

# Fine-tuned fire

***Fire-Maker: How humans were designed to harness fire and transform our planet***

Michael Denton

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Michael Denton is a Senior Fellow at the Discovery Institute's Center for Science and Culture. He has an M.D. from Bristol University in the UK and a Ph.D. in biochemistry from King's College in London. He has also commented extensively on the creation evolution debate, with influential books such as *Evolution: A theory in crisis*,<sup>1</sup> *Nature's Destiny*,<sup>2</sup> and *Evolution: Still a theory in crisis*.<sup>3</sup> These showed that there are fundamental discontinuities in biology that undermine the Darwinian expectation of a functional continuum between different creatures.

However, *Fire-Maker* has a different sort of focus. It is the first in a series of books called 'The Privileged Species Series' Denton has authored which spell out the empirical fact of *fine-tuning*—that there are many factors about our situation that have a 'Goldilocks' property—conditions that, if they were much different in any way from what they are, life like us would not be possible. Arguments of this nature concerning the constants and quantities of nature are well-known.<sup>4</sup> However, fine tuning goes *much* further than factors in basic physics. They also attend to all sorts of facts about the conditions within the cosmos. In circumstances that can and do obtain in the cosmos, life is impossible; it can only exist in a very specific set of circumstances. Even fewer, it turns out, enable life like us to flourish in the way we have here on Earth. It is these factors that Denton

enumerates and explains in this book. In *Fire-maker*, he focuses on the fact that our situation is fine-tuned for making and using fire (figure 1).

## Fine-tuned fire

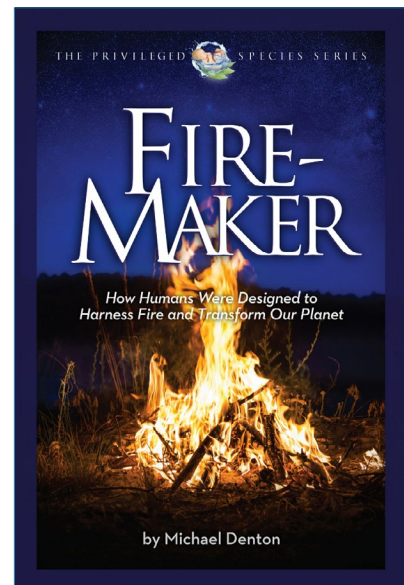
Fire was a crucial human technological advancement. We have moved from simple metal tools to landing robots on other planets in the space of a few thousand years. And much of that advancement has happened in only the last 100 years. Denton points out that the key to all this is fire. He even cites Darwin to this effect:

“He has discovered the art of making fire, by which hard and stringy roots can be rendered digestible, and poisonous roots or herbs innocuous. This last discovery, probably the greatest, excepting language, ever made by man, dates from before the dawn of history.”<sup>5</sup>

Taming fire led to cooking and the invention of pottery. It also led to the discovery of charcoal, and that it can generate far greater heat than an ordinary wood fire. This allowed for the development of kilns that improved pottery technology and allowed for the birth of metallurgy. Copper and iron smelting led to all sorts of new technologies, e.g. glassmaking, alcohol, soap, and lime cement. But metallurgy is the one more than any other modern civilization would be impossible without.

Nobody can deny that human ingenuity was critical to technological advancement through the mastery of fire. However, as Denton explains, it would have also been impossible if we did not live in an environment in which we could master fire.

Denton points out that combustion is a unique chemical reaction, “providing enormous energy and heat to perform many useful tasks while at the same time being non-explosive



and readily controlled” (p. 14). The low reactivity of carbon and oxygen at ambient temperatures means fire can be safely controlled and used, while also meaning carbon-based life doesn't spontaneously combust in an atmosphere of 21% oxygen. It needs the application of special catalysts (as in living systems) or heat (as in fire) to be useable for energy. It's unreactive *enough* at ambient temperatures to be safe, but still utilizable with the right sort of activation under those same conditions.

Moreover, Denton explains that charcoal reacts more vigorously with oxygen than raw wood, creating hotter temperatures needed to extract metals from their ores. But it also provides the reducing conditions needed to smelt iron. This one ingredient for two distinct tasks can be sourced merely from 'cooking' wood. As Denton points out, this is a rather “fortuitous coincidence”. However, it does not end there. Charcoal being highly porous means airflow can be used to control the temperature in the kiln. As Denton says:

“Given the range of temperatures in the cosmos and the fantastic diversity of the properties of matter, it beggars belief that the smelting temperatures of metal ores are in

reach of the temperatures that can be generated in wood or charcoal fires—a coincidence upon which the whole subsequent development of technology depended” (pp. 15–16).

### A planet fine-tuned for fire

But fire itself cannot arise in ways that are useful to us in just any circumstances. As Denton explains, it requires the right sort of planet for it to work.

For instance, we need an atmosphere that can support *both* respiration and combustion. These factors are independent of each other, so an atmosphere can support respiration but not fire, and vice versa. Denton explains:

“Because the factors which influence uptake in the lungs (including partial pressure of oxygen in the atmosphere, currently 160 mm Hg) and the factors which influence fire spread (including the percentage of oxygen, currently 21 percent, and the presence of dilutents in the atmosphere) are quite different, it is possible to engineer atmospheres capable of sustaining oxygen uptake in the lungs but not fire” (pp. 22–23).

Moreover, nitrogen has a specific heat capacity *just* high enough to make it an effective flame retardant. As Denton concludes:

“On the one hand, the overall atmospheric pressure (currently 760 mm Hg) cannot be much increased or the work of breathing would be significantly increased, as would the risk of fire. On the other hand, it cannot be radically less or the oceans would have long ago evaporated, although recent work suggests that at times in the distant past it may have been less than half its current level” (p. 24).

Moreover, we need a rocky planet like Earth. It must have a size, mass, and gravitational field similar to Earth to sustain stable oceans and atmosphere. Gravity must be strong enough to retain

gaseous nitrogen, oxygen, and carbon dioxide, but weak enough to allow for the escape of hydrogen and helium. However, this size/mass profile is also ‘just right’ to allow carbon-based creatures our size an upright, bipedal posture, which is of course needed to manipulate fire.

Metallurgy also requires a planet where the right elements are easily accessible and usable. Metals such as copper and iron have a high tensile strength while also being remarkably malleable and ductile at ambient temperatures on Earth. Metals soften considerably at much above ambient temperatures, and they become brittle below 0°C. Moreover, electrical conductivity of common electrical conductors like copper decreases with temperature. But it is not the conductivity profile which allows it to be made into thin wires, making ambient temperatures the best conditions in which to miniaturize motors and dynamos. Lower temperatures would mean copper would be more prone to breakage; higher temperatures make it less electrically conductive, requiring wires with a greater cross-sectional area to function, thus increasing the mass of copper needed to make motors run.

It also requires metals to be concentrated as ores in the crust for us to access. If there were less metal atoms in the Earth’s crust, different properties of the mineral ores, or different viscosity properties of the crust, etc., then mineral ores might not have formed.

### Fine-tuned fire fuel

However, even with the right sort of inorganic planet and the right properties of fire, fire is still not guaranteed. We need the right *fuel* as well. For that, we need wood.

But not all forms of wood are useful for technology. Twigs and grass will burn but will not produce the charcoal needed to reach temperatures at which we can smelt metals from their ores. And of course we need oxygen to

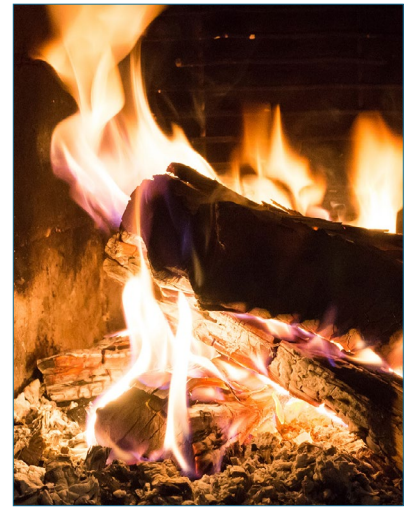


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**Figure 1.** Conditions must be ‘just right’ for fire to be useful to building civilization.

make them burn. But these are not our inventions—they are both the product of *photosynthesis*. Fire is not something that we can separate from plant life—without woody plants, fire is not possible. Denton briefly mentions how the atmosphere is fit for photosynthesis, letting in the right sorts of radiation and blocking the wrong sorts.

But Denton concentrates most of his time on the properties of plants that make fire possible. Lignin and cellulose make the plants sturdy and strong. For instance, lignin is sturdy and breaks down slowly, which makes soil a viable medium for plant growth. This seems to raise a chicken and egg problem: woody plants need lignin to grow well in soil, but are the only organisms that produce lignin in sufficient measure to ‘feed’ it to the soil.

However, Denton spends most of his time describing the transpiration system in plants. It moves water from the soil to the atmosphere much more effectively than direct evaporation from the soil. It does so by some amazing use of the physical properties of water, and pressure differentials and capillary action caused by the structure of the conduits. And of course water is a crucial component of photosynthesis. As Denton concludes:

“Trees are only possible because of an ensemble of elements of fitness in nature—the physical factors which prevent leaves from overheating in the sun, the unique properties of the cellulose lignin composite that confer tensile strength and durability to tree trunks and promotes the formation of soil, and the unique mechanism to raise water to the top of tall trees. Trees only exist because the physical properties of water including its tensile strength and density are exactly as they are, and only because the force of surface tension generated in small, curved surfaces is as strong as it is, and only because the laws of hydraulics are precisely as they are” (p. v44).

Trees could not exist without all these uniquely fit properties. And without trees, fire would be impossible.

### Fine-tuned fire-maker

But even with the fitness of our circumstances to the existence of fire, it would not be utilized if we were not fit to do so. First, we need to be terrestrial. Underwater creatures cannot master fire; their ‘atmosphere’ is not right for it.

But also, our bodily form makes it possible. Without our upright stance and our most impressive tool—our hands—we couldn’t make and master fire.

But even with these elements in place, they would be useless for making fire if we were not the size we are. Organisms much smaller than about 1 m tall could not cut lumber needed to make charcoal or mine in solid rock. An ant-sized man could not get close enough to the flames to manipulate them without being consumed, let alone collect the lumber and mine the rocks as needed. Indeed, even ant-sized tools for ant-sized people would be useless; they don’t have enough kinetic energy to work.

Organisms of our morphology much bigger than us would find it impossible, too, but for different reasons. It is an application of the *square-cube law*

(figure 2), where an object’s surface area increases by  $n^2$  as its volume increases by  $n^3$ . This has a detrimental effect on muscle and bone strength as we increase the size of an animal:

“For example, if a human were scaled up 10 times, his surface area and cross-section would be 100 ( $10^2$ ) times larger—so his bones and muscles would also be 100 times stronger. However, his volume would be 1,000 ( $10^3$ ) times larger—and so will his mass and weight. So his muscles and bones would be far too weak to support his weight.”<sup>6</sup>

And since the average human thigh bone breaks under about 10 times the average human weight, the opportunities for upscaling our size are very limited. Indeed, there are grave safety risks in doing so. A small child of 20 kg can fall over with little harm, but a fully grown man may break a bone from a similar sort of fall. As the old adage goes: ‘the bigger they are, the harder they fall’. When bipeds are upscaled in size to us (in the fossil record, e.g. the largest theropods), they require a very different bodyplan from us—one that is far less suited to manipulating fire than ours.

But our ability to stand up is not simply a feature of size, but also of muscle *strength*. Ants appear so much stronger than us not because their muscles are proportionately stronger. They are not.<sup>7</sup> Rather, it is again a function of the square-cube law. In fact, the muscles of all organisms have the same basic design. And the elements that make up muscle are tightly packed as they can conceivably be. As such, they are about as strong as they can be. This affects *all* muscle activity, from the muscles that support us standing upright, to our hand grip strength, to how well our heart pumps blood around the body.

But aside from the size and strength, we also need fast reflexes and fine motor control for our muscles. This requires a fast-functioning nervous system that is proportionate to our size. And once again, as Denton points out:

“Consideration of the basic characteristics of nerve impulse propagation suggests that the speed of conduction in mammals is close to the maximum possible that is compatible with the electrical properties and general design of cells” (p. 60).

Not only is fire a ‘Goldilocks’ fit for us to make technology, but so is Goldilocks herself!

### Whence the fine-tuning?

Denton in this book has only touched on a sample of the ways the cosmos is fit for life like us. Indeed, since he wrote *Fire-Maker* in 2016, he has published another four books on how many different aspects of the cosmos reveal its fine-tuned fitness for life like us.

But what can we *infer* from this fine-tuning? Denton draws a helpful distinction between the *empirical fact* of fine-tuning and design as an *explanation* of fine-tuning:

“The unique fitness of nature for carbon-based life and intelligent beings of our biology is an empirical discovery, no matter how many cogent arguments a skeptic might introduce to counter any claim that the fitness is the result of design. Fitness is a fact ... whether it is the result of design or not!” (p. 67).

But he also correctly points out: “Whatever the ultimate causation may eventually prove to be, as it stands, the evidence of fitness is at least *consistent* with the notion that the fine-tuning for life as it exists on Earth is the result of design” (p. 67).

And he does go further in suggesting that this fine-tuning is evidence against us being here merely as an accident of deep time and chance:

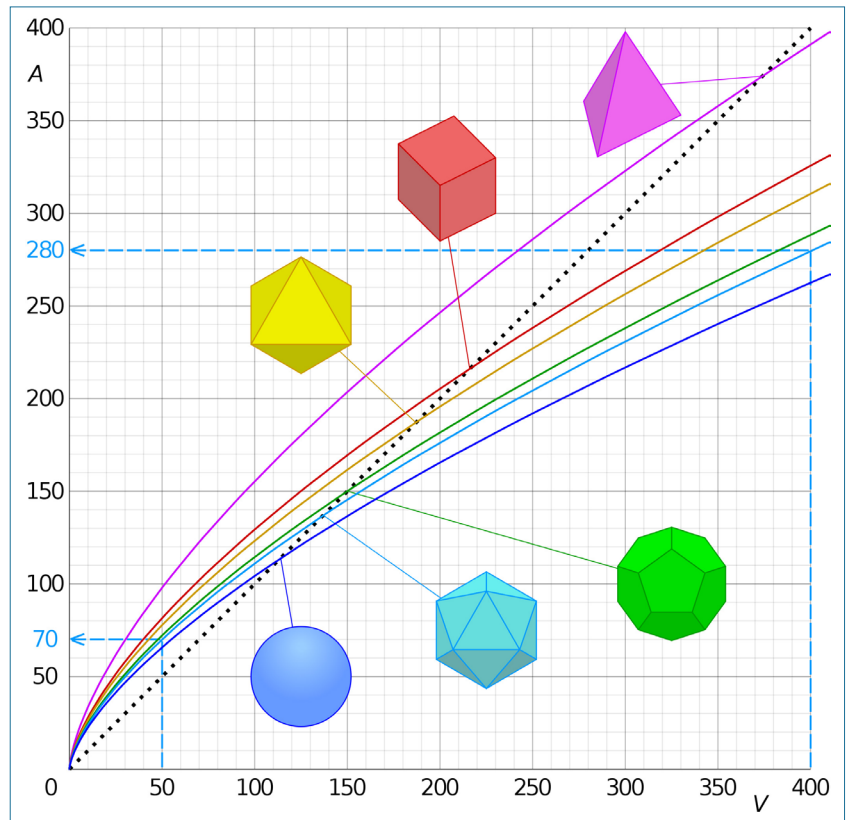
“Although the current *Zeitgeist* would have us believe that humanity is little more than a cosmic accident, one of a million different possible outcomes that happened to arrive and survive on an unexceptional planet, the evidence examined in

this short book suggests otherwise—that whatever the causation of the fine tuning, *we are no accident of deep time and chance* [emphasis in original]” (p. 69).

Nonetheless, anyone familiar with Denton’s work will know that he does *not* believe in a transcendent designer. Instead, he seems to prefer attributing the teleology of nature to “internal causal factors according to a structuralist ‘laws of form’ framework”.<sup>8</sup> However, he does not press this view in this book. Rather, he focuses on the *empirical fact* of fine-tuning.

What should the biblical creationist make of this? The first thing to point out is that Denton’s broad conclusion and practically all the factors he lists as fine-tuned are consistent with biblical creation. The one or two that are not are among the weakest factors he points to. Still, if such factors are required for us to be fire-makers, God plausibly parameterized the design of our environment within Creation Week to achieve similar ends. Indeed, it may be a better explanation. It fits the ‘time maturation’ elements into a broader parametric design schema rather than singling them out for origination by natural processes.

And there are reasons, both biblical and philosophical, to reject Denton’s preferred explanation for the fine-tuning. It clearly conflicts with Scripture, and since it is God’s word, it should be given epistemic priority. From the philosophical angle, however, we have no experience of the sort of ‘intrinsic teleology’ in nature of which Denton speaks. Rather, every instance of such extreme functional fine-tuning we have everyday experience of is produced by intelligent, personal agents. Positing a transcendent designer is much simpler, more elegant, and more intrinsically plausible than arguing for some teleological ‘I don’t know what’ of which we have no experience. Clearly the burden of proof is on those like Denton who would seek to posit a teleological ground



**Figure 2.** Graphs of surface area *A*, against volume *V*, of all five Platonic solids and a sphere. It shows that the surface area decreases for rounder shapes (sphere being the lowest), and the surface-area-to-volume ratio decreases with increasing volume. The dashed blue lines show that when the volume of a randomly selected solid increases 8 ( $2^3$ ) times, its surface area increases 4 ( $2^2$ ) times. The dotted black line shows surface-area-to-volume ratio of 1.

foundationally different from personal agency.

### Conclusion

Denton has done us a massive service in collating many of the empirical facts showing that nature, the earth, and humans are all together fine-tuned for making fire. There are many independent parameters that, if they were changed just a little bit in any direction, would mean we could not make fire. Nonetheless, merely noting this fine tuning cannot be an end in itself. It points beyond itself. Denton is hesitant to go where it properly points, but we do not need to be so hesitant. It is wonderfully consistent with the God of Scripture because he is the one who made nature fit for fire-makers.

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