

Controlled fire, cooking and shared learning

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Core question

How did control of fire change the range of environments, materials, foods and social situations that hominins could reliably transform?

Historical and evolutionary context

Fire is both a natural phenomenon and a technology. This makes its archaeological history unusually difficult: burned sediment or bone does not automatically prove deliberate control. Evidence must distinguish wildfire, accidental burning, repeated hearth use, maintenance of fire and deliberate fire-making.

Claims for early fire use extend deep into the Pleistocene, but confidence varies by site and method. At Wonderwerk Cave in South Africa, microscopic and spectroscopic evidence places in-situ burning in an Acheulean occupation at about 1.0 million years ago. At Gesher Benot Ya'aqov in Israel, spatially patterned burned materials support hominin control of fire around 780,000 years ago. In Europe, the archaeological record suggests that habitual fire use became much more visible around 400,000-300,000 years ago, although earlier evidence remains debated. A study published online in 2025 and in volume 649 of *Nature* in 2026 reported evidence interpreted as deliberate fire-making at Barnham in the United Kingdom around 400,000 years ago, including heated sediments, fire-cracked flint and pyrite consistent with spark production. These sites should not be collapsed into one threshold: opportunistic use, maintained fire, habitual use and deliberate ignition are distinct claims.

What could communities know before controlled fire?

Natural fires expose cooked foods, alter landscapes and provide warmth or protection. Opportunistic use requires recognition of these effects but leaves humans dependent on rare ignition events. Reliable control changes the problem: heat becomes a repeatable environmental variable rather than a chance occurrence.

What changed?

Maintained fire creates a stable source of heat, light and material transformation. It can extend activity into darkness, reduce cold stress, deter predators, alter food texture and digestibility, harden or modify some materials and create focal locations for social interaction.

Cooking is often proposed as a major evolutionary transition. Wrangham argued that cooking had major evolutionary consequences, but the timing and magnitude of those effects remain debated. PIO should therefore distinguish the well-supported statement that controlled fire eventually enabled systematic cooking from stronger hypotheses that assign a particular anatomical transition directly to cooking at a specific date.

The epistemic significance is broader. Fire teaches that invisible changes can be produced reproducibly by controlled conditions. Raw plant or animal material becomes different after time at heat; clay hardens; wood chars; pigments change. These are early forms of process knowledge.

Why could this capability emerge?

Control required more than ignition. It required fuel selection, transport, maintenance, spatial organisation, risk management and social coordination. Fire must be fed, protected and sometimes shared. These recurrent tasks favour transmission of procedures rather than isolated discovery.

A hearth is therefore simultaneously a physical technology and a social institution at small scale: a persistent place around which food, activity and information can be organized.

What later forms of knowledge did it enable?

Fire is a precursor to many later transformations: cooking, heat treatment, ceramics, lime, metallurgy, glass and eventually engines. It also changed the temporal organisation of human activity by making light and warmth partly controllable.

New limits and risks

Fire creates hazards: burns, smoke exposure, accidental landscape fires and dependence on fuel. It can also transform ecosystems. Control is never absolute; the same process that enables heating and cooking can escape management.

What changed in the architecture of human knowledge?

Humans gained a **repeatable transformation technology**. Knowledge was no longer only about selecting what nature already provided; it increasingly concerned controlling conditions so that materials acquired new properties.

Loss, exclusion and uncertainty

Fire leaves an especially ambiguous record. Ash disperses, hearths are disturbed, natural burning can mimic human burning, and many episodes of transport or maintenance leave little trace. Archaeology therefore preserves only a biased sample of the knowledge needed to acquire, sustain and use fire.

The chronology of fire use is contested because natural and anthropogenic burning can resemble one another. Evidence for habitual use, maintenance and independent ignition should not be collapsed into a single date. Likewise, archaeological fire history is geographically uneven.

Dependency map

- DIRECT ← PIO-001 Cooperation and cumulative culture
- INDIRECT ← PIO-002 Stone tools and cumulative design
- DIRECT → PIO-008 Pottery, containers and controlled transformation
- INDIRECT → later metallurgy and industrial heat technologies

References

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