WHERE DO WE COME FROM? WHAT ARE WE? WHERE ARE WE GOING?

AVINASH KUMAR

Beginning with an account of the discovery of some fossilized 'cave bear bones' in a small valley in 19th century Germany, this article describes the evolution of our genus *Homo* and the many species that comprise it. It ends with outlining some suggestions on how the study of human evolution can be integrated with science classrooms.

It was August of the year 1856. Summer was turning to autumn in Elberfeld, a small town in western Germany. Johann Carl Fuhlrott, a teacher at the local high school and an amateur naturalist and fossil collector, was heading purposefully in the southwest direction.

Fuhlrott had received a message from a mining foreman working in a nearby valley called Neanderthal: workers in his limestone-quarry had broken through the rock-hard layers of clay at the entrance of a cave (refer **Fig. 1**), accidentally unearthing some fossilized bones. It had seemed to the foreman that they were the remains of an ancient cave bear, and he wanted Fuhlrott to come and take a look[1].

A few hours later, Fuhlrott found himself in a cave about 18m above the valley floor and 30m below the top of a cliff. The cave was 2m high, 2.5m wide, and 4.5m deep. He was standing on loam, almost 1.5m thick, which covered the floor of the cave[2].

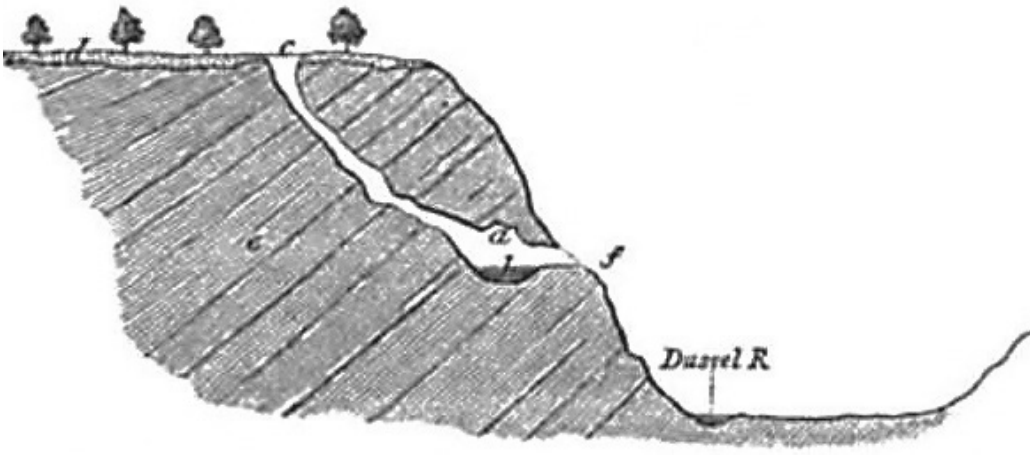


Fig. 1. The location of the cave where Johann Carl Fuhlrott made his discovery.

Credits: Gerbil & HerrAdams, Wikimedia Commons. URL: https://en.wikipedia.org/wiki/File:Kleine_Feldhofer_Grotte.jpg. License: Public Domain

Fig. 2. (a) The bones found in the Neander Valley.

Credits: LVR-LandesMuseum Bonn. URL: http://donsmaps.com/neanderthaloriginal.html. License: Public Domain.

(b) A reconstruction of a Neanderthal man.

Credits: Matanya, Wikimedia Commons. URL: https://en.wiktionary.org/wiki/File:%D7%A0%D7%99%D7%90%D7%A0%D7%93%D7%A8%D7%98%D7%9C%D7%99.jpg. License: CC-BY-SA.

The fossilized bones, he was informed by the miners, had been found in the loamy floor at a depth of about 0.5m. Though initially ignored, they had later fortuitously come to the attention of the quarry owners who managed to salvage 16 bones and bone fragments from the rubble. Knowing Fuhlrott's keen interest in the subject, they now offered these to him.

Back home in Elberfeld, Fuhlrott took stock of the fossilized collection of bones — it included a skullcap with a fragment of the left temporal bone (situated at the sides and base of the skull), a part of the right shoulder bone, a right collarbone, both long bones of the forearm, a complete forearm bone along with some other fragments of the forearm, five ribs, the left half of a pelvis, and both thigh bones[3]. Bent over his desk studying the fossilized remains, the intuition that Fuhlrott originally felt in the cave grew even stronger — the bones were clearly not that of an ancient bear as the miners had assumed; but more importantly — **they seemed like the remains of a human being who was significantly different from modern humans!**

Within a month of Fuhlrott's visit to the cave, a local newspaper published the story of his curious find. This drew the attention of Hermann Schaaffhausen, a Professor of Anatomy at the University of Bonn, who was researching the prehistoric humans of Europe.

Fuhlrott and Schaaffhausen met in Bonn the following November, and Fuhlrott passed on the bones to Schaaffhausen. After about six months of detailed study, they jointly presented the results of their investigations at an academic gathering — with Fuhlrott highlighting the age of the bones as proved by the depth of the stratum in which they were discovered and the mineralization and dendrite formation on the surface, and Schaaffhausen describing the unusual shape of the skull cap (low, sloping forehead and the bony ridges above the eyes) as well as the remarkable thickness of all the bones in general (refer **Fig. 2**).

Both suggested that the bones belonged to a human of pre-historic times, who had inhabited Germany before the arrival of the ancestors of modern humans.

Box 1. Species, Genus and Family:

Starting from Aristotle's time until the late 18th century, it was commonly believed that species do not change or go extinct; and are not genetically related to each other, even if some of them appeared to be similar. It was only in the early 19th century that the idea that species could change over time started to take root among some European naturalists and scientists, such as Lamarck. In 1859, Charles Darwin famously suggested that populations evolved (into different species) through the selection of naturally-occurring variations among its individuals.

Broadly, all organisms that tend to mate naturally, and produce fertile offspring easily, are considered as being from the same species. At times, however, different groups (or populations) of the same species may become isolated from one another. Over thousands of years, each of these different populations tend to accumulate certain genetic changes (or mutations) which are beneficial to their members but may not be present in the other populations of the same species. After a point, such genetic and behavioral changes make inter-breeding between the individuals of these different populations increasingly rare and, subsequently, impossible. These populations are then said to have become distinct species.

Two or more species that have evolved in this manner from a common ancestor are grouped under one genus, and similar genera are grouped under one family. For example, lions, tigers, jaguars, leopards and snow leopards are all considered distinct species as they tend to not mate with each other, and in the rare cases that they do, their offspring tend to not be fertile. These five species are, however, related to a common ancestor, believed to have lived about 6 to 10 million years ago, and hence, these species are grouped together under the genus *Panthera* (refer **Fig. 3**).

The scientific name of each species consists of two parts — the first part, which is common to all five, is the name of the genus; whereas, the second part is specific to each species. So, for example, in scientific terms, lions are called *Panthera leo*, tigers *Panthera tigris*, jaguars *Panthera onca*, leopards *Panthera pardus*, and snow leopards *Panthera uncia*.

These five species of the genus *Panthera*, along with some other species such as those of cougars, cheetahs and domestic cats (which belong to various other genera), together, form the family *Felidae* — more commonly known as the 'family of cats'.

Fig. 3. Some species in the family *Felidae*.

Credits: LittleJerry, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:The_Felidae.jpg. License: CC BY-SA.

Where do we come from?

The practice of identifying organisms using binomial nomenclature, and classifying them using different 'levels' (kingdom, class, order, genus, and species) was formalized by a famous Swedish scientist of the 18th century — Carl Linnaeus. It was also Linnaeus who coined the scientific name of our species: *Homo sapiens* (literally: sapient/wise human).

For almost a century thereafter, it was believed that our genus *Homo* had no other species and other members of our family *Hominidae* (commonly known as the family of great apes) were believed to be our closest relatives (refer **Fig. 4**). The great ape family comprises of four extant (meaning: surviving) genera and seven extant species: the Bornean and Sumatran orangutans (genus: *Pongo*), eastern and western gorillas (genus: *Gorilla*), chimpanzees and bonobos (genus: *Pan*), and humans (genus: *Homo*).

Six years after Fuhlrott and Schaaffhausen had presented the findings of their investigations on the fossilized bones of the Neandertal (*tal* is German for valley), William King, an Irish geologist, began a process that continues to change our understanding of ourselves and our place in this world — he proposed that the Neanderthal bones were neither those of *Homo*

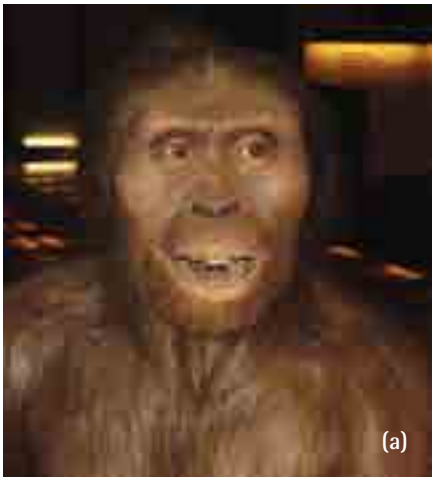


Fig. 5. (a) A reconstruction of *Australopithecus.*

Credits: Wikimedia Commons. URL: https://en.wikipedia.org/wiki/File:Australopithecus_afarensis.JPG License: CC BY-SA.

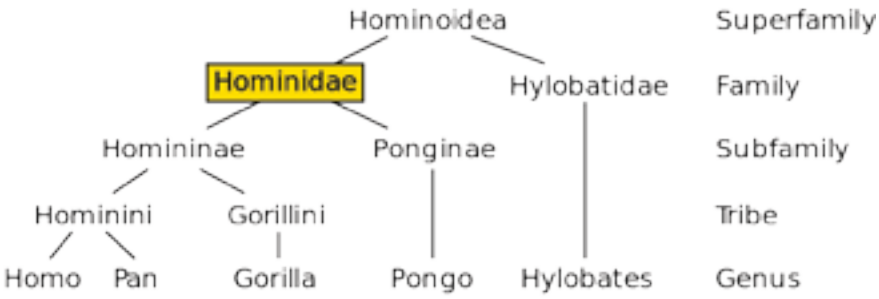


Fig. 4. Members of the family Hominidae.

Credits: Fred the Oyster, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Hominidae_chart.svg License: CC BY-SA.

(b) 3.7 million years old fossil foot-prints.

Credits: Momotarou2012, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Laetoli_footprints_replica.jpg. License: CC BY-SA.

sapiens, nor of any other genus of the *Hominidae* (great apes) family but that of **another human species** — which he called Homo neanderthalensis[4, 5].

Over the last one and a half centuries, with the help of hundreds of newly found fossil records and archeological sites in different parts of the world as well as advancements in fields such as molecular biology and genetics, we have managed to piece together a relatively clearer picture of our evolution as a species.

These detailed investigations tell us that our genus, *Homo*, originally evolved from a now-extinct genus of the great ape family: *Australopithecus* (refer **Fig. 5**). The *Australopithecus* evolved in eastern Africa about 4 million years ago, and gradually spread throughout the African continent. Although their brain size (about 450 cm^3) and jaw-shape were very different from modern humans, *Australopithecans* were obligate (i.e. habitual) bipeds. This was first indicated by a 24m line of 3.7 million old fossil foot-prints of three of its members, that were found preserved in volcanic ash (and discovered in 1976) in what is now Tanzania[6, 7].

An isolated population of one species of the Australopithecus genus is believed to have given rise to our genus *Homo* between 2 and 3 million years ago, before this entire genus became extinct about 2 million years ago.

The oldest known species of the *Homo* genus that is believed to have evolved from *Australopithecus* — i.e. the first humans — were *Homo habilis* (refer **Fig. 6a**). Members of this species were shorter than us in stature (about 4 feet 3 inches tall) with disproportionally long arms, but a much-enhanced cranial capacity of about 600-650 cm^3 as compared to Australopithecans. They were also the first to use advanced stone-tools and flakes regularly, often to butcher and skin dead animals.

The next to evolve were the two closely related *Homo* species – *Homo ergaster* and *Homo erectus. Homo ergaster* is believed to have evolved (either from or independent of *Homo habilis*) about 2 million years ago, and lived in eastern and southern Africa till about 1.4 million years ago. Their cranial capacity, at about 900 cm^3, was higher than that of *Homo habilis* and they used much more advanced and diverse tools, such as bifacial axes.

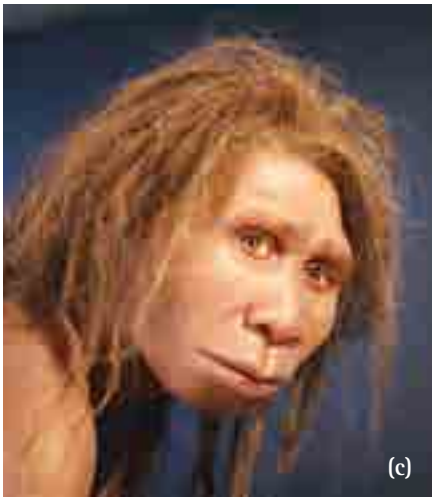
Although it has not been proven conclusively yet, many scientists believe that *Homo ergaster* was the first human species to migrate out of Africa into Europe and Asia, and it was this branch of the *Homo* genus that later evolved into another species: *Homo erectus*. Others hold the view that *Homo erectus* evolved in Africa, and then spread to Asia and Europe. *Homo ergaster* specimens, in their view, are not of a separate species, but of a population of *Homo erectus* that stayed back in Africa. What is commonly agreed upon in the scientific community, however, is that *Homo erectus* spread to regions as far as Georgia, India, Sri Lanka, China, Vietnam and Indonesia between 1.8-1.3 million years ago. This is also believed to be one of the most enduring human species, surviving in some parts of the world till 70,000 years ago.

Homo erectus stood 5 feet 10 inches tall on average, and the cranial capacity of some of the specimens is as high as 1100-1200 cm^3 — which is similar to modern-day humans. They are also believed to be the first humans to cook their food and make controlled use of fire (refer **Fig. 6b** and **6c**).

Fig. 6. Reconstructions of a *Homo habilis* (a), *Homo erectus* man (b), and *Homo erectus georgicus* woman (c).

(a) Credits: Lillyundfreya, Wikimedia Commons. URL: https://en.wikipedia.org/wiki/Homo_habilis#/media/File:Homo_habilis.JPG. License: CC BY-SA.

(b) Credits: Rafaelamonteiro80~commonswiki, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Homo_erectus_new.JPG. License: CC BY-SA.



(c) Credits: User 120, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Homo_georgicus.jpg. License: CC BY-SA.

Meanwhile, a population of *Homo ergaster* (or, of the *Homo erectus* that had stayed back in Africa — depending on which version is finally proven to be right) evolved into another species: *Homo heidelbergensis*, which shared anatomical features with both *Homo erectus* and modern humans. This species seems to have appeared around 700,000 years ago in Africa.

Between 300,000 and 400,000 years ago, some groups of *Homo heidelbergensis* migrated into Europe and some others into Asia. Archaeological sites linked to the European groups have been found in Spain, Italy, France, England, Germany, Hungary and Greece. It was these groups that eventually evolved into the species whose specimen was found by the limestone miners in the picturesque Neander valley of western Germany in the August of 1856: *Homo neanderthalensis*.

The Asian groups of *Homo heidelbergensis* developed into Denisovans (described in the next section) and a group of this species that had stayed back in Africa (and is, at times, categorized as *Homo rhodesiensis*) gradually evolved into our own species: *Homo sapiens* or 'modern humans' (*Homo heidelbergensis*, *Homo neanderthalensis* and *Homo rhodesiensis*, are generally grouped together as archaic/ancient humans).

Recent developments in the field

In everyday language, being called a Neanderthal is taken as an insult — the image of Neanderthals as uncivilized, stupid and uncouth 'cavemen' developed as a result of wrong interpretation of scanty evidence in the 19th century, as well as the religious/political biases of the experts of the time.

Neanderthals evolved approximately (300,000-400,000 years ago) around the same time as modern humans (approximately 200,000 years ago) and shared a common ancestry till *Homo heidelbergensis*. Physically, they were more than a match for us modern humans — comparable in height (about 5 feet 6 inches on average), they had proportionally shorter, but stronger limbs, a reduced chin, a large nose, and a larger, barrel-shaped rib-cage. Overall, they are believed to have been stocky and very strong (refer **Fig. 7**). They also had a greater cranial capacity (1600 cm^3) as compared to us (1300 cm^3).

Neanderthals made highly advanced tools out of bones, antlers, wood and stones — such as hammers, task-specific axes and spears. They kindled fire at will; could use artificial lighting when inhabiting caves; and built dwellings and hearths. They were apex hunters (laying sophisticated traps and hunting in groups to bring down even large animals such as woolly mammoths). While they generally lived in groups of 10-15 individuals, they were, nevertheless, capable of forming larger and more complex social groups at times. Some early mitochondrial DNA evidence indicates that males of this species usually remained in the same social group, while females joined the groups of their 'partners'.

Fig. 7. Reconstructions of Neanderthals.
(a) Credits: Stefan Scheer, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Neandertaler_reconst.jpg. License: CC BY-SA.
(b) Credits: Tim Evanson, Wikimedia Commons. URL: https://en.wikipedia.org/wiki/File:Homo_neanderthalensis_adult_male_-_head_model_-_Smithsonian_Museum_of_Natural_History_-_2012-05-17.jpg. License: CC BY-SA.

Fig. 8. Hollow bear femur with spaced holes.
Credits: File Upload Bot (Magnus Manske), Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Fl%C3%BBte_pal%C3%A9olithique_(mus%C3%A9e_national_de_Slov%C3%A9nie,_Ljubljana)_(9420310527).jpg. License: CC BY-SA.

We have also discovered skeletal evidence which shows that Neanderthals buried their dead at times, took care of their injured — nursing them back to health, were capable of uttering words, and may even have had a language. Other than meat, their diet consisted of cooked and uncooked plant matter, nuts, mushrooms, seals and shellfish. Although we do not know if they traded, we do have evidence that they were navigating the Mediterranean Sea in dug-outs as early as 110,000 years ago. Some archeological sites indicate that they extracted glue from birch bark by heating it at extremely high temperatures; used jewelry and dyes, and collected bird-feathers — possibly for personal ornamentation. One of these sites has also yielded a hollow bear femur with what appears to be intentionally spaced and neatly cut holes (refer **Fig. 8**). It has been suggested that this may have been part of a flute or some other musical instrument.

Homo neanderthalensis and *Homo sapiens* — lived in the same regions (roughly from present-day England to Uzbekistan) for many thousands of years; at times even dwelling at the same sites or in the same caves in which a group of the other species had lived a few decades or centuries earlier. The last group of Neanderthals seem to have survived (in Southern Spain) till about 25,000 years ago. For a comparative perspective, consider the fact that the Halfan culture of Egypt started to appear around the same time, and the first agricultural settlements of modern humans date back to about 12,000 to 10,000 years ago.

Studies of the DNA recovered from bone fragments of a Neanderthal female, by the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, have helped answer a question that has been on the mind of many researchers: did our species inter-breed with Neanderthals? The answer is a stunning yes! Between 1- 4% of the genes of modern humans outside Africa come from *Homo neanderthalensis*. This includes genes that regulate our immune system; our skin, hair growth and pigmentation; even our metabolism, and our tolerance for cold weather. What is more — in 2010, scientists found the remains of another subspecies of humans (temporarily being called *Homo sapiens ssp. Denisova*) in a remote cave in Siberia, which had also been inhabited, at different times, by both Neanderthals and modern humans.

Box 2. Teaching resources on human evolution:

Some of the many resources that you can use to help students explore questions related to evolution are listed below:

- **Teaching Evolution through Human Examples** (http://humanorigins.si.edu/education/teaching-evolution-through-human-examples): Using examples such as evolution of human skin colour and humankind's adaptation to altitude, these four curriculum units help explain the difference between acclimation and adaptation, the scientific evidence for natural selection, and how evolution is a continuous process.
- **Comparison of Human and Chimpanzee Chromosomes** (http://www.indiana.edu/~ensiweb/lessons/chromcom.html): What can a study of our chromosome, especially when compared with chromosomes of other species, tell us about our evolutionary history? This lesson plan helps students compare the banding patterns seen on stained chromosomes from humans and chimpanzees and explore their evolutionary relationships.
- **Mystery Skull Interactive** (http://humanorigins.si.edu/evidence/human-fossils/mystery-skull-interactive): How do scientists know whether a newly discovered fossil is that of an already identified species or a new species? This interactive website allows students to identify a 'mystery skull' using methods similar to that scientists use in their work.
- **Becoming Human** (a documentary): Based on recent scientific findings, this documentary explains the significance of *Australopithecus* in human evolution. It also describes a nearly-complete specimen of *Homo erectus* found in Kenya and explores the fate of Neanderthals. The website http://www.pbs.org/wgbh/nova/evolution/ has many more audio-visual resources for teaching evolution.
- **A Different Flesh**: A collection of short stories by Harry Turtledove set in an imagined world in which *Homo erectus* survives till modern times.

The fact that perhaps there were a dozen or more species of humans could also lead to rich and lively discussions in classrooms. After all, some of these species were barely distinguishable from us; others ultimately survived for as many as 2 million years (as compared to 0.2 million years that we have been around) in harsh and ever-changing climatic and geographical conditions. Some even existed at the same time and in the same geographical regions as our own species! Explore some of these questions with your students - are *Homo sapiens* as different from other 'animal' species as we often assume? Are we really, as many religions and cultures would like us to believe, at the 'pinnacle' of evolution? Assuming one other human species had managed to survive till the present time, how do we think we'd have treated them? Would these humans — who bequeathed part of their genomes to us — be part of our societies, or our zoological gardens? Would 'human rights' be extended to them? And, also, why have none of the other human species survived till modern times when they had managed to survive for hundreds of thousands of years before our species appeared? What role, if any, did our ancestors have in their mass disappearance? And what does their disappearance and our evolutionary history mean for our future?

Denisovans shared their origins with Neanderthals, and were spread across Siberia to South East Asia. Genetic studies have indicated that modern humans interbred with this species as well, and between 3-5% of the DNA of modern-day Melanesians and Aboriginal Australians come from Denisovans. In fact, the specific gene-variant that allows native Tibetans to survive better than others in the low-oxygen and high altitude conditions of their homeland is likely to have been acquired from our Denisovan ancestors[8].

The only *Homo* species, other than ours, to have survived to modern times may have been *Homo floresiensis*. This species is believed to have evolved from migrating populations of *Homo erectus*, and lived on the geographically isolated island of Flores in Indonesia. Some studies suggest that they may have survived on this island till about 12,000 years ago — long after the island was also inhabited by our own species!

Conclusion

The story of evolution of our genus and species attempts to (at least partly) answer some of our eternal questions — who are we, where do we come from, and where are we headed. But it is also fascinating because it presents a good example of how scientists work: hypothesizing, assiduously piecing together evidence over generations, building on findings and contributions of others, discarding hypotheses that are no longer tenable in the face of new evidence, and, of course, the occasional strokes of serendipity! This story draws from fields as diverse as anthropology, geology, biology, anatomy, physics, chemistry, and molecular biology — and can thus also be used as an example of how different scientific fields are brought together to answer questions that were once considered 'unanswerable' or outside the 'scientific magisterium'.

Note: Credits for the article title and the image used in its background: *D'où venons-nous? Que sommes-nous? Où allons-nous?* Paul Gauguin (oil on canvas), Museum of Fine Arts Boston, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Paul_Gauguin_-_D%27ou_venons-nous.jpg. License: CC-BY-SA.

References

1. Aczel A (2008) The Jesuit and the skull. Penguin Group, USA.
2. Lyell C (1863) Geological evidences of the antiquity of Man. Cosimo Classics, United Kingdom.
3. Schrenk F, Müller S (2005), Die Neandertaler. C. H. Beck, Münich.
4. King W (1864). The reputed fossil man of the Neanderthal. Retrieved from: http://www.boneandstone.com/articles_classics/king_1864.pdf.
5. Toth N and Schick K (2005). African origins in the human past: World prehistory and the development of human societies (Editor: Chris Scarre). London: Thames and Hudson.
6. Masao, Fidelis T et al. New Footprints from Laetoli (Tanzania) Provide Evidence for Marked Body Size Variation in Early Hominins. Ed. George H Perry. eLife 5 (2016): e19568. PMC. Web. 2 July 2017.
7. Mooallem J (2017). Neanderthals were people too. New York Times. Retrieved on 13th March, 2017 from: https://www.nytimes.com/2017/01/11/magazine/neanderthals-were-people-too.html?
8. Singer E (2016). How Neanderthal DNA helps humanity. Quanta Magazine. Retrieved on 13th March, 2017 from: https://www.quantamagazine.org/20160526-neanderthal-denisovan-dna-modern-humans/.

Avinash Kumar works with Wipro Applying Thought in Schools, a social initiative of Wipro, which supports civil society organizations that are working to improve the quality of Indian school education in different states of the country. He can be contacted at avinash.kumar@apu.edu.in