts) seven species, include the orangutan, which lives in Asia, and African species - the chimpanzee, the bonobo, the gorilla (and humans).

As long ago as 1837, Charles Darwin was struck by the close similarities between the great apes and humans, and was convinced of their close evolutionary relationship. He had seen an orangutan, Jenny, at London Zoo, the very first ape to be brought to England. Jenny disturbed those who saw her, because her close resemblance to humans blurred the perception of a sharp distinction between humans and animals. In 19th century Europe, humans were regarded as 'special', set apart from and above animals. The first part of the TV programme provides us with an opportunity to experience a little of what Darwin must have felt when he first saw an orangutan.

Activity 1

Watch the TV programme from 00.33-13.39. The first part is about the rescued orangutans at Camp Leakey in the Tanjung Puting Reserve in central Borneo, and the second covers wild orangutans in northern Sumatra. The final part looks at the behaviour of rescued chimpanzees living in a reserve at the mouth of the Congo River. Jot down notes as you watch, focusing in your note-taking on:

(a) anatomical features of the apes, including relative lengths of arms and legs, anatomy of hands, and facial structure;

(b) aspects of behaviour, including style of locomotion, whether arboreal or terrestrial, and manual dexterity;

(c) learning and social interactions.

Download and print the PDF of Table 1, linked below, then use your notes for (a) and (b) to fill in the columns. Information for humans in the final column is already given for comparison.

Click 'View document' to open Table 1

View document

Check your entries with the completed version of Table 1 given below.

Table 1 Comparison of anatomical features and locomotion in orangutan, chimpanzee and human (completed)

Feature	Orangutan	Chimpanzee	Human
relative length of arms and legs	arms longer than legs	arms longer than legs	legs longer than arms
length of fingers	long relative to size of hand	long relative to size of hand	long relative to size of hand
position of eyes	forward pointing	forward pointing	forward pointing
face flat or forwardly projecting	face forwardly projecting; high forehead	face forwardly projecting	face flat with high forehead
body hair	thick and long orange fur	long sparse hair over body	very little body hair
arboreal or ground-living	arboreal; wild individuals spend very little time on the ground	arboreal but also spends time on the ground	lives on the ground; never arboreal
locomotion	four limbs used for moving through canopy; sometimes brachiation used	four limbs used for moving through canopy; sometimes brachiation used; knuckle walker on ground; sometimes bipedal	bipedal, but can also climb
manual dexterity; tool use	very good; makes and uses tools	very good; makes and uses tools	excellent; makes and uses tools
childhood	prolonged (around 13 years)	prolonged (around 10-12 years)	prolonged (around 15-18 years)

As the completed table suggests, there are significant differences between humans and orangutans and chimpanzees, but the similarities you have recorded suggest our close evolutionary relationship to apes. Darwin's publication of *The Origin of Species* in 1859, in which he so eloquently explained his view of evolution, implied that natural selection applies to human evolution too. He concluded:

> When I view all beings not as special creations, but as the lineal descendants of some few beings which lived long before the first bed of the Cambrian system was deposited, they seem to me to become ennobled.

Later, in his book *The Descent of Man* (published in 1871), Darwin suggested that humans had evolved from an African ape-like ancestor. He thought that the existence of predators and the harsh climatic conditions in Africa had provided the intense selection pressure that resulted in the evolution of a biped from an ape, via the process of natural selection. Darwin did not have much evidence for his view, as little fossil evidence and no molecular evidence was available in the 19th century. Nevertheless, subsequent research has shown that he was right.

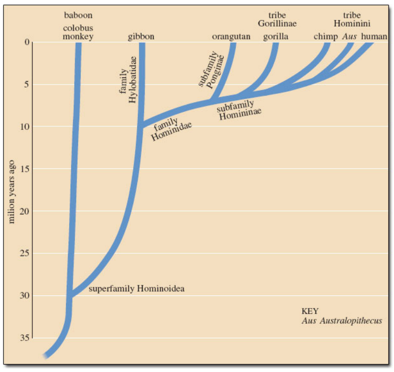

Figure 1 family tree for Hominoidea (apes and humans) showing how the classification is linked to what is known about evolutionary relationships. For example, the chimpanzee, *Australopithecus* and *Homo* lines diverged from the gorilla line about 6.5-7 million years ago, which is reflected in their grouping in the tribe Hominini. Dates of splits between groups are known only approximately. For example, the earliest known fossil of a hominoid (ape) is dated at 26 million years old, so the date for the origin of Hominoidea is placed at 30 million years

You will be aware that classification systems aim to reflect evolutionary relationships and are based on both anatomical and genetic similarities. The classification of apes and humans takes account of the close evolutionary relationship between humans and the chimpanzee, as revealed in Figure 1, above. Look at Figure 2 in S182_8 *Life in the trees* and notice the links between the two diagrams; for example, both diagrams show the split between the lesser and great apes (Hylobatidae and Hominidae), about 10 million years ago. The split between the Cercopithecidae (i.e. Old World monkeys, of which the baboon and colobus monkey identified on Figure 1 are just two examples) and the superfamily Hominoidea (Figure 1) occurred about 30 million years ago, which corresponds to the same branch point shown in Figure 2 of S182_8 .

Biologists are generally agreed that humans and all types of ape are grouped within the superfamily Hominoidea, as in Figure 1. But there is disagreement about more detailed groupings, so you will probably come across different classification schemes. The classification followed here groups the great apes and humans in the family Hominidae. Apes and humans are subdivided in two subfamilies, Ponginae (orangutans) and

Homininae (other great apes and humans). Note that there are extinct *Homo* species, e.g. *Homo erectus*, as well as our own species, *Homo sapiens*, and also an extinct group of ape-like creatures, the australopithecines; these are all grouped together in the tribe Hominini. *Homo* species and australopithecines are known as hominines; you may recall the term 'humanoid' that author David Attenborough (DA) uses to refer to extinct hominines [p. 296].

The big question implicit in LoM Chapter 10 is, of course, who were our ancestors? In Section 4 and Section 5, I will be looking in more detail at the two ancient species, known only from their fossils - an australopithecine and *Homo erectus* - briefly mentioned by DA [p. 300]. Such fossil species are considered to be on or close to the evolutionary line leading to *Homo sapiens*, because their dates are appropriate and they have some of the defining anatomical features of humans, such as adaptations for bipedal walking and a large brain size.

Before we explore the fascinating question of who our ancestors were, I'll be looking more closely at living species of apes, in order to pick up clues about social structure and lifestyle in our ancestors. In Section 2, I'll be building on what you know from watching apes in the TV programme and reading LoM Chapter 10, applying the information to a more detailed study of social structure in the orangutan and the chimpanzee. From LoM and the programme you will already be aware that chimpanzees are expert tool-users - Section 3 looks at a few examples of tool use in detail and shows how tool use is related to culture. Prior to the 1960s, both tool use and culture were fixed in many biologists' and anthropologists' minds as being defining features of *Homo* species. Now views have changed; our society is far more complex than those of apes, but we should not conclude that only humans have culture. By exploring the social structure of the great apes, we can pick up clues about the lifestyles of our ancestors and gain some understanding about why we humans behave as we do.

2 Variable structure of ape societies

You will be aware from watching the TV programme that information on behaviour and social structure of apes is gathered by many hours of patient observation.

Activity 2

Use your notes from Activity 1, and also LoM Chapter 10, as source material for writing about 200 words on how orangutans obtain their food and how diet and feeding is related to the social structure and way of life of the orangutan.

In most areas where they live, orangutans are solitary, and range through their forest territories feeding on tree fruits. A large animal like an orangutan has to find a substantial amount of food each day and it's unusual for there to be enough fruit trees in one area of forest to feed a group. Living in large groups might therefore be difficult, as one adult orangutan might well need sole access to all the trees to obtain sufficient fruit. But orangutans in the swamp forests of northern Sumatra live in large groups, a habit that is linked to the abundant food supply there. The trees in the swamp forest, e.g. *Neesia* [p. 289], have frequent peaks of fruit production because of the nutrients provided by flood waters. Large groups of orangutans feed together on *Neesia*, using carefully prepared twigs to remove the irritant hairs from the coat of the fruit. They also collect honey from bees' nests in tree branches by inserting trimmed twigs into the entrance holes. While feeding in groups, the orangutans usually appear to be in harmony - the young play with each other, for example. Disputes between males over opportunities for mating are generally settled by the dominant male in the area.

On this evidence, you might think that orangutans do not have a specific social structure - each individual more or less 'doing their own thing', depending on where he or she lives. In fact, there is a social structure; the core is a single female, who lives with her dependent offspring in a defined home range that overlaps with the ranges of other females. Each solitary male defends a large territory that includes the home ranges of several females with whom he mates. The male, weighing around 90 kg, is about twice the size of the female and defends his territory aggressively against incursion by other males, using his large canine teeth as weapons. The photograph of a male in LoM p. 286 shows the large fleshy cheek pads of orangutans; these can become inflated when vocalising and it is often suggested that this helps increase the volume of their calls, though some experts dispute this. What is certain, however, is that the loud, prolonged bellowing sounds emitted by males advertise their presence to other orangutans. The male mates with the several females that live in his territory, but each female lives alone with her offspring for most of the time. This social structure is termed 'exploded' unimale, which means that one male defends a harem of females scattered over a wide area. Figure 2a shows the arrangement in diagrammatic form. However, the recent discoveries in the forests of northern Sumatra referred to above have shown that orangutans do live in more coherent groups when huge quantities of fruit are available.

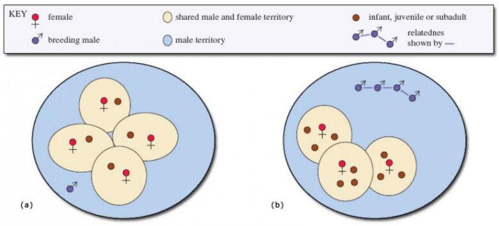

Figure 2 (a) single male orangutans defend a group of females (and their offspring), but the females may be distributed over a large area - exploded unimale. (b) In chimpanzees, several related males mate with and defend a group of widely distributed females (and their offspring); this is a multimale-multifemale group with female territories

You will be aware from your reading of LoM Chapter 10 that, compared to orangutans, African apes live in larger social groups that have complex social structures. For primates a social group provides opportunities for intense social interaction, including planning, deception and forming alliances. There are also opportunities for the young to learn from other members of the group, and their mothers. Chimpanzees live in loose groups of 20-120 individuals, including mature males and females and offspring. Each female has her own core area that she maintains, although it may overlap with that of one or more other females. A female generally lives and travels with her offspring, but sometimes joins other females and their offspring, a social structure sometimes described as 'fusion-fission' or, more formally, multimale-multifemale groups with female territories (Figure 2b). Contact between the scattered members of the group is maintained by means of distance calls, known as pant hoots.

Baby chimpanzees spend a long time being cared for by their mothers, and are weaned at 4-5 years old. They then go through a long juvenile phase, lasting about 8-11 years, before sexual maturity. Young adult females may transfer or be kidnapped into other communities, but males remain in their own native group.

Activity 3

Watch the TV programme from 13.41-22.40, which is about the chimpanzees from the largest troupe known (150 individuals) in Ngogo, Kibali National Park, Uganda, and jot down notes about the behaviour of the males, focusing on disputes, forming and maintaining social bonds, and cooperation for hunting. Write a summary of your observations in no more than 150 words.

Males associate with each other and form dominance relationships, whereby one individual gains the dominant position. His status is maintained by support from allies. As the males within the group compete, fights break out occasionally. After a noisy battle in which the males may shake tree branches and chase and hit each other, the dispute is resolved and social bonds re-established by hugging and mutual grooming. Grooming is important for creating and maintaining close social relationships between males.

Occasionally, groups of males will attack a young male - the sequence from 15.20-16.30 shows one such attack in which the victim almost certainly died of his wounds. Males cooperate closely when hunting colobus monkeys, some actively chasing the colobus and others stationed in spots where they can head off potential escapees. Meat-sharing may serve to strengthen social bonds between males.

The discovery by Jane Goodall in 1960 that chimpanzees kill relatively large prey and eat meat was a shock to the scientific community who had viewed chimpanzees as frugivores. Jane's first report of meat-eating by chimpanzees was her observation of one of the Gombe chimpanzees in Tanzania eating baby bushpig. We should not be surprised by the close cooperation between the males of the Ngogo group when they are out hunting. All males in a group are closely related to each other, and cooperate to defend their community range against males of neighbouring groups. Therefore, it is important to maintain close social bonds, but cooperation conflicts with their competition with each other for access to females. Male chimpanzees have enlarged canines, which they use as weapons, and are about 25-30% larger than the females - a typical situation where males compete for access to females. All adult male chimpanzees are dominant to all females. There is occasional contact between males and females of the community, e.g. for mating, or during disputes when females may join forces to support a favoured male.

The social structure of the chimpanzee is shown diagrammatically in Figure 2b. For the chimpanzee, such a group structure appears to be quite loose, with females wandering off and male conflict interspersed with alliance building, cooperative hunting and fighting other groups. Nowadays, it is recognised that chimpanzees are genuine omnivores. DA notes that they eat fruits and leaves of more than 300 species of plants, as well as insects, lizards, monkeys, baboons, duikers (small antelopes), young mammals, eggs and chicks [p. 291]. In the next section, I'll examine more closely some of the ways in which chimpanzees obtain their food, and show how feeding habits link to tool use and culture.

3 Tool use and culture in ape and human societies

Another surprising discovery first reported by Jane Goodall in 1960, was the routine use of tools by the Gombe chimpanzees for obtaining food. Since then, observations on other groups of chimpanzees have highlighted the diversity of tool-using techniques. The TV programme and LoM Chapter 10 provide fascinating examples of the techniques used; some are remarkably complex and ingenious.

Question 1

Question: On the basis of the description in LoM Chapter 10, what tool-using techniques are employed by chimpanzees to obtain food?

Answer

Chimpanzees 'fish' for termites by inserting a twig that they have stripped into a hole in a termite hill. The chimpanzee pulls the twig out of the hole and, using the lips and tongue, sucks up the insects that adhere to it [photograph on p. 292]. Water is collected from a small tree hole by inserting a crumpled leaf into the hole. The most sophisticated example of tool use involves breaking open hard nuts by a hammerstone and anvil. The chimpanzee places the nuts on the anvil and hits them with the hammerstone until the shell cracks open [p. 291].

As you saw in the TV programme, use of an anvil and hammerstone involves each hand being used for a different purpose and is one of the most complex examples of tool use observed in animals. A research group from Kyoto University, Japan, is studying tool use by chimpanzees living in Bossou, Guinea. These chimpanzees select two types of stone: large, flat anvil stones and rounded hammerstones. Handfuls of palm nuts are brought for processing to a selected anvil or platform stone. Shallow cavities worn on the anvil stones, and adjacent piles of old nutshells, indicate that they have been in use for a long time. Those who observe this behaviour in the field report a degree of expertise in these animals that far exceeds the proficiency of humans when they first try the technique. What is fascinating is that villagers around Bossou use the same technique: their tools resemble those of the chimpanzees. We will never know whether the chimpanzees learned the technique from the humans or vice versa!

The Bossou researchers investigated how young chimpanzees learn the technique; fine coordination is needed and it takes the young chimpanzees about three to four years to learn the skills. Infant chimpanzees join the group at the nut-cracking area and watch the adults, and play with the nuts and stones. They often play a game that involves putting a nut on a stone and hitting it with a hand or foot. Mothers give their infants kernels of cracked nuts to eat, so the infants learn to associate their play activity with food. Mothers at Tai Forest, Côte d'Ivoire, leave nuts, hammerstones and anvils arranged correctly for use by infants, and sometimes perform nut-cracking in slow motion in front of their offspring - rather like a chimpanzee school. The Dutch primatologist Frans de Waals interprets the infants' behaviour as socially motivated. The young chimpanzees imitate their mothers and have a strong urge to act like her. By doing so, they learn the 'language' and culture of the group. After three or four years of such messing about with nuts and stones, the young begin trying to use the stones as anvils and hammers. The motivation to do so must be very strong; the years of learning often result in little more than crushed fingers, without the reward of obtaining a kernel.

All these observations suggest that we can add tool use to our list of similarities between humans and chimpanzees. Such a skill was formerly regarded as one of the unique attributes of humans - you may be familiar with the phrase: 'Man the tool-maker'.

When Jane Goodall first reported her observations to Louis Leakey (famous for having discovered many of the fossil hominid specimens in Africa), he said: 'Now we must redefine tool, redefine Man or accept chimpanzees as humans'. Of course, there is a distinction to be made between the *use* of tools (as in chimps) and examples of tool *manufacture*, on the scale seen in the earliest human settlements. For humans, the design, manufacture and use of complex tools is very much part of our 'culture'. If culture is defined in human terms as complex technology, agriculture, art, science and literature, then clearly animals, including apes, do not appear to have it. But culture need not be defined so narrowly, as I'll argue later. In each human population, or social group, aspects of the population's culture are taught to offspring - the long childhood of *Homo sapiens* provides plenty of time for cultural learning.

In the TV programme, DA provides us with a glimpse of the spectacular diversity of human cultures.

Activity 4

Watch the TV programme from 29.38-43.40 and jot down notes on how the San bushmen of the Kalahari, the Fulani people of Mali and the Dogon of Mali and Burkhina Faso obtain their food. Drawing on these notes, explain in less than 200 words how the three groups obtain their food, highlighting comparisons where appropriate.

San people rely on wild animals for meat, and hunt in small groups, using the persistence technique. Initially, the men look for tracks of prey animals, e.g. kudu, and follow them. When a herd is spotted, the hunters select their animal and separate it from the herd. Tracking and pursuit may take hours (or days) and requires considerable endurance during the heat of the day. When the kudu shows signs of tiring, a single hunter chases it to the point of exhaustion, finally spearing the collapsed animal. San women collect tubers and plants to supplement the meat.

In contrast, the Fulani are nomadic cattle herders who follow their cattle herds as they migrate seasonally to their traditional grazing areas. In this way, the Fulani always have a large supply of animals available for milk, meat and hides.

The Dogon people are agriculturalists and live sedentary and settled lives in villages, in contrast to the nomadic San and Fulani peoples. The principal crop grown by the Dogon is millet, which is stored in the numerous granaries of the villages. The villagers mark good harvests by celebratory dancing, dressed in large colourful masks.

These three groups - the San, the Fulani and the Dogon, all living on the continent of Africa - have different techniques for obtaining their food, and different ways of life. How a people obtain and prepare their food is a central part of their culture and links with all aspects of life, including tool use, social interactions, and even art. Our own culture relies on agriculture, including plant and animal domestication, for food; like the Dogon, the vast majority of the human population living today have a more sedentary lifestyle, but agriculture is no less significant.

This brief survey, based on a little more than 10 minutes of a TV programme, can do scant justice to the huge range of culture in human populations. But even the briefest of surveys should serve to loosen any preconceptions as to what constitutes culture. You will recall from LoM Chapter 10 DA's mention of orangutans in the forests of northern Sumatra having a unique culture linked to their techniques for feeding on *Neesia* fruit. You may have been puzzled by his use of the word 'culture' in relation to the feeding behaviour of a great ape. In the early 1950s, the Japanese anthropologist Kinji Imanishi proposed that culture should be defined as a form of behavioural transmission that does not depend on genetics. As apes live in social groups, and take up to 13 years to reach maturity, there is plenty of time for cultural information to be transmitted to younger generations. Imanishi's view of culture is accepted by many biologists now, displacing the earlier view, neatly summarised by the declaration (dated 1959) that 'man and culture originated simultaneously; this by definition'. I've mentioned how infant chimpanzees at Bossou learn from adult members of their group the skills needed for breaking open palm nuts - behavioural transmission is indeed not dependent on genetics. Use of anvils and hammerstones is unusual and has only been observed in a few groups of chimpanzees, including those at Bossou. And ape culture, as with humans, varies from one location to the other. In some areas in which chimps are living, nuts, stones and anvils are available and yet these animals show no signs of developing the palm-nut cracking habit of conspecifics living in Bossou.

Furthermore, behaviours not linked to obtaining food are also observed in particular chimpanzee groups and not in others. You should recall that in the TV programme at 14.12, you saw the Ngogo chimpanzees indulging in handclasp grooming. The behaviour involves one chimpanzee taking the hand of another and then raising the linked hands high into the air, forming a symmetrical A-frame, with the free hand of each grooming the armpit of the other. This posture is typical of a group living at Mahale in Tanzania, but is not seen in a group living on the same side of Lake Tanganyika, 170 km away, in Gombe National Park. Researchers who observed this behaviour conclude that it is cultural, and transmitted through the group along social lines. The handclasp is therefore one of the cultural characteristics that define the Mahale and Ngogo troupes of chimpanzees - manifestations of culture perhaps not fundamentally different in kind from those witnessed in Activity 4.

Now that we have questioned tool use and culture as uniquely human attributes, you may be wondering what is distinctive about humans. In the rest of this study period, I'll be concerned with human attributes that appear to be unique, discussing them in the context of what we know about the evolution of our own species, *Homo sapiens*.

4 Who were the ancestors of *Homo*?

Fossil evidence supports Darwin's view that humans and apes evolved from an ape-like ancestor and, furthermore, suggests that the ape line diverged from the *Homo* line at least five million years ago (Figure 1). From our current knowledge of the fossils available to us, the evolutionary tree in Figure 3 (below) begins at about six million years (6 Ma) ago, with an ape-like creature, identified as a hominine, and named *Orrorin tugenensis*. You will notice that from this point on the human evolutionary tree is quite 'bushy', having a number of branches.

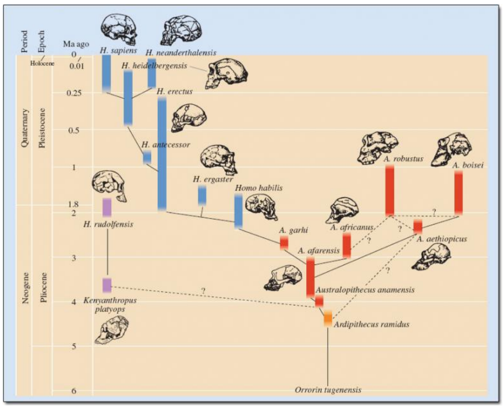

Figure 3 a human evolutionary tree. The dashed lines indicate that evolutionary relationships between species are uncertain. Note the 'bushiness' of the tree; the australopithecine line branches into several species of *Australopithecus* and also to several *Homo* species

Figure 3: Compiled by Douglas Palmer and Patricia Ash

There was great excitement among the scientific community when fossil remains of *Orrorin tugenensis* were found, because the limb bones suggested that it was capable of bipedal walking. Coming down to the ground from the trees (terrestriality) and walking upright on two legs (bipedality) are regarded as key events in the evolution of *Homo*. DA talks about the importance of bipedalism in LoM p. 294; it is a defining feature of *Homo*, so placing fossil species on or close to the evolutionary line for *Homo* has to include evidence of features associated with bipedalism.

Question 2

Question: Referring to your notes on chimpanzee behaviour from Activity 1, describe the technique used by chimpanzees to move about on the ground. If you have completed course S182_9, compare the technique used by chimpanzees with that used by monkeys.

Answer

Chimpanzees are knuckle-walkers when moving on the ground. They use all four limbs for walking, but they do not walk on the palms of their hands as monkeys do - the macaque monkey has a hand that functions in just this way. By contrast, the hands of chimpanzees curl under, so that their weight is supported by their knuckles. Occasionally, chimpanzees stand on two hindlimbs and walk bipedally for short distances, but the gait is slower and less efficient than human walking. As you know from the TV programme, chimpanzees walk bipedally when wading in water (see 26.10-28.10).

Activity 5

Watch the TV programme from 23.08-29.25 and write notes on the walking technique suggested by the Laetoli footprints. Use your notes to explain, in about 100 words, the likely origin of the Laetoli footprints. Focus on the style of walking and the possible number of individuals involved.

Answer

The Laetoli footprints are 3.6 million years old and provide spectacular evidence for bipedal walking. There is no evidence of footprints from the forelimbs, or knuckle prints, as you would expect if the prints were made by an ape. Two individuals walked side-by-side in the soft mud, possibly accompanied by a child, walking in the footsteps of the larger individual. Each footprint has a deeper depression where the heel hit the ground; there is no evidence of a gap between the big toe and the remaining toes as would be seen in prints made by an ape that still climbs trees.

The Laetoli footprints were almost certainly made by australopithecines. At least eight species of australopithecines have so far been identified from their fossil remains. Such fossils are restricted to Africa so it appears that they never migrated to other parts of the world. Evidence from their fossilised teeth suggests that their diet was mainly fruit, with some species eating soft fruits and others eating seeds enclosed in hard husks. The length and shape of the Laetoli footprints, and their age, suggest they were made by a species called *Australopithecus afarensis*. Over 100 fossils of *A. afarensis* have been found, some quite close to Laetoli. The dates for the fossils range from 3.9 to 2.9 million years old, so the species was around for a considerable period (Figure 3). One of the most famous fossils is a 40% complete skeleton called Lucy found at Hadar, Ethiopia in 1974. Lucy generated a great deal of argument about whether *A. afarensis* was bipedal or arboreal (a tree climber), and the following activity will provide you with a taste of the issues involved.

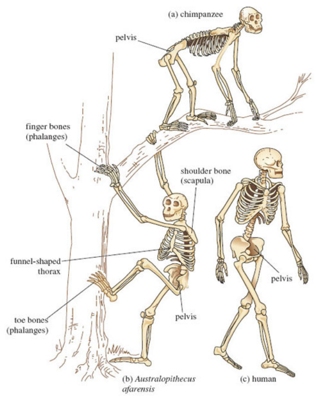

Figure 4 skeletons of (a) chimpanzee, (b) *Australopithecus* and (c) human

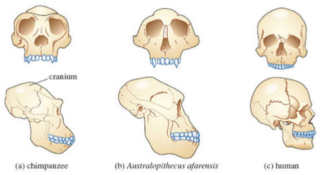

Figure 5 skulls of (a) chimpanzee, (b) *Australopithecus* and (c) human

Activity 6

Study Figures 4 and 5 (above) carefully. Information from these figures has been used to compile a summary of anatomical features of the human skeleton in the final column of Table 2. Print the PDF of the table, linked below. Complete the table by filling in the columns for the chimpanzee and *Australopithecus afarensis* as indicated by the headings for each row. You will need to use a ruler to make measurements of the long bones in the arms and legs and the hands and feet for comparisons of their relative lengths within each skeleton. Look too at the bones of the digits, i.e. of the fingers and toes, termed the phalanges.

Click 'View document' to open Table 2

View document

Check your entries with the completed version of Table 2 below.

Table 2 Comparison of anatomical features of chimpanzee, australopithecine and human skeleton

Feature	Chimpanzee	*Australopithecus afarensis*	Human
cranium	relatively flat	relatively flat	domed
pelvis	long and narrow	short and broad	short and broad
hindlimb	relatively short compared to arm length	relatively short compared to arm length	relatively long compared to arm length

feet	feet longer relative to length of leg	feet longer relative to length of leg	feet shorter relative to length of leg
hand bones (phalanges)	long, thin, and curved at ends of digits	long, thin and curved	long, thin and straight
foot bones (phalanges)	long and curved	long and curved	straight
skull	perched at right angles to vertebral column, eyes point forwards	perched on top of vertebral column; eyes point forwards	perched on top of vertebral column; eyes point forwards

As you'd expect, researchers who assert that *A. afarensis* was a bipedal walker focus on those aspects of the fossil skeleton of *A. afarensis* that support their view. Recall from the TV programme that the Laetoli footprints have the big toe aligned parallel to the other toes, as in humans. Such a structure indicates that the foot of *A. afarensis* was not used for grasping as in some apes, notably gibbons, but was better adapted as a platform for bipedalism, as in humans. The skull of *A. afarensis* is perched on top of the vertebral column, as it is in humans, suggesting strongly that Lucy stood upright. Lucy's pelvis resembled that of humans - short and broad - unlike the long narrow pelvis of the ape.

In contrast, supporters of the view that Lucy was arboreal argue that the relatively short hindlegs have proportions more like those of tree-climbing apes. The curved hand and foot bones would provide grip and suggest tree-climbing. The feet are relatively long, compared to the legs, which argues against persistent bipedal walking, in that such movement would require the feet to be lifted quite high off the ground.

Question 3

Question: Can you conclude from the fossil evidence whether *Australopithecus afarensis* was arboreal or walked bipedally on the ground?

Answer

On the existing evidence, it's impossible to choose between these two habits. Overall, the conclusion from the fossil evidence is that *A. afarensis* was more bipedal than not when on the ground, but was also likely to be skilled at climbing trees.

So, there now seems the beginnings of a consensus that *Australopithecus afarensis* was partly arboreal, partly bipedal. Indeed, the environment in which it lived was variable; Laetoli was open savannah, but Hadar, in Ethiopia, was wooded. Although the arguments continue, at least some degree of development of bipedal walking in australopithecines can be viewed as an evolutionary change of crucial importance. More generally, changes in the shape of the pelvis are thought to be important in hominid evolution, linked to the development of a form of locomotion that is more efficient than that of apes.

Question 4

Question: What are the advantages of bipedal walking suggested by DA in the TV sequence from Activity 5 and in LoM Chapter 10?

Answer

A number of advantages are suggested. Walking bipedally enables individuals to carry items: food, stone tools, juveniles [p. 294]. Standing upright helps an individual to wade in water for collecting molluscs [p. 296]. In savannah grassland, standing upright makes it easier to spot a predator from a distance [p. 296]. More significantly, an upright posture reduces the area of the body exposed to the tropical sun's vertical rays, and increases the area of the body exposed to cooling breezes.

A number of other factors come to mind; standing upright helps when picking fruits and nuts from trees. The assertion that human bipedal walking is more economical in terms of energy used per distance travelled than walking on four limbs is an issue that many see as crucial, as is the notion of the additional cooling that standing upright might bring. In contrast to a good many other less fussy mammals, apes and humans - as large and complex species - are obliged to keep their body temperature constant. For an organ such as the brain, an increase in temperature of even a few degrees would be fatal. For the australopithecines in Africa, the additional cooling possible from standing upright could offer considerable advantages. The notion that wading is of evolutionary significance with regard to bipedal walking is more controversial, and we will be looking at this idea more closely in the latter part of Section 5.

Australopithecus afarensis is of interest because many biologists consider this species to be on or close to the evolutionary line for *Homo*. You'll notice its prominence in the evolutionary tree shown in Figure 3, where *A. afarensis* is an ancestor for the first species of *Homo*. This view is by no means universal; indeed, there is a forest of evolutionary trees, with each tree slightly different from the rest. Although *A. afarensis* shows some adaptations for bipedal walking, as evident in fossil and living *Homo* species, it did not have another major defining feature of *Homo* that I want to discuss in the next section - increased brain size in comparison to apes. You'll notice from Figure 5b that *A. afarensis* has a relatively flat cranium compared to that of *Homo*, indicative of a modest-sized brain. The domed cranium that is typical of *Homo* reflects a very significant attribute of our species.

5 Who were the ancestors of *Homo sapiens*?

Large brain size is a defining feature of *Homo sapiens*, which means that evolution of increased brain size in *Homo* is crucial evidence. Indeed, an increase in both the size and the complexity of the brain is a defining feature of primate evolution as a whole. It's possible to estimate brain sizes from fossil skulls or parts of skulls, e.g. by filling what there is of the skull with sand and then measuring the volume of the sand. Use of computer technology fills in 'gaps' in a fossil skull and provides a more complete estimate. Figure 6a is a plot of estimated brain volume for skulls of various species of australopithecine and named species of *Homo* against the dates for the skulls. Each red dot represents an estimate from one skull; the dots form a scatter plot, though there's no certainty that there is a straight-line relationship between the two variables.

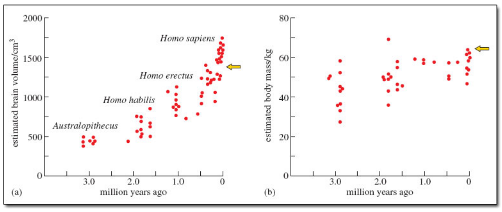

Figure 6 (a) change in brain size (volume) in early and modern-day humans. (b) Plot of changes in body mass over the same period. The arrows indicate modern-day values. Given the approximations involved, the individual points are unreliable, but the trends are probably representative. Estimates of body mass of fossil species were derived from measurements of the length of long bones and are subject to error. (Note the unusual horizontal scale here, showing millions of years ago; the values increase from right to left - a pattern you may not have seen before.)

Figure 6: Jones, S., Martin, R. and Pilbeam, D. (1992) *The Cambridge Encyclopaedia of Human Evolution*, Cambridge University Press

Question 5

Question: Study the data in Figure 6a. Read off the brain volume for *Australopithecus*, and describe the trend in brain size (volume) for the *Homo* species. (You may find it helpful to look back at Figure 3 to identify the different species of *Homo*.) Is there evidence of a sudden change in brain size?

Answer

The mean brain size for *Australopithecus* species was about 400-450 cm^3. The oldest known *Homo* species, *H. habilis*, had a brain size of about 600-700 cm^3; data for *H. erectus* are scattered, with values ranging from 750-1200 cm^3. Mean brain size for *Homo sapiens* is about 1300 cm^3, but the range is wide, from 1200-1700 cm^3. Values overlap between succeeding species. There is no evidence of a sudden change in brain size - the rate of increase in brain size over this time period appears relatively constant. Overall, however, the increase over about three million years - from about 400 cm^3 in *Australopithecus*, to 1300 cm^3 in *Homo sapiens* - is a more than threefold increase.

Figure 6b shows the estimates of body mass of early *Homo* species. The mean value for *Homo sapiens* is not hugely different, demonstrating that the increase in brain size is disproportionate, not merely a reflection of increased body mass.

In the TV programme, DA describes one view of how natural selection promoted evolution of bipedalism. He suggests that early humanoids (hominines) discovered the rich food supplies available in shallow waters - molluscs and crabs. The idea that evolution of bipedalism links to the advantages of wading in water for obtaining a rich food supply ties in with the 'aquatic ape hypothesis', a contentious explanation for the evolution of humans. Supporters of this hypothesis quote our very sparse body hair [p. 297], the oily protective secretions of our skin and the layer of fat under our skin [p. 298] as supporting evidence. The subcutaneous fat is said to have provided insulation against low water temperatures for our ancestors. I find the arguments against the aquatic ape hypothesis more convincing; they include the fact that the distribution of human fat is virtually the same as that in furred terrestrial primates. Lack of fur in humans is more likely to derive from the advantages of being able to cool the body in a hot African climate, rather than from an aquatic lifestyle. (After migration out of warm regions of Africa, *Homo* used animal skins and furs for insulation against the cold.) There is no fossil evidence supporting an aquatic lifestyle for any of the species usually placed on the evolutionary tree for *Homo*. Needless to say, the arguments against the aquatic ape hypothesis are not accepted by its proponents.

However, the idea that early *Homo* found molluscs to be a good source of food is a sound one. DA links a diet of energy-rich shellfish to the huge increase in brain size in *Homo* [p. 298], though fish and a whole range of aquatic animals would also have provided much the same benefit. Let's look at the association between brain size and diet in *Homo* more closely.

The oldest fossils of *Homo* species, about 2.4 million years old, were found in Africa (see Figure 3). Rather than describe all such finds here, I'll focus on just one ancient species, *Homo erectus*. Fossil evidence suggests that *H. erectus* evolved about two million years ago in Africa and spread rapidly, migrating to Asia, reaching Georgia and East Asia. 'Peking Man' refers to *H. erectus* fossils found in China, at a site close to Beijing. Figure 7, below, compares the skulls of *Homo sapiens* and *Homo erectus*.

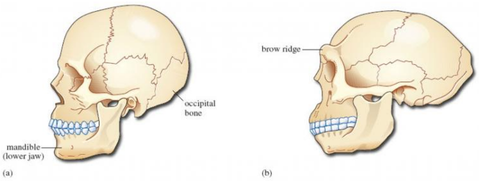

Figure 7 comparison of skulls of (a) *Home sapiens* and (b) *Homo erectus*

Figure 7: Lewin, R. (1999) *Human Evolution* (4th edn) Blackwell Publishers Ltd

Question 6

Question: Write a bulleted list summarising the differences between the skulls of *Homo sapiens* and *Homo erectus*.

Answer

This list highlights just the most striking differences between the two skulls:

- Huge brow ridges are prominent in the *Homo erectus* skull, but not in the *Homo sapiens* skull.
- *Homo sapiens* has a high vertical forehead, whereas the *Homo erectus* skull has a low flat forehead.
- The teeth are larger in *Homo erectus* than in *Homo sapiens*.
- There is a distinct bulge (formed from the occipital bone) at the back of the *Homo erectus* skull, which is not apparent in the *Homo sapiens* skull.
- The face of *Homo erectus* is more massive and forward-projecting than that of *Homo sapiens*.
- The mandible (lower jaw) is larger and longer in *Homo erectus* than it is in *Homo sapiens*.

The differences between the two skulls are so clear that you may now be wondering why *Homo erectus* is classified as *Homo*. Increased brain size is a major defining feature of *Homo*. As you've seen, available *Homo erectus* skulls have a brain size of about 750-1200 cm^3, a considerable jump in brain size compared to 450 cm^3 for *Australopithecus afarensis* (Figure 6). How can we link the increased brain size of *Homo erectus* to diet?

Brain tissue has a continuous high rate of energy consumption, so the larger the brain relative to body size, the greater the energy demand. LoM states that the human brain accounts for about 20% of the body's total energy expenditure [p. 298]. It is logical then to suggest that increasing brain size would have increased pressure on *Homo erectus* to find high-energy food. Fossil and archaeological evidence indicate that *Homo erectus* increased consumption of bone marrow and meat. Meat is a high-energy food that contains little indigestible material. Bone marrow, especially that of ungulates, is mainly fat, and so even richer in energy.

Activity 7

Drawing on your notes from the TV sequences showing how orangutans obtain fruit (Activity 2), how chimpanzees obtain fruit, leaves and meat (Activity 3), and how human hunters obtain meat (Activity 4), explain, in about 100 words, how techniques used for obtaining meat differ from those used for obtaining fruits and nuts.

Answer

Fruits and nuts are abundant seasonally and locally and require picking. Orangutans and chimpanzees have to travel to fruit-bearing trees at appropriate times. Access to the flesh of some fruits and the kernels of nuts may require removal of a hard husk. In contrast, the meat of wild animals is a food resource that has to be chased and caught (e.g. chimpanzee hunting colobus). Furthermore, prey animals are usually widely distributed, and mobile; a predator may have to travel many kilometres before finding prey, and needs to walk or run even further and much faster in order to catch it (San people).

Biologists describe meat as a high-quality food that is distributed in small patches, in contrast to leaves, which are an abundant low-quality food. Fruit is a high-quality food, distributed in occasional large patches.

As DA points out, early humanoids (hominines), did not have dagger-like canine teeth or powerful jaws, and could not run fast enough to catch an antelope [p. 298]. Modern-day hunter-gatherers cooperate with each other when hunting large animals and use weapons to kill the animals from a distance. *Homo erectus* is likely to have used similar strategies. We can imagine a group of *H. erectus* in which males cooperated both in hunting, and in defending their territory. *H. erectus* probably also scavenged the kills of carnivores such as lions or hyenas.

Sites where associations of fossil animal bones and stone tools have been found are interpreted by many archaeologists as areas used by groups of ancient hunter-gatherers. Site 50 at Koobi Fora in Kenya, dated at about 1.5 million years old, is one such example. Fossil remains of *H. erectus* have been found there, and also many tools made of local stones and many fossilised animal bones. Several stone flakes show signs of wood whittling and a few of them appear to have been blackened by fire. Evidence of fireplaces, basin-shaped reddish patches, was found at the site. This suggests that these groups of hominines, *H. erectus*, were processing and eating meat and bone marrow, spending at least some time at the site. In some bones, carnivore tooth marks are overlapped by cut marks made by stone tools, suggesting that hominines scavenged from carnivore kills. Other bones have tooth marks overlapping cut marks, indicating that hominines used the bones first. Therefore, the evidence suggests that both hunting and scavenging were important.

Although we are unsure about precisely how *Homo erectus* used supposed base camps, a picture is emerging of a complex social structure. Catching prey requires stamina and strength, together with skills such as designing and making stone tools. Increased brain size and complexity links to social skills, including planning, cooperation and communication between individuals. Another factor linked to increased brain size includes the long time taken for post-natal brain development in offspring. Infant helplessness means that females have to devote much time to caring for babies. Nursing females require support from a male partner and from the group as a whole. Prolonged childhood after infancy provides the time for infants to learn from their mothers and from other members of the group. When we put all these factors together, it becomes apparent that we are now looking at natural selection operating within a complex social group. We know that the basis for natural selection is reproductive success. Genes possessed by those individuals that produce the most offspring become prominent in a population, and also within a social group.

Question 7

Question: Speculate on the features of an individual male *Homo erectus* that would increase his chances of reproductive success within a complex social group of hunter-gatherers.

Answer

Presumably those males who are the most skilled in obtaining food would leave the most offspring, because of their physical prowess, their social standing within the group, and also their ability to provide food for females with infants. The difficulties of hunting prey animals mean that individuals with both physical strength and social skills enabling them to make alliances, plan and cooperate with others would be the most successful. Physically weaker individuals who can build up alliances within the group may triumph over a stronger challenger, with the help of allies. Furthermore, for *Homo* - a meat eater - the ability to communicate with other members of the group would improve cooperation during hunting.

Forming alliances within a social group, and thereby gaining dominance, itself opens up opportunities for mating. Social interaction is important in primates for successful mating and production of offspring. For *Homo*, social interaction reaches levels of complexity not seen in other primate species. The ability to plan, predict consequences, cooperate and compete with others links to increased brain size and complexity. The effects of natural selection in a social environment would increase brain complexity still further. Such a process has been termed an 'evolutionary ratchet', which acts like a self-winding watch, increasing brain complexity and intelligence of the species.

6 Modern *Homo sapiens*

Modern *Homo sapiens* evolved in Africa about 200 000 years ago, migrating out of Africa over a long period of time. In doing so they colonised much of the world, displacing populations of *Homo erectus* and other *Homo* species. The term 'modern' implies that the people were similar to *Homo sapiens* living today, in both appearance and behaviour. Evidence for an African origin includes the find in Ethiopia of the oldest known *H. sapiens* fossil, the Omo Kibish skull, dated at 130 000 years old. Fossil *H. sapiens* dated at 120 000 years old have been found in Israel, suggesting there was relatively little delay in human migration. LoM Chapter 10 offers a brief glimpse of the Cro-Magnon people, the first *H. sapiens* population to colonise areas now known as France and Spain, about 40 000 years ago.

Question 8

Question: Use the information on the Cro-Magnon art in LoM to summarise the way of life and behaviour of the Cro-Magnon people.

Answer

The example of cave art in LoM p. 301 demonstrates that the Cro-Magnon people were exceptionally skilled artists. The painting depicts a bison, partly disembowelled. A human figure is close to the bison, together with a bird with a spear sticking into it. Other paintings described in the text are of animals with what look like spears in their flanks. Such art suggests that the Cro-Magnon people were skilled hunters.

Such evidence as this suggests that the evolution of *Homo sapiens* coincided with an unprecedented flowering of art, culture and social behaviour, which some anthropologists explain in terms of an underlying genetic change coincident with an increase in brain size. What else do we know of the way of life of Cro-Magnons? Fossil and artefactual evidence shows that they used caves as shelters. They used fire for cooking; ancient hearths have been found in cave sites containing evidence of occupation by Cro-Magnons. They were skilled toolmakers, using stone to make blades for cutting and slicing animal carcasses and also bone and antler for harpoon-like spears. Figure 8a and b show a range of such Cro-Magnon tools.

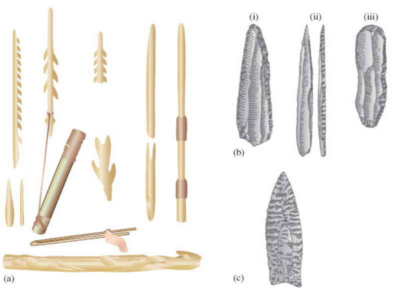

Figure 8 examples of tools used by modern humans. (a) Cro-Magnon bone and antler tools and the use of a spear thrower. (b) Cro-Magnon stone tools: (i) blade, (ii) point (two views), and (iii) end-scraper. (c) Clovis point, about 7 cm long. (This was inserted into the split end of spear shaft and tied in place by hide.)

Figure 8: Stringer, C. and McKie, R. (1997) *African Exodus: The Origins of Modern Humanity*, Vintage/Ebury (a division of Random House Group)

The precise timing of the earliest human migrations to what is now America and Canada is the subject of argument. We do know that around 12 000 years ago, during the last Ice Age, people from Siberia crossed the Beringia land bridge and entered what is now called Alaska. They were able to move south by means of an ice-free corridor stretching from Alaska through Canada's Yukon and Northwest territories, to southern North America.

These people, the Clovis, were efficient hunters, using spears tipped with a sharp, fluted stone point, the Clovis point, which is illustrated in Figure 8c. When the Clovis first arrived in America, there were vast populations of indigenous large and giant mammals, including bison, elk, yak and lion. The largest mammals, including mammoth, giant ground sloth and mastodon, became extinct by 10 900 years ago. Some researchers argue that these animals were exterminated by Clovis hunters. Although the numbers of Clovis people were not very large, it was likely that they were killing more animals than they could eat. Other experts argue that massive change in climate at the end of the last Ice Age caused the extinctions.

We will never know for sure how the large mammals became extinct, because the extinctions coincide with both the establishment of modern human populations in the Americas, and the end of the last Ice Age.

There is evidence that as mammoth populations declined, Clovis people switched to hunting bison. Fossil evidence from the Jake Bluff site in Oklahoma, dated at 10 800 years old, indicates that a group of hunters herded about 8-15 bison into a dead- ended gully, an arroyo. Hunters sitting at the top of the arroyo, 3 m above the bison, speared them with Clovis points. The bison were processed at the site, with legs passed up to the top of the arroyo and the main body of the bison processed on the arroyo floor. But the hunting activities of Clovis and succeeding peoples did not have a significant effect on the bison population. Bison were abundant in America and Canada, with numbers estimated at 150-300 million, until the continent was colonised in the 17th to 20th centuries by European settlers. This colonisation was accompanied by a sustained and massive overkill of bison. By 1900, the vast herds of bison had been reduced to 1000 animals, by the activities of a relatively small population of humans.

Some seek to justify the massacre of the bison on grounds of the need to make space for the livestock and arable farms of the European settlers. Farming, accompanied by a more settled lifestyle, had been long established in Europe by the time Europeans arrived in America. In fact, animal and plant domestication had started about 12 000 years ago, in the Near East.

Question 9

Question: Speculate on the possible pressures that resulted in most populations of *Homo sapiens* becoming sedentary agriculturists.

Answer

Population increase would have resulted in an increased demand for food and the extinction of prey animals. Climate change may have promoted plant growth, making it easier to domesticate food plants such as cereals. Social factors may have contributed too; groups of people found a sedentary way of life more comfortable and compatible with increasing social complexity.

Question 10

Question: Summarise the advantages associated with domestication of plants and animals that are suggested by DA in LoM Chapter 10.

Answer

Domestication of plants and animals enabled humans to settle in permanent communities. By having plant and animal food under their control, human communities were able to increase in size. Division of labour became feasible, with individuals having specific roles within communities, e.g. cloth weaving, pottery making and eventually metal work.

The decline of prey animals and the increasing numbers of people provided the pressure for continuing development of agriculture in most populations. Agriculture is linked to development of towns and cities, because it forces a sedentary existence. Within settled human communities, the culture and hierarchy has become more complex, and food production techniques have had to intensify. As DA demonstrates by his chilling description of the lost Mayan city of Tikal [p. 307], huge populations of cities have to depend on food produced by agriculture. Parallels with modern-day cities are tempting, if only as a reminder of our dependence on intensive and perhaps non-sustainable agricultural practices.

7 The threat of extinction

DA ends his book by writing eloquently of the dangers of extinction faced by mammals, from habitat loss as we exploit our environment to produce more and more food, for our growing population. However bleak the picture, there is still time and opportunity to save mammal species from extinction. Although bison in the USA and Canada were reduced to barely 1000 individuals in 1900, their numbers have now risen to well over 150 000 thanks to the efforts of First Nation indigenous peoples, and ranchers and conservationists.

Unfortunately, the news is not so good for primates, especially apes. The Primate Specialist Group of the World Conservation Union, states that one in three of all primate species is now threatened with extinction. Half of the world's most endangered primates live in Asia; one of those species is the Sumatran orangutan. On their website, the Sumatran Orangutan Society (SOS) reports that orangutans may become extinct in the wild within 10 years. SOS documents the tragic consequences on the Sumatran orangutan population, of illegal logging and the deliberate starting of fires for forest clearance for timber and palm oil plantations. Such activities account for the loss of over 80% of orangutan habitat over the last 20 years. The loss of forest forces orangutans to stray into farms or palm oil plantations where they are captured or killed. Some captured orangutans, along with those that were kept as pets until 'owners' tired of them, are taken to rescue centres, similar to Camp Leakey which featured in the TV programme. There is another rescue centre at Bohorok, adjacent to the Gunung National Park, but rescued orangutans cannot be released into the park because of the risk of spreading infectious diseases. The loss of orangutans from the forest ecosystem would have severe consequences. They play a crucial role in forest regeneration because of their diet; the fruits and seeds they eat are dispersed in their faeces - without orangutans in the forest, many species of plants could disappear.

The Gunung National Park in northern Sumatra is part of the vast Leuser Ecosystem, which occupies two million hectares and includes swamp forest, lowland forest, lakes, rivers, and two active volcanoes. The rainforest in the area is considered to be sacred by the local people. The Sumatran orangutan, genetically different from the Bornean orangutan, lives in the swamp and lowland forests of the National Park. In the TV programme, you saw a group of Sumatran orangutans feeding in the swamp forest. Other species living in the National Park include the Sumatran tiger (you caught a brief glimpse of this species in the programme from 03.42-03.50), elephant, rhinoceros, clouded leopard, sun-bear, slow loris, gibbons and monkeys. Even though one-third of the Leuser Ecosystem, including the swamp forest, is National Park, it is under threat. In September 1999, the Suaq Balimbing research station in the Park was abandoned by the staff, at a point where it was entirely surrounded by illegal logging activity. Despite requests for help from the authorities, no assistance was provided and illegal logging continued without interruption. The area around Suaq Balimbing had a high density of orangutans, seven individuals per square kilometre. Researchers had been studying the growth and productivity of the trees used by the orangutans as sources of fruit. All trees with a trunk diameter greater than 20 cm were removed by the illegal loggers.

Even planned selective logging would cause problems, as removal of the mature fruit trees that orangutans depend on for food puts the animals at risk of malnutrition. To date, over 25% of the Gunung National Park has already been damaged by the illegal logging that is still ongoing. The damage to the Leuser ecosystem has been exacerbated by the large-scale flooding and landslides in northern Sumatra and Aceh in 2000, which destroyed thousands of hectares of rice fields and killed ten people. During the initial preparation of this course (2003), the local Acehnese authority planned to build a network of roads in the park. The one road that now crosses the Gunung National Park is used by illegal loggers and poachers as an entry route into the heart of the Leuser ecosystem.

Sumatran Orangutan Society

Other news from Sumatra

June 2002

Indonesia still contains some large tracts of pristine tropical rainforest, with an abundance of mammal, bird, reptile and plant life. The Leuser Ecosystem, approximately two million hectares in extent, is the only place on the planet where Sumatran orangutans, tigers, elephants, rhinoceroses and clouded leopards can be found together. Other wildlife includes the sun bear, slow loris, jungle rabbit, gibbons, monkeys and countless reptile, amphibian, bird and plant species, many of which are highly endangered.

The area consists mostly of forested mountain slopes, but also contains lowland forests, swamp forests, rivers, lakes, and two major volcanoes. Orangutans are mostly found in the swampy and lowland forest. The rainforest is of great importance to many local people, and unoccupied primary forest is considered sacred according to traditional beliefs.

In recent years, logging and poaching in the Leuser Ecosystem has decimated vast tracts. At present only about one third of the Leuser Ecosystem has been designated as a protected area. However, even the protected Gunung Leuser National Park has been severely damaged by illegal incursion. One conservation organisation, the Leuser Development Programme (LDP), funded by the European Union, is campaigning for the park to be extended and for effective law enforcement to protect the forest. Their programmes include working with local people to reduce their dependence upon unsustainable forest exploitation, and to encourage their embrace of the benefits of maintaining the forest, including lasting water, soil fertility, local climate regulation, flood control, and the potential of eco-tourism in some places.

These projects are being jeopardised by a new plan to build several roads across the Leuser ecosystem, linking the province of Aceh to Sumatra Utara. At present only one major road exists dissecting the forest, and this has already caused an influx of loggers and poachers into the heart of the forest. The LDP team predicts that if the road-building project is implemented, the resultant logging will fragment the forest into nine unconnected areas by 2010. This will mean that many creatures are isolated in ever diminishing areas where future viability is in doubt. At the same rate of deforestation, it will not be long before the entire forest has vanished.

The project is being pushed forwards by the Acehnese authority, despite opposition from Indonesia's central government. LDP is lobbying potential funders to reconsider their role in this project, and is petitioning authorities in Aceh to abandon the plan, citing the potentially catastrophic effects this would have on local communities, as well as on the Leuser's ecosystem's future. It is imperative that this project be stopped. S.O.S has offered to support LDP in an international campaign to prevent the road-building plan from being implemented. Please visit our campaign page for ways to help stop the road-building.

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Figure 9 extract from the website of the Sumatran Orangutan Society. For an enlarged version, click on 'View document' below

Figure 9: Courtesy of the Sumatran Orangutan Society

Click 'View document' to open a larger version of Figure 9

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Activity 8

Study Figure 9, which shows an extract from the SOS website, including the map of the Leuser Ecosystem showing the plans for the new roads (depicted in orange through the green rainforest areas). Predict two likely effects of the roads, listing your ideas as bulleted points.

Four possible effects are listed here; you may have thought of others.

- From the map, it looks as if the roads will split the Leuser Ecosystem into nine unconnected parts, isolating the animals in each part. Orangutans move around the forest, harvesting fruits as they come into season and the roads will block their access to important sources of food.
- Animals will follow their traditional routes around the ecosystem and will be at risk of being killed by traffic.
- The roads will provide an even easier route for poachers and illegal loggers to gain access for their activities.
- Increased illegal logging is likely to exacerbate the problem of flooding - not surprising, since much of the swamp forest is regularly inundated.

Given the vulnerability of so many of the mammalian species discussed in the 'Studying mammals' units, the topic of conservation is an appropriate one with which to close this course, and indeed the series as a whole. This information about the Sumatran orangutans was obtained from the web source identified. Such websites are invaluable for gaining up-to-date information about conservation issues. I hope you will feel prompted to find out more about these pressing issues on your own initiative.

Conclusion

This free course provided an introduction to studying Environment & Development. It took you through a series of exercises designed to develop your approach to study and learning at a distance, and helped to improve your confidence as an independent learner.

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Figure 4 Reprinted from Fleagle, J. G. (1987) *Primate Adaptation and Evolution*, pp. 81 and 107, copyright © 1997, with permission from Elsevier;

Figure 6 Jones, S., Martin, R. and Pilbeam, D. (1992) *The Cambridge Encyclopaedia of Human Evolution*, Cambridge University Press;

Figure 7 Lewin, R. (1999) *Human Evolution* (4th edn) Blackwell Publishers Ltd;

Figure 8 Stringer, C. and McKie, R. (1997) *African Exodus: The Origins of Modern Humanity*, Vintage/Ebury (a division of Random House Group);

Figure 9 Courtesy of the Sumatran Orangutan Society.