

Control of fire by early humans

The **control of fire by early humans** was a turning point in the cultural aspect of human evolution. Fire provided a source of warmth, protection, improvement on hunting and a method for cooking food. These cultural advancements allowed for human geographic dispersal, cultural innovations, and changes to diet and behavior. Additionally, creating fire allowed the expansion of human activity to proceed into the dark and colder hours of the evening.

Claims for the earliest definitive evidence of control of fire by a member of *Homo* range from 1.7 to 0.2 million years ago (Mya).^[1] Evidence for the controlled use of fire by *Homo erectus*, beginning some 600,000 years ago, has wide scholarly support.^{[2][3]} Flint blades burned in fires roughly 300,000 years ago were found near fossils of early but not entirely modern *Homo sapiens* in Morocco.^[4] Evidence of widespread control of fire by anatomically modern humans dates to approximately 125,000 years ago.^[5]



A diorama showing *Homo erectus*, the earliest human species that is known to have controlled fire, from inside the National Museum of Mongolian History in Ulaanbaatar, Mongolia.

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Control of fire

Use and control of fire was a gradual process, proceeding through more than one stage. One was a change in habitat, from dense forest, where wildfires were rare and potentially catastrophic, to savanna (mixed grass/woodland) where wildfires were very rare and of lower intensity. Such a change may have occurred about three million years ago, when the savanna expanded in East Africa due to cooler and drier climate.^{[6][7]}

The next stage involved interaction with burned landscapes and foraging in the wake of wildfires, as observed in various wild animals.^{[6][7]} In the African savanna, animals that preferentially forage in recently burned areas include Savanna chimpanzees (a variety of Pan troglodytes verus),^{[6][8]} Vervet monkeys (Cercopithecus aethiops)^[9] and a variety of birds, some of which also hunt insects and small vertebrates in the wake of grass fires.^{[8][10]}

The next step would be to make some use of residual hot spots that occur in the wake of wildfires. For example, foods found in the wake of wildfires tend to be either burned or undercooked. This might have provided incentives to place undercooked foods on a hotspot or to pull food out of the fire if it was in danger of getting burned. This would require familiarity with fire and its behavior.^{[11][7]}

An early step in the control of fire would be transporting it from burned to unburned areas and lighting them on fire, providing advantages in food acquisition.^[7] Maintaining a fire over an extended period of time, as for a season (such as the dry season) may have led to the development of base campsites. Building a hearth or other fire enclosure such as a circle of stones would have been a later development.^[12] The ability to make fire, generally with a friction device with hardwood rubbing against softwood (as in a bow drill) was a late development.^[6]

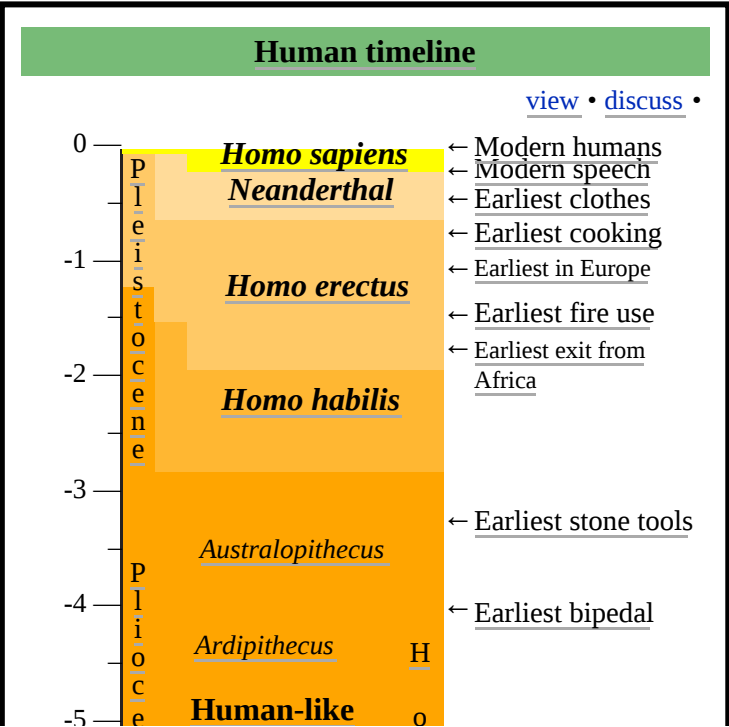
Each of these stages could occur at different intensities, ranging from occasional or "opportunistic" to "habitual" to "obligate" (unable to survive without it).^{[7][12]}

Lower Paleolithic evidence

Most of the evidence of controlled use of fire during the Lower Paleolithic is uncertain and has limited scholarly support.^[13] The inconclusiveness of some of the evidence lies behind the fact that there exist other plausible explanations, such as natural processes, that could explain the findings.^[14] Recent findings support that the earliest known controlled use of fire took place in Wonderwerk Cave, South Africa, 1.0 Mya.^[13]

Over time, early humans figured out how to create fire. Archaeological evidence suggests that this happened between 700,000 years ago and 120,000 years ago.^[15]

Africa



Findings from the Wonderwerk Cave site, in the Northern Cape province of South Africa, provide the earliest evidence for controlled use of fire. Intact sediments were analyzed using micromorphological analysis and Fourier Transform Infrared Microspectroscopy (mFTIR) and yielded evidence, in the form of burned bones and ashed plant remains, that burning took place at the site 1.0 Mya.^[13]

East African sites, such as Chesowanja near Lake Baringo, Koobi Fora, and Olorgesailie in Kenya, show some possible evidence that fire was controlled by early humans.^[14]

In Chesowanja archaeologists found red clay clasts dated to 1.4 Mya. These clasts must have been heated to 400 °C (750 °F) to harden. However, tree stumps burned in bush fires in East Africa produce clasts which, when broken by erosion, are like those described at Chesowanja. Controlled use of fire at Chesowanja is unproven.^[14]

In Koobi Fora, sites FxJzoE and FxJ50 show evidence of control of fire by Homo erectus at 1.5 Mya with findings of reddened sediment that could come from heating at 200–400 °C (400–750 °F).^[14]

Evidence of possible human control of fire has been found at Swartkrans, South Africa.^[16] The evidence includes: several burned bones, including ones with hominin-inflicted cut marks, along with Acheulean and bone tools.^[14] This site also shows some of the earliest evidence of carnivorous behavior in H. erectus.

A "hearth-like depression" that could have been used to burn bones was found at a site in Olorgesailie, Kenya. However, it did not contain any charcoal and no signs of fire have been observed. Some microscopic charcoal was found, but it could have resulted from a natural brush fire.^[14]

In Gadeb, Ethiopia, fragments of welded tuff that appeared to have been burned were found in Locality 8E but re-firing of the rocks might have occurred due to local volcanic activity.^[14]

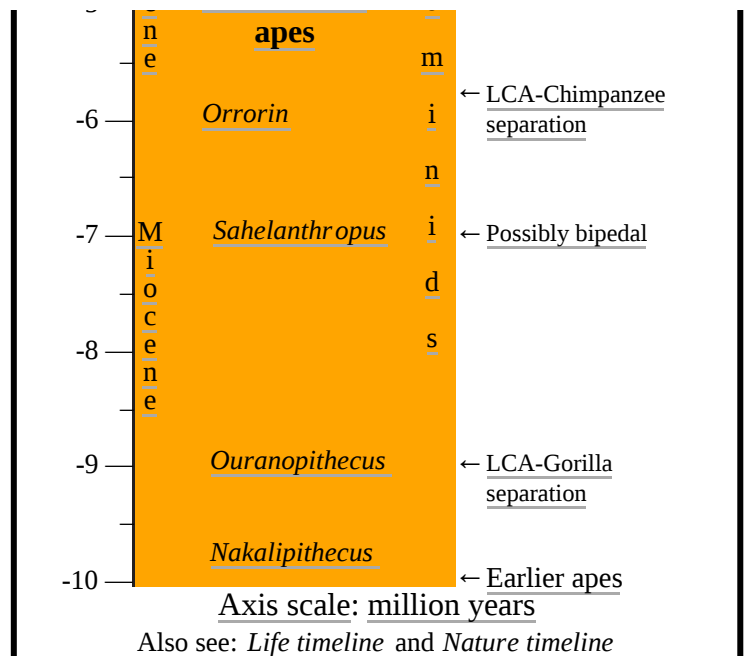
In the Middle Awash River Valley, cone-shaped depressions of reddish clay were found that could have been formed by temperatures of 200 °C (400 °F). These features, thought to have been created by burning tree stumps, were hypothesized to have been produced early hominids lighting tree stumps so they could have fire away from their habitation site. However, this view is not widely accepted.^[14] Burned stones are also found in Awash Valley, but volcanic welded tuff is also found in the area which could explain the burned stones.^[14]

Burned flints discovered near Jebel Irhoud, Morocco, dated by thermoluminescence to approximately 300,000 years, were discovered in the same sedimentary layer as skulls of early Homo sapiens. Paleoanthropologist Jean-Jacques Hublin believes the flints were used as spear tips and left in fires used by the early humans for cooking food.^[4]

Asia

In Xihoudu in Shanxi Province, China, the black, blue, and grayish-green discoloration of mammalian bones found at the site illustrates the evidence of burning by early hominids. In 1985, a parallel site in China, Yuanmou in the Yunnan Province, archaeologists found blackened mammal bones which date back to 1.7 MyBP.^[14]

Middle East



A site at Bnot Ya'akov Bridge, Israel, has claimed to show that *H. erectus* or *H. ergaster* controlled fires between 790,000 and 690,000 BP.^[17]

Pacific Islands

At Trinil, Java, burned wood has been found in layers that carried *H. erectus* (Java Man) fossils dating from 830,000 to 500,000 BP.^[14] The burned wood has been claimed to indicate the use of fire by early hominids.

Middle Paleolithic evidence

Africa

The Cave of Hearths in South Africa has burn deposits, which date from 700,000 to 200,000 BP, as do various other sites such as Montagu Cave (200,000 to 58,000 BP) and the Klasies River Mouth (130,000 to 120,000 BP).^[14]

Strong evidence comes from Kalambo Falls in Zambia where several artifacts related to the use of fire by humans have been recovered including charred logs, charcoal, ironized areas, carbonized grass stems and plants, and wooden implements which may have been hardened by fire. The site has been dated through radiocarbon dating to be at 110,000 BP and 61,000 BP through amino acid racemization.^[14]

Fire was used for heat treatment of silcrete stones to increase their workability before they were knapped into tools by Stillbay culture.^{[18][19][20]} These Stillbay sites date back anywhere ranging from 164,000 BP to 72,000 BP.^[18]

Asia

At the Amudian site of Qesem Cave in Tel-Aviv, evidence exists of the regular use of fire from before 382,000 BP to around 200,000 BP at the end of Lower Pleistocene. Large quantities of burned bone and moderately heated soil lumps were found, and the cut marks found on the bones suggest that butchering and prey-defleshing took place near fireplaces.^[21]

Evidence at Zhoukoudian cave in China suggests control of fire as early as 460,000 to 230,000 BP.^[5] Fire in Zhoukoudian is suggested by the presence of burned bones, burned chipped-stone artifacts, charcoal, ash, and hearths alongside *H. erectus* fossils in Layer 10, the earliest archaeological horizon at the site.^{[14][22]} This evidence comes from Locality 1, also known as the Peking Man site, where several bones were found to be uniformly black to grey. The extracts from the bones were determined to be characteristic of burned bone rather than manganese staining.

These residues also showed IR spectra for oxides, and a bone that was turquoise was reproduced in the laboratory by heating some of the other bones found in Layer 10. At the site, the same effect might have been due to natural heating, as the effect was produced on white, yellow, and black bones.^[22] Layer 10 itself is described as ash with biologically produced silicon, aluminum, iron, and potassium, but wood ash remnants such as siliceous aggregates are missing. Among these are possible hearths "represented by finely laminated silt and clay interbedded with reddish-brown and yellow brown fragments of organic matter, locally mixed with limestone fragments and dark brown finely laminated silt, clay and organic matter."^[22] The site itself does not show that fires were made in Zhoukoudian, but the association of blackened bones with quartzite artifacts at least shows that humans did control fire at the time of the habitation of the Zhoukoudian cave.



Zhoukoudian Caves, a World Heritage Site and an early site of human use of fire in China

Europe

Multiple sites in Europe such as Torralba and Ambrona Spain, and St. Esteve-Janson, France have also shown evidence of use of fire by later versions of *H. erectus*. The oldest has been found in England at the site of Beeches Pit, Suffolk; Uranium series dating and thermoluminescence dating place the use of fire at 415,000 BP.^[23] At Vértesszőlős, Hungary, while no charcoal has been found, burned bones have been discovered dating from c. 350,000 years ago. At Torralba and Ambrona, Spain, objects such as acheulean stone tools, remains of large mammals such as extinct elephants, charcoal, and wood were discovered.^[14] At Saint-Estève-Janson in France, there is evidence of five hearths and reddened earth in the Escal Cave. These hearths have been dated to 200,000 BP.^[14]

Impact on human evolution

Cultural innovations

Uses of fire by early humans

The discovery of fire came to provide a wide variety of uses for early hominids. It acted as a source of warmth, making it easier to get through cold nighttime temperatures and allowing hominids to survive in colder environments, through which geographic expansion from tropical and subtropical climates to areas of temperate climates containing colder winters began to occur. The discovery of the use of fire and the sharing of the benefits of the use of fire may have created a sense of sharing as a group by the participation of gathering fire wood that may have become the first concept of Taxation although not realized at the time ^{[24][25]} The use of fire continued to aid hominids at night by also acting as a means by which to ward off predatory animals.^[26]

Fire also played a major role in changing how hominids obtained and consumed food, primarily in the new practice of cooking. This caused a significant increase in hominid meat consumption and calorie intake.^[26] In addition to cooking, hominids soon discovered that meat could be dried through the use of fire, allowing it to be preserved for times in which harsh environmental conditions made hunting difficult.^[25] Fire was even used in forming tools to be used for hunting and cutting meat.^[27] Hominids found that large fires had their uses as well. By starting wildfires, they were able to increase land fertility and clear large amounts of bushes and trees to make hunting easier.^[25] As early hominids began to understand how to use fire, such a useful skill may have differentiated societal roles through the separation of cooking tasks groups from hunting task groups.^[28]

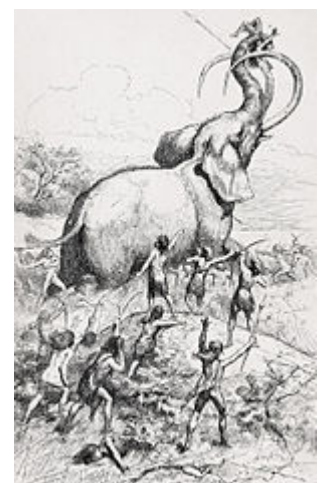
Protection and hunting

The early discovery of fire had numerous benefits to the early hominids. With fire, they were able to protect themselves from the terrain, and were also able to devise an entirely new way of hunting. Evidence of fire has been found in caves, suggesting that fire was used to keep the early hominids warm. This is significant, because it allowed them to migrate to cooler climates and thrive. This evidence also suggests that fire was used to clear out caves prior to living in them.^[29] Living in caves was a major advancement in protection from the weather and from other species.

In addition to protection from the weather, the discovery of fire allowed for innovations in hunting. Initially, early hominids used grass fires to hunt and control the population of pests in the surrounding areas.^[30] Evidence shows that early hominids were able to corral and trap animals by means of fire prior to cooking the meat.

Tool and weapon making

In addition to the many benefits that fire provided to early humans, it also had a major impact on the innovation of tool and weapon manufacturing. The use of fire by early humans as an engineering tool to modify the effectiveness of their weaponry was a major technological advancement. In an archeological dig that dates to approximately 400,000 years ago, researchers excavating in an area known as the 'Spear Horizon' in Schöningen, county Helmstedt, Germany, unearthed eight wooden spears among a trove of preserved artifacts.^{[31][32]} The spears were



Fanciful restoration of a Columbian mammoth hunted by Palaeoamericans (Children's book cover 1885)

found along with stone tools and horse remains, one of which still had a spear through its pelvis. At another dig site located in Lehringen, Germany, a fire-hardened lance was found thrust into the rib cage of a 'straight-tusked elephant'.^[33] These archeological digs provide evidence that suggests the spears were deliberately fire-hardened, which allowed early humans the ability to modify their hunting tactics and use the spears as thrusting rather than throwing weapons. Researchers further uncovered environmental evidence that indicated early humans may have been waiting in nearby vegetation that provided enough concealment for them to ambush their prey.^{[32][34]}

More recent evidence dating to approximately 164,000 years ago found that early humans living in South Africa in the Middle Stone Age used fire as an engineering tool to alter the mechanical properties of the materials they used to make tools and improve their lives. Researchers found evidence that suggests early humans applied a method of heat treatment to a fine-grained, local rock called silcrete.^[35] Once treated, the heated rocks were modified and tempered into crescent shaped blades or arrowheads. The evidence suggests that early humans probably used the modified tools for hunting or cutting meat from killed animals. Researchers postulate that this may have been the first time that the bow and arrow was used for hunting, an advancement that had a significant impact on how early humans may have lived, hunted, and existed as community groups.^{[35][36]}



Fire hardened spear circa 380,000 to 400,000 years old. (See Schöningen Spears)

Art and ceremonial uses

Fire was also used in the creation of art. Scientists have discovered several small, 1 to 10 inch statues in Europe referred to as the Venus figurines. These statues date back to the Paleolithic Period and all depict nude, curvaceous women.^[37] Several of these figures were created from stone and ivory, while some were created with clay and then fired. These are some of the earliest examples of ceramics.^[38] Fire was also commonly used to create pottery. Although it was previously thought that the advent of pottery began with the use of agriculture around 10,000 years ago, scientists in China discovered pottery fragments in the Xianrendong Cave that were approximately 20,000 years old.^[39] However it was during the Neolithic Age, which began about 10,000 years ago, that the creation and use of pottery became far more widespread. These items were often carved and painted with simple linear designs and geometric shapes.^[40]



Early Evidence for the Extensive Heat Treatment of Silcrete in the Howiesons Poort at Klipdrift Shelter (Layer PBD, 65 ka), South Africa.

Developments and expansion in early hominid societies

Fire was an important factor in expanding and developing societies of early hominids. One impact fire had was that it caused social stratification. Those who could make and wield fire had more power than those who could not and had a higher position in society.^[25] The presence of fire also led to an increase in length of "daytime", and allowed more activity to occur in the night that was not previously possible.^[41] Evidence of large hearths indicate that the majority of this nighttime activity was spent around the fire, contributing to social interactions among individuals.^[42] This increased amount of social interaction is believed to be important in the development of language, as it fostered more communication among individuals.^[41] Another effect that the presence of fire had on hominid societies is that it required larger and larger groups to work together in order to maintain and sustain the fire. Individuals had to work together to find fuel for the fire, maintain the fire, and complete other necessary tasks. These larger groups might have included older individuals, grandparents, to help care for children. Ultimately, fire had a significant influence on the size and social interactions of early hominid communities.^{[41][42]}

Environment and nighttime activity

The control of fire enabled important changes in human behavior, health, energy expenditure, and geographic expansion. As a result of “domesticating” fire as previously achieved with plants and animals, humans were able to modify their environments to their own benefit.^[43] This ability to manipulate their environments allowed them to move into much colder regions that would have previously been uninhabitable after the loss of body hair. Evidence of more complex management to change biomes can be found as far back as 200,000 to 100,000 years ago at a minimum. Furthermore, activity was no longer restricted to daylight hours due to the use of fire. Exposure to artificial light during later hours of the day changed humans’ circadian rhythms, contributing to a longer waking day.^[44] The modern human’s waking day is 16 hours, while most mammals are only awake for half as many hours.^[42] Additionally, humans are most awake during the early evening hours, while other primates’ days begin at dawn and end at sundown. Many of these behavioral changes can be attributed to the control of fire and its impact on daylight extension.^[42]

The cooking hypothesis

The cooking hypothesis proposes the idea that the ability to cook allowed for the brain size of hominids to increase over time. This idea was first presented by Frederich Engels in the article The Part Played by Labour in the Transition from Ape to Man and latter recapitulated in the book Catching Fire: How Cooking Made Us Human by Richard Wrangham and later in a book by Suzana Herculano-Houzel.^[45] Critics of the hypothesis argue that cooking with controlled fire is not enough to be the reason behind the increasing brain size trend.

The supporting evidence of the cooking hypothesis argues that compared to the nutrients in the raw food, nutrients in cooked food are much easier to digest for hominids as shown in the research of protein ingestion from raw vs. cooked egg.^[46] Such a feature is essential for brain evolution: through studying the metabolic activities between primate species, scientists had found that there is a limitation of energy harvesting through food sources due to limited feeding time.^[47] Besides the brain, other organs in the human body also demand a high level of metabolism.^[48] At the same time, the body mass portion of different organs was changing throughout the process of evolution as a means for brain expansion. Homo genus was able to break through the limit by cooking food to lower their feeding time and be able to absorb more nutrients to accommodate the increasing need for energy.^[48] In addition, scientists argue that the Homo species was also able to obtain nutrients like DHA (Docosahexaenoic acid) from algae that were especially beneficial and critical for brain evolution and, as mentioned in the previous sections, the detoxification of the cooking process enabled early humans to access these resources.^[49]

Changes to diet

Before the advent of fire, the hominid diet was limited to mostly plant parts composed of simple sugars and carbohydrates such as seeds, flowers, and fleshy fruits. Parts of the plant such as stems, mature leaves, enlarged roots, and tubers would have been inaccessible as a food source due to the indigestibility of raw cellulose and starch. Cooking, however, made starchy and fibrous foods edible and greatly increased the diversity of other foods available to early humans. Toxin-containing foods including seeds and similar carbohydrate sources, such as cyanogenic glycosides found in linseed and cassava, were incorporated into their diets as cooking rendered them non-toxic.^[50]

Cooking could also kill parasites, reduce the amount of energy required for chewing and digestion, and release more nutrients from plants and meat. Due to the difficulty of chewing raw meat and digesting tough proteins (e.g. collagen) and carbohydrates, the development of cooking served as an effective mechanism to efficiently process meat and allow for its consumption in larger quantities. With its high caloric density and store of important nutrients, meat thus became a staple in the diet of early humans.^[51] By increasing digestibility, cooking allowed hominids to maximize the energy gained from consuming foods. Studies show that caloric intake from cooking starches improves 12-35% and 45-78% for protein. As a result of the increases in net energy gain from food consumption, survival and reproductive rates in hominids increased.^[52]

Biological changes

Before their use of fire, the hominid species had large premolars which were used to chew harder foods such as large seeds. In addition, due to the shape of the molar cusps, it is inferred that the diet was more leaf or fruit-based. In response to consuming cooked foods, the molar teeth of Homo Erectus had gradually shrunk, suggesting that their diet had changed from crunchier foods

such as crisp root vegetables to softer cooked foods such as meat.^{[53][54]} Cooked foods further selected for the differentiation of their teeth and eventually led to a decreased jaw volume with a variety of smaller teeth in hominids. Today, you can see the smaller jaw volume and teeth size of humans in comparison to other primates.^[55]

Due to the increased digestibility cooked foods conferred, less digestion was needed to procure the necessary nutrients. As a result, the gastrointestinal tract and organs in the digestive system decreased in size. This is in contrast to other primates, where a larger digestive tract is needed for fermentation of long carbohydrate chains. Thus, humans evolved from the large colons and tracts that are seen in other primates to smaller ones.^[56]

According to Wrangham, control of fire allowed hominids to sleep on the ground and in caves instead of trees and led to more time being spent on the ground. This may have contributed to the evolution of bipedalism as such an ability became increasingly necessary for human activity.^[57]

Criticism

Critics of the hypothesis argue that while there is a linear increase in brain volume of the *Homo* genus over time, adding fire control and cooking does not add anything meaningful to the data. Species such as *Homo ergaster* existed with large brain volumes during time periods with little to no evidence of fire for cooking. Little variation exists in the brain sizes of *Homo erectus* dated from periods of weak and strong evidence for cooking.^[42] In Cornélio's experiments involving mice fed raw versus cooked meat, the results found that cooking meat did not increase the amount of calories taken up by mice, leading to the study's conclusion that the energetic gain is the same, if not greater, in raw meat diets than cooked meats.^[42] Studies such as this and others lead criticisms of the hypothesis to state that the increases in human brain-size occurred well before the advent of cooking due to a shift away from the consumption of nuts and berries to the consumption of meat.^{[58][59]} Other anthropologists argue that the evidence suggests that cooking fires began in earnest only 250,000 BP, when ancient hearths, earth ovens, burned animal bones, and flint appear across Europe and the Middle East.^[60]

See also

- Hunting hypothesis
- Savanna theory
- Raw Foodism

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Further reading

- Goudsblom, Joop(1992): *Fire and Civilization*, Allen Lane.

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- How our pact with fire made us what we areArticle by Stephen J Pyne
 - Human Timeline (Interactive)– Smithsonian, National Museum of Natural History(August 2016).
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