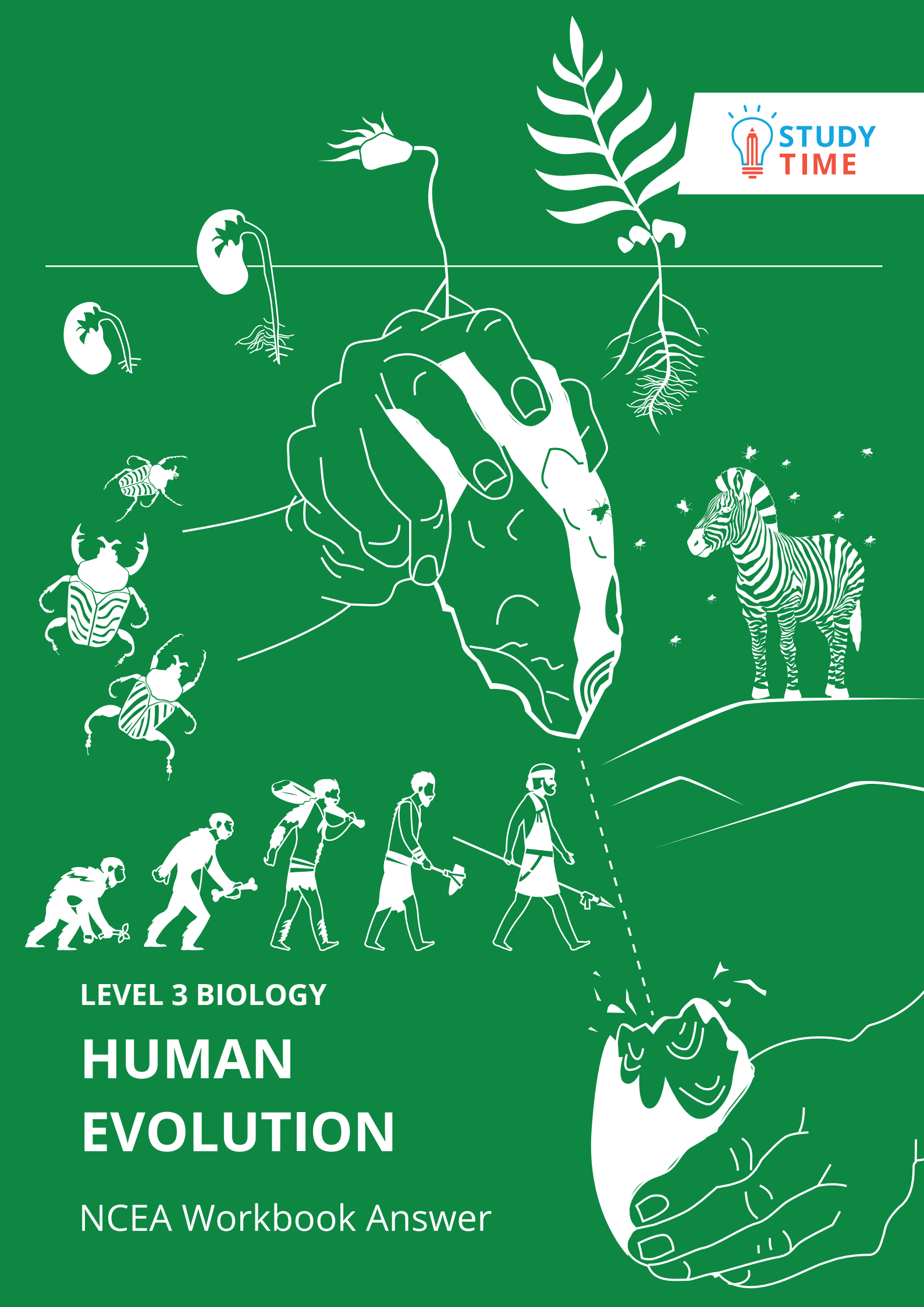


LEVEL 3 BIOLOGY

HUMAN EVOLUTION

NCEA Workbook Answer

Section One
The Foundations

1. Early Hominids

a. The group of primates made up of humans and our most recent closely related ancestors.

b. Hominids encompass all great apes, as well as hominins, whereas hominins only refer to humans and our early ancestors.

c. *i.* Prosimians.

ii. New World monkeys.

iii. Old World monkeys.

iv. Great apes.

v. Hominins.

d. An entirely, or primarily tree-dwelling lifestyle. Arboreal species sleep, eat, and socialise in the tree canopy.

e. *i.* Opposable toes to better grip tree branches.
ii. A tail for balance and an extra limb to grip trees.
iii. Quadrupedal limbs to better climb and move between trees.

f. The environment became hotter, and the trees receded to create a savannah environment.

g. When a species' niche changes, the adaptations they have may no longer be suited to the environment. They will either be out competed by new species and forced into new niches, adapt in new ways, or become extinct.

h. *i.* Little shade due to few trees.

ii. Tall grasses covering the plains.

iii. Higher temperatures.

i. *Australopithecus afarensis.*

i. 3-4mya (million years ago).

ii. Lucy's remains are the oldest to date that showed a primarily bipedal lifestyle. This aligns with geographical changes in Africa, from an arboreal niche to the new savannah landscape.

j. *Homo habilis.*

i. 1.5-2.4mya in the African savannah landscape.

ii. Homo habilis was the first species to begin using tools (Oldowan tool culture). They were also the first species to use speech, however, this is limited to grunts and sounds, as opposed to any fully developed language.

k. *Homo erectus.*

i. 1mya-300,000kya (thousand years ago).

ii. The use of fire and more advanced tools (Acheulean tool culture).

l. Germany.

i. ~300,000kya.

m. *Homo neanderthalensis* (i.e. Neanderthals).

i. 230,000-28,000kya.

ii. A more advanced tool culture (Mousterian).
Culture and ritualistic behaviour.

n. ~160,000kya-present day.

o.

Hominin	Time Period	Brain Size	Tool Culture	Advancements
A. afarensis	4 - 3 million years ago (mya)	380 - 450 cm^3	No tools	Fully bipedal
H. habilis	2.4 - 1.5 mya	500 - 800cm^3	Oldowan	First to make stone tools
H. erectus	1 - 0.3 mya	800 - 1100cm^3	Oldowan + Acheulean	First to use fire
H. neanderthla - lensis	230,000 - 28,000 years ago	1200 - 1750 cm^3	Mousterian	First to care for elderly and bury dead
H. sapiens	160,000 years ago - present day	1200 - 1700cm^3	Upper Palaeolithic	Current hominin species

2. Structural Changes

a. Walking primarily on two legs.

i. The change in climate and landscape from an arboreal niche to that of a savannah environment.

ii. Better thermoregulation as less surface area is directly exposed to the sun.
Free arms could carry offspring and food long distances.
Free hands to better manipulate objects and eventually create tools.

iii. An increased risk of back issues, i.e. a slipped disc.
More difficulty in pumping blood around the body.

b. Foramen magnum.

i. In H. sapiens, the foramen magnum is centrally located at the bottom of the skull to better balance an upright posture. In great apes and our earlier quadrupedal ancestors, this is located at the back underside of the skull to position the head forward when on all fours.

ii. The nuchal crest is where the neck muscles attach to the skull. For quadrupedal species, this needs to be larger as the head is positioned out from the body and requires more muscle to hold it up. Therefore, in H. sapiens, the nuchal crest is relatively small, as the head is already positioned over the body and does not require the extra muscle.

c. An S-shaped spine helps to keep the centre of gravity above the hip joints and allows species to walk without as much stress on the legs. Additionally, it acts as a shock absorber for ground impact.

i. Quadrupeds have a C-shaped spine. This counterbalances the force of all of their organs pushing downward due to gravity when walking on all fours.

d. A bowl-shaped pelvis is short and wide to reduce the stress on the pelvis from the upper body. Additionally, this shape is able to support the internal organs and allow for the further encephalization (growth and complexity) of the human brain, as the bowl-shaped pelvis is large enough to give birth to offspring with larger heads.

i. Quadrupeds (apes) have long, narrow pelvises which have a large surface area to attach to large leg muscles.

e. The angle where the femur angles inward from the pelvis.

i. The valgus angle keeps the centre of gravity, positioning the body weight through the middle of the pelvis when walking and giving humans a knock-kneed stance.

f. In humans, the big toe faces forward to better provide forward thrust while walking. Alternatively, in apes, the big toe faces outwards (i.e. is opposable) which allows them to grip with their feet to move in trees and handle items.

i. Foot arches help to absorb the shock of walking in humans, as their full body weight is in each step. Therefore, humans have foot arches.

g.

Structural Features	Humans (Bipedalism)	Apes (Quadrupeds)
Skull	Central foramen magnum and small nuchal crest	Foramen magnum right and the back and a large nuchal crest
Spine	S-shaped spine	C-shaped spine
Pelvis	Bowl-shaped (short and wide) pelvis	Long and narrow pelvis
Femur	Valgus angle (femur angled inwards)	No valgus angle (femur hanging vertically downwards)
Foot	Forward-facing big toe and presence of arch in the feet	Opposable big toe facing outwards and no arch in the feet.

h. A U-shaped jaw, small teeth with a combination of molars and incisors, and small zygomatic arches.

i. Apes have a rectangular jaw, with larger teeth (especially canines) and large zygomatic arches to support the muscles necessary to chew. Additionally, apes have larger brow ridges to ease the stress on the jaw that results from chewing difficult-to-eat foods.

i. Bipedalism is an adaption which catalysed brain development in the Homo genus as it freed up hands to become more dexterous, allowing for tool development and the eventual hunter-gatherer lifestyle which further selected for intelligence.

i. The size of the brain in relation to the body mass (known as the encephalization quotient), as well as the arrangement of the brain in regards to cortex development.

3. Human Cultural Evolution

a. Cultural evolution is defined as the passing on, and development of knowledge from one generation to the next through social learning and interactions, over any biological means.

i. Cultural evolution develops much faster than that of biological, as a lot of new information can be passed down through just one generation. Comparatively, biological evolution takes a much longer time and developments (i.e. adaptations) need to be bred into a generation, rather than taught.

b. The conscious development of materials into an object intended to carry out tasks.

c. Oldowan.

i. H. habilis.

ii. Oldowan tools were created with river stones and were chipped on one side to make a sharp edge.

d. Acheulean.

i. H. erectus, but they were also used by H. heidenbergenesis.

ii. Acheulean tools were symmetrical, flattened handaxes, made by chipping at both sides of the stone.

e. Mousterian.

i. The Levallois technique, a method of scraping tools which provided more control.

ii. Handaxes, choppers and scrapers, and spears, all variations of carved/chipped stone heads often bound to wood.

f. Upper Palaeolithic.

i.

Bone	Needles
Antler	Hooks
Flint	Harpoons

ii. Punch blade method.

g. H. erectus.

i. Enabled the cooking of food which made digestion easier and made a wider range of food available to consume as microbes were killed by the fire.

Warmth! A heat source allowed for our early ancestors to occupy colder environments. Fire created more light to allow people to be active for longer during the day.

Fire also warned off predators and allowed early ancestors to be safer (especially at night).

h. Farming allowed for a more predictable and steady supply of food for early humans.

Domestication of animals allowed for more meat and other animal products that could be used for further crafting.

Less time spent hunting and gathering food meant more time could be spent on other tasks.

i. Diets were restricted to whatever humans could grow in that environment which could become problematic for nutritional balance. Increased dependence on crops also meant that if little was grown, the group as a whole would suffer.

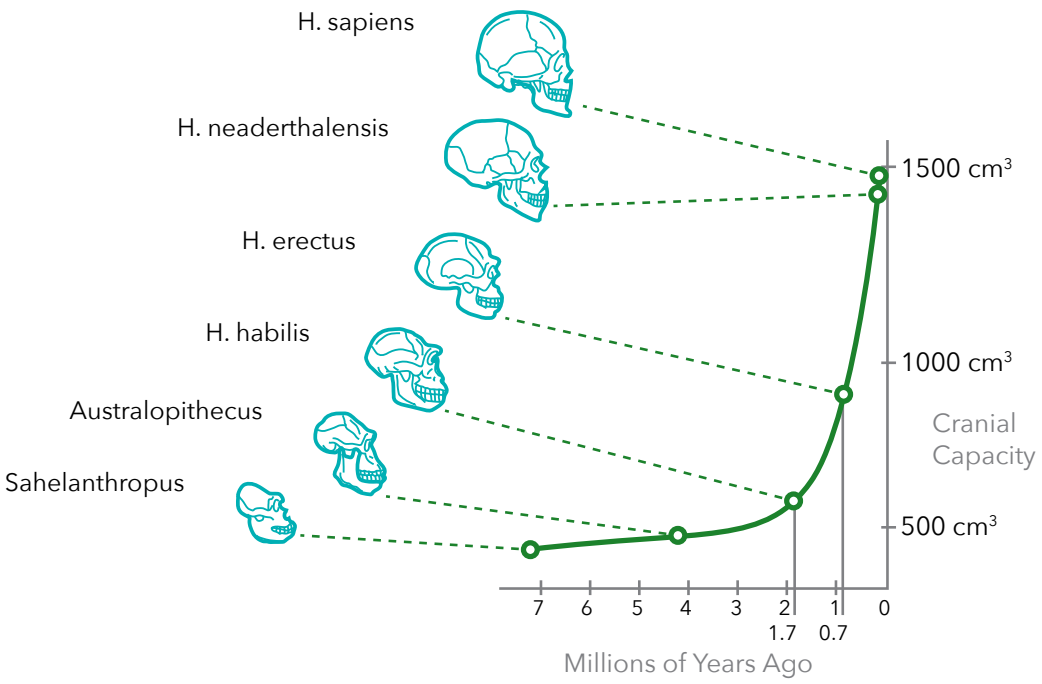
Further settlement of humans and larger population densities mean that disease and illness became more common.

Increased intraspecific competition over other settlements, land, animals and resources.

i. The general trend of increasing brain size is associated with higher levels of intelligence.

i. H. neanderthalensis, they had a very similar average brain size to H. sapiens and displayed cultural and ritualistic behaviours. However, H. sapiens were more intelligent due to the **structure and arrangement** of the brain, as opposed to size alone.

ii.



j. The Broca's and Wernicke's areas. The Broca's area of the brain is responsible for producing speech, while the Wernicke's area is responsible for speech comprehension. Both of these areas have to work together to successfully communicate.

i. Grunts and other sounds. Early species like H. habilis didn't have a voice box, so they would not have been able to communicate in the same way we consider language today.

4. Human Origin and Dispersal

a. The mass migration of our early ancestors out of Africa.

i. The Replacement theory.
The Out of Africa model.

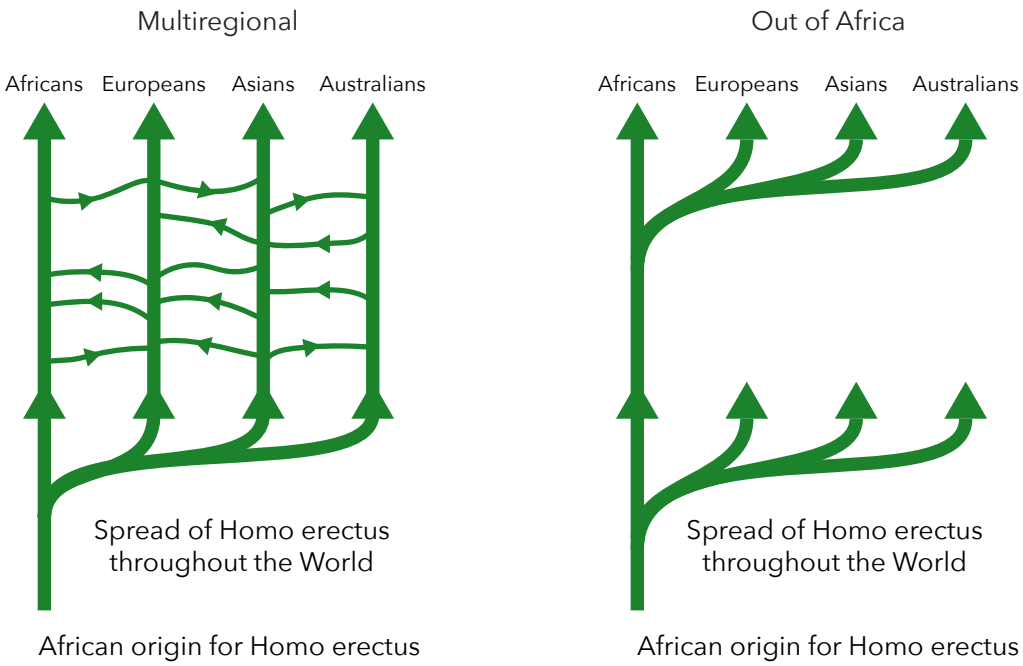
b. Fossil evidence.
Mitochondrial DNA.
Y chromosome analysis.

i. Fossil evidence can tell us when and where an organism came from, and what they may have looked like.

Mitochondrial DNA is inherited exclusively from the maternal side and is arranged in double-stranded circles that are not prone to processes like crossing over which introduces genetic variation. Therefore, the rate of mutation is slower and can be traced through one lineage, rather than nucleic DNA.

Y-chromosome evidence works similarly to mitochondrial DNA, but the y-chromosome is traced through the paternal line instead of the maternal.

c.



d. The Multiregional theory suggests that H. erectus left Africa and formed different populations in different geographical areas before eventually evolving into modern humans.

i. Transitional fossils (i.e. not quite H. sapiens) found in places such as Asia which supports the idea that H. sapiens evolved simultaneously in a range of locations.

e. The model of dispersion whereby H. erectus first evolved into H. sapiens while still in Africa, and then some early humans left Africa and colonised other locations around the globe.

i. Genetic analysis of African individuals are more genetically diverse than Asian and European populations, suggesting that H. sapiens originated in Africa, as there has been the most time for mutations to arise. Additionally, this model is supported by fossil evidence, where some fossils in Africa have been dated back to as far as 200,000 years. Comparatively, H. sapiens fossils in other continents are not nearly as old.

Section Two
Exam Skills & Mixed Practice

Question One

Evolutionary forces have dictated the adaptations that became selected for in our early ancestors. Some of the most notable changes are that of the ape and human skull. Some of the main changes between an ape and human skull are the location of the foramen magnum, the jaw shape and teeth structure, as well as the size of the zygomatic arches and brow ridge between each species.

The foramen magnum (the hole at the base of a skull that connects the spinal cord) is located directly beneath the skull in H. sapiens, which allows for the skull to be oriented directly above the body. In comparison, the foramen magnum in apes is oriented at the back of the skull, to hold the head out from the body instead. This difference relates to how each species moves around. Namely, that apes are quadrupeds (i.e. walk on all fours), whereas humans are bipedal. Bipedalism refers to moving around on two legs and was a significant contributor to the development of modern humans.

Another endocranial difference between these two species is the jaw and teeth structure. Humans have a U-shaped jaw, smaller teeth, and a combination of incisors and molars to eat an omnivorous diet. Apes, on the other hand, have a rectangular-shaped jaw, with large canines and molars for chewing vegetation and intimidation of other apes. The changes observed between each species is supported by their varying diets (i.e. human food is less fibrous and requires less chewing).

Lastly, the zygomatic arches and brow ridges in apes are much larger than that of humans. This is because their vegetarian diets require more mechanical chewing and therefore they need larger muscles to support this. The brow ridge and zygomatic arches are larger to accommodate these larger muscles and reflect their diet. Humans, on the other hand, can cook food as well as being omnivorous, meaning they have much less difficulty breaking food down for digestion.

Each adaptation noted between each species allows them to better survive in their respective niches. It is in an ape's best interest to be quadrupedal, as their niche is in trees and their diet is vegetarian. Humans, on the other hand, adapted to a savannah environment where it was more beneficial to move on two legs, and broaden their diet. The endocranial features of H. sapiens ancestors look increasingly similar to an apes' skull, the older the skull is. This suggests that over millions of years, these adaptations have allowed for our early ancestors to survive and further catalysed later adaptations in the Homo genus that have resulted in H. sapiens today.

Question Two

The development of both fire and tools are significant in the path of H. sapiens cultural evolution, where cultural evolution refers to the passing down of knowledge to the next generation through social learning, as opposed to anything biological. Tools were used by our early ancestors first, with H. habilis (otherwise known as the 'Handy Man') 2.4-1.5mya. The first age of tools is known as the Oldowan tool culture. These kinds of tools were river stones, with intentional chips taken out of it to make a sharper edge. Tools were a huge advantage to our early ancestors, as it allowed them to manipulate different materials, cut, scrape, and create things previously unthought of.

As tools became increasingly complex, H. erectus also gained control over fire, around 1-0.3mya. At this stage, tools had developed to the Acheulean tool culture which resulted in slightly more complex tools such as handaxes. Fire introduced more advantages to H. erectus, such as the ability to cook food (thus allowing for more food to be palatable, as well as safe), safety from predators, a way to create new materials (e.g. hardening wood), as well as the warmth that allowed them to occupy a wider range of niches.

Both tools and fire have been significant in further selecting for intelligence in our early ancestors. As tool cultures became increasingly complex, more foresight and intention can be seen in the resulting tools. From the very basic river stones with a few shards cut off, right up to the upper Palaeolithic era using the much more complex punch-blade method. Not only did tools become more specialised, but they also required more steps to create them, showing the increasing level of intelligence required to be able to create such a tool. Fire has also helped select for intelligence in early Homo species as it requires conscious control over (both because it can harm, and to be able to create). Fire made life for early ancestors significantly easier, and required that they were intelligent enough to be able to confidently control it.

Question Three

Domestication refers to the cultivation or taming of plants and animals to readily supply another species with resources. Early humans domesticated certain plants and animals to their benefit, but it also indicated a significant shift in their lifestyles from hunter-gatherer to an agricultural lifestyle.

Early ancestors survived through a hunter-gatherer lifestyle, where groups continuously moved around in the search of food and resources. However, by taming certain animals and farming crops such as cotton, wheat and barley, humans were able to secure these resources more readily. As a result of this, it was more beneficial to settle in one location and early humans adopted an agricultural lifestyle.

An agricultural lifestyle changed human habits so that they focussed on cultivating the land and raising livestock as opposed to constantly moving around. The benefits of adopting this lifestyle were that early humans could better control their food supply, use other resources for things like clothing and tools, and save themselves a lot of time. Ultimately, these benefits changed the way our early ancestors lived and further sped up the cultural evolution of early humans.

However, domestication did come with its disadvantages. Firstly, early humans became increasingly dependent on farming, meaning groups were left vulnerable if crops were unsuccessful or yields were short. Secondly, this dependence meant that the diets of early humans became limited to what was grown or killed, meaning there was a higher risk of nutritional deficiencies. Thirdly, as humans settled, populations grew and with this came higher risks of disease. Lastly, as multiple groups settled, inter-group competition for resources grew as they fought for land, animals, and crops. These disadvantages did not hinder early ancestors from this way of life though, as the benefits outweighed the costs of an agricultural lifestyle over that of a hunter-gatherer lifestyle.

Section Three Practice Exam

Question One

Biological evolution refers to the increased adaptation of an organism to its chosen environment. Over generations, the most favourable alleles are continuously selected for, resulting in the gradual change of the species' population as a whole.

The zygomatic arches of early hominins were larger than that for modern H. sapiens. These bones supported large jaw muscles which run down the sides of the face and allowed for digestion of more fibrous foods. Australopithecus had large teeth, zygomatic arches, and sagittal crests because their diets consisted of fibrous and difficult-to-chew food. Large teeth, supported with large neck muscles (held up by the zygomatic arches and sagittal crest) allowed Australopithecus to consume this food and, therefore, better survive in their environment.

P. robustus had even larger teeth, sagittal crests, and zygomatic arches than Australopithecus, while this was once thought to be due to an entirely vegetarian diet, it is now thought to be an adaption to be able to eat less-desirable foods when the staples were unavailable or out of season. Therefore, the large endocranial features of P. robustus acts as a safety net, allowing them to break down hearty grasses and foods in less abundant times, such as the extreme cold or heat which could impact their food sources.

H. erectus had the smallest teeth, sagittal crests, and zygomatic arches. Additionally, H. erectus is further down the evolutionary chain than both Australopithecus and P. robustus, and in that time our early ancestors were able to produce fire. Fire has allowed for a wider variety of foods to be eaten, while also making most foods easier to eat and break down. As a result, large teeth, and supporting the neck and facial muscles were not selected for by the Homo genus and they have decreased in size over successive generations.

Both H. erectus and P. robustus have adaptations that have held since their common ancestor, Australopithecus, such as bipedalism. However, their main differences stem from a variation in primary diet. As a result, P. robustus selected for larger endocranial features to consume their food, whereas H. erectus relied on other methods (i.e. fire) to break down the tougher foods for them. As a result, large endocranial features were selected for in the robust Australopiths, while it was not selected for in later Homo species.

Question Two

Cultural evolution is defined as the passing on, and development of knowledge from one generation to the next through social learning and interactions, over any biological means. An example of cultural evolution can be seen through progressive tool cultures, defined as the conscious development of materials into an object intended to carry out tasks.

The Oldowan tool culture was the first, created by H. habilis around 2.4-1.5mya, These tools were chipped river stones that created sharp edges that could then be used to scrape and cut materials. There was no specific method, as there were only a few chips to make it functional.

As later Homo species arose, the tool culture developed and became more complex. The Acheulean tool culture was introduced by H. erectus roughly 1mya and involved more chipping at stones to create flattened tools that could then be used as a handaxe. The Acheulean tools required more time to create with more steps, indicating an increased ability to put in forethought to work towards the final product.

Modern humans, H. sapiens, took tool creation further and introduced the upper Palaeolithic tool culture. This tool culture used a range of materials, including flint, bone and antler to create a range of specialised tools such as needles, hooks, and spears. Specific methods were developed to create these tools, one such being the Punch-blade method. These methods required even more forethought and problem-solving, as early humans had to be able to know in advance what they wanted to make and the order of steps to successfully create it.

Tools are an indicator of increased intelligence in early Homo species as their ability to perceive and manipulate ideas in their head. This is supported by the increased brain mass of our early ancestors. As a result of this, intelligence was selected for by our early ancestors, as the ability to manipulate thought, and turn this into tools bettered their chances of survival. As a result, brains increased in both mass and the complexity of the brain cortexes. Intelligence allowed early ancestors to manipulate their environment which, in turn, better ensured their survival. Therefore, the use of tools not only better ensured their survival but also selected for intelligence which has allowed H. sapiens to thrive.

Question Three

Early Homo ancestors dispersed out of Africa, beginning with H. erectus. The tools and advancements made by the Homo genus allowed them to occupy a wider range of niches, encouraging the mass movement of H. erectus.

One theory, the Out of Africa model, theorises that H. erectus first evolved into H. sapiens while still in Africa, and then some early humans left Africa and colonised other locations around the globe. This theory is supported by genetic analysis of African individuals using mitochondrial DNA found in female samples. It finds that African individuals are more genetically diverse than Asian and European populations, suggesting that H. sapiens originated in Africa as there has been the most time for mutations to arise. Additionally, this model is supported by fossil evidence, where some fossils in Africa have been dated back to as far as 200,000 years. Comparatively, H. sapiens fossils in other continents are not nearly as old.

Alternatively, the Multiregional theory suggests that H. erectus left Africa and formed different populations in different geographical areas before eventually evolving into modern humans. Transitional fossils (i.e. not quite H. sapiens) found in places such as Asia, supports the idea that H. sapiens evolved simultaneously in a range of locations. These transitional fossils are some of the strongest evidence that supports this theory.

In terms of evidence, the Out of Africa model has more support, particularly with more modern methods of genetic tracing. However, each theory is not without its caveats, and the reason that both theories still exist is that one has not been able to fully explain all the evidence available. For example, transitional fossils are difficult to explain through the Out of Africa model, and the DNA analysis of remains cannot be fully explained by the Multiregional hypothesis.

