"Life Science" field

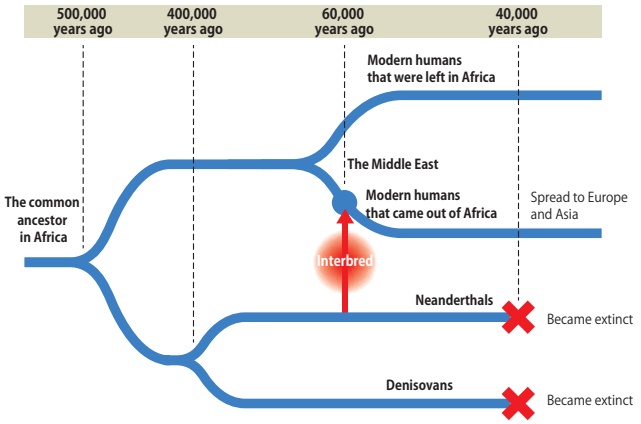
Achievement : Pioneering contributions to paleoanthropology through decoding ancient human genome sequences

Dr. Svante Pääbo (Sweden)
Born: April 20, 1955 (Age: 64)
Professor, Max Planck Institute for Evolutionary Anthropology

The ancestors of modern humans interbred with Neanderthals

Neanderthals are a species of archaic humans that once existed. They left Africa around 500,000 years ago and spread across Europe and the Middle East, but became extinct about 40,000 years ago. For this reason, it was long thought that Neanderthals were unrelated to modern humans. However, when Dr. Pääbo analyzed the DNA of excavated Neanderthal bones, he discovered that modern humans had in fact inherited Neanderthal DNA.

Figure 1 The ancestors of modern humans interbred with Neanderthals



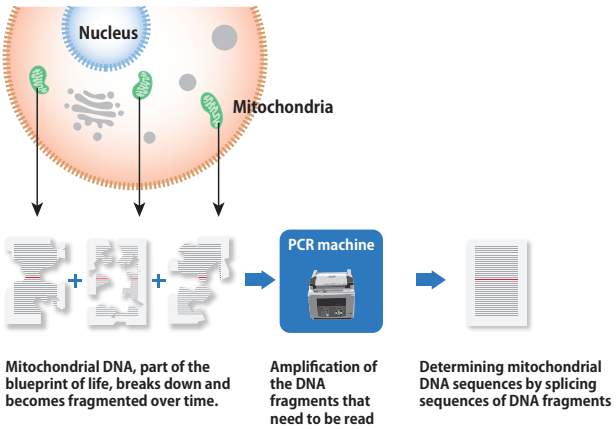
Achievements (1): Analysis of mitochondrial DNA (1997)

The difficulty of studying ancient DNA is that DNA, the blueprint of life, breaks down and becomes fragmented over time, therefore, it is difficult to obtain enough quantity required for proper analysis. In order to increase the small number of DNA fragments, Dr. Pääbo employed a newly developed DNA amplification method called the "Polymerase chain reaction" (PCR). There was, however, a limitation to this method. Modern DNA contaminated by airborne dust or human sweat could be mistakenly be amplified if the sequence was similar to ancient human DNA. Because the handling of ancient DNA requires great care, Dr. Pääbo devised new research methods, including a new method of DNA extraction and the use of a cleanroom.

In 1997, a portion of Neanderthal mitochondrial DNA was first sequenced, followed by the entire mitochondrial DNA. Mitochondria are a type of organelle that has DNA different from that of the nucleus.

Mitochondrial DNA is only 16,000 base pairs long and can easily be obtained in large quantities because a single cell alone contains several thousand of them. The sequence was able to be determined using the PCR method and the DNA analysis technology that was available at the time.

Figure 2 Achievements (1): Analysis of mitochondrial DNA (1997)



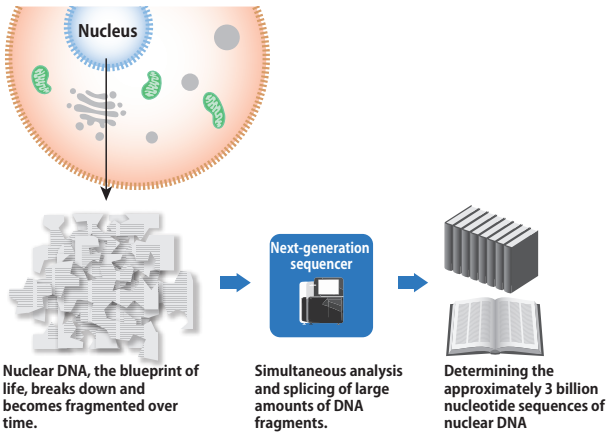
Ancient DNA fragments are like pieces of a torn-up document. By the same analogy, a mitochondrial DNA, composed of approximately 16,000 base pairs, is a single-page document. The various DNA fragments were amplified using PCR, analyzed and fitted together, and in 1997, the hyper-vari-able region of the mitochondrial DNA was sequenced.

When the sequenced mitochondrial DNA was compared with that of modern humans, no commonalities were found, thus, proving the theory that Neanderthals were not the direct ancestors of modern humans as some had suggested.

Achievements (2): Analysis of nuclear DNA (2010)

Dr. Pääbo hypothesized that analysis of mitochondrial DNA alone was not enough to unravel the mysteries of modern human evolution. Beginning in the 2000s, a next-generation sequencer capable of simultaneously sequencing large quantities of DNA became available. In 2010, it was used to sequence the entire Neanderthal nuclear DNA for the first time in the world. He analyzed large quantities of DNA fragments,

Figure 3 Achievements (2): Analysis of nuclear DNA (2010)



Ancient DNA fragments are like pieces of a torn-up document. By the same analogy, the 3 billion base pairs long nuclear DNA, is the equivalent to a collection of books. A large number of DNA fragments were analyzed and fitted together using next-generation sequencers to restore the reconstruct book collection.

mapped them on a modern human reference sequence, and reconstructed the nuclear DNA sequence consisting of 3 billion base pairs.

The analysis of Neanderthal nuclear DNA showed that 1 to 4% of the total DNA of modern humans, excluding the people of Africa, had Neanderthal origins. It was thus proven that the ancestors of modern humans interbred with Neanderthals. Furthermore, Dr. Pääbo sequenced the nuclear DNA from a bone fragment of an unknown group of hominins, excavated from the Denisova Cave in Russia, and named them "Denisovans".

Significant contributions to paleoanthropology

The fact that Neanderthal DNA is present in modern humans, excluding the people of Africa, illustrates a scenario of modern human migration in which "the ancestors of modern humans who left Africa between 60,000 to 70,000 years ago are thought to have interbred with Neanderthals who already inhabited the Middle East around 60,000 years ago and spread around the world".

In this manner, Dr. Pääbo's DNA analysis using ancient bones has revolutionized the paleoanthropological research of exploring "the origin of modern humans". His research methods and achievements have also significantly impacted all disciplines related to the study of modern human species, including anthropology, archeology, and history, thereby contributing tremendously to the advancement of these disciplines.

Dr. Pääbo, who has contributed significantly to the field of paleoanthropology, is currently a professor at the Max Planck Institute for Evolutionary Anthropology. There, he continues to lead many projects on ancient human genomes, expand the horizons of paleoanthropological genomic research, and nurture the next generation of researchers.

Figure 4 Significant contributions to paleoanthropology