Fire in the air

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During the 18th century, scientists understood fire and combustion to be the result of a mysterious substance called phlogiston. Although this theory had great explanatory power and was widely accepted among scientists for approximately 100 years, it nevertheless fell eventually (and its fall, once it occurred, happened very quickly). Phlogiston teaches us that just because a theory is widely accepted among scientists, is believed to explain all the evidence, and reigns supreme for a long time, does not mean that it is true. Indeed, phlogiston was in many ways a stronger theory than is evolution today; however, since evolution allows mankind to shake his fist at his Creator, it is not subjected to the same standard of proof as other, more empirical theories such as phlogiston.

What is fire? What happens when something burns? The search for the answers to these questions lasted for centuries, involved many people, and also has much to teach us today as Christians.

Robert Boyle


Robert Boyle (1627–1691)

Courtesy TFE Graphics

Robert Boyle (1627–1691), a devout Christian who is often called 'the father of chemistry',[1] was very much interested in combustion and made many contributions in this area. Many of his experiments used an air pump invented around 1658 by his assistant Robert Hooke. Boyle had heard of the air pump invented by Guericke[2] in 1647, and instructed Hooke to construct a similar device: one that would allow Boyle to evacuate air from a large glass vessel, accessible through a hole in the top. Although crude by today's standards, this apparatus allowed Boyle to perform and observe experiments in a near vacuum.

Boyle discovered that candles, glowing coals, and sulfur would not burn without air. He also found that flies, bees, butterflies, mice, and birds would 'swoon' and then die in a vacuum. Obviously there was some similarity between respiration and combustion. Also, before dying, the mice and birds would first produce vapors—'steams'[3]—that would condense inside the glass first. Boyle surmised that they died because they were poisoning their own air. (He wrote about 'recrementitious steams that are separated from the mass of blood in its passage through the lungs'[3]—he understood that some sort of waste was removed during respiration, but didn't understand as well that air supplied anything necessary for life.)

Stahl and phlogiston

Subsequently, German chemist Georg Ernst Stahl (1659–1734) popularized[4] an idea called *phlogiston*. Like most scientists of his time, Stahl was heavily influenced by Greek philosophy and the idea that there were certain 'essences' which made up all physical matter. The phlogiston theory was that all material was made up of three basic components: the pure form of the material, the essence of fire (called phlogiston, after the Greek word *phlogistos*, meaning 'burning'), and finally any impurities that also happened to be present. Combustion was merely a process by which the inherent phlogiston of a material, its essential fire, was released into the air. As the phlogiston escaped, it produced a whirling motion in the air—the flame.

Stahl's theory made sense. After all, when a piece of wood burns, the ash that's left over was obviously much less substantial than the wood itself had been. Something must have left, and that something was phlogiston. The leftover ash was therefore the essence of the wood (plus any contaminants).

Different materials varied in their amount of phlogiston. Rock had almost none—thus it wouldn't burn. Conversely, lampblack was perhaps pure phlogiston, since it burned readily and left very little residue.

The new theory explained past observations very well. For example, it had been known for centuries that the heating of most metals in open air resulted in the formation of a powder. This powder was called a *calx* (and the process *calcination*). Now it was understood that the calx was the pure essence of the metal after the phlogiston was removed. The transformation was quite often reversible—many calces could be smelted with charcoal (a source of phlogiston) and be transformed into the metal again.

The phlogiston theory required that air be present during combustion to absorb the phlogiston. Of course, the experiments of Boyle and others had already shown that combustion couldn't occur in a vacuum. Neither could respiration, which was consistent since respiration was thought to be a form of combustion. However, scientists also realized that a given amount of air can only absorb so much phlogiston. Creatures or flames placed into airtight spaces lived for a while, then died. Obviously, the air would only accept phlogiston until it was saturated, then combustion would cease. Air that was saturated with phlogiston became known as 'phlogisticated air'.

British chemist Joseph Priestley (1733–1804) even discovered[5] that he could manipulate the amount of phlogiston in the air. He heated mercury in air, which turned it into a reddish substance that he called the *precipitate per se*. Then, when the *precipitate per se* was heated again to a different temperature, it not only turned back into mercury but also produced a new kind of air. This new air allowed mice to live longer, and wood burned more brightly in it. Obviously this new kind of air could accept more phlogiston than normal air—that must mean it started out with less phlogiston in the first place. Therefore, Priestley named it 'dephlogisticated air'.

The phlogiston idea was applied to a wide variety of phenomena. Left to its own devices, iron will slowly produce its calx (rust). Therefore, the rusting process was also a (slow) form of combustion. Fermentation, the interactions of acids and alkalis, and the formation of salts, were all explained using phlogiston. Some investigators even suspected that phlogiston itself could be isolated. English scientist Henry Cavendish (1731–1810) dissolved metals in acids and produced 'inflammable air', so named because it burned so easily. Cavendish thought it to be pure phlogiston.[6]

Antoine Lavoisier (1743–1794). Engraved by C.E. Wagstaff after the painting by Jacques-Louis David.

Phlogiston was widely accepted, but it did have some problems. For example, wood ash obviously weighed much less than the wood itself had weighed, and so the phlogiston that had been released must have accounted for at least some of that weight that was lost. However, it had been known for some time that metals *gained* weight when they were calcified. For example, Boyle had heated tin in a sealed flask. When he opened the flask and weighed the tin afterwards, he found that it had gained weight. (He attributed this to 'particles of fire' being absorbed by the metal.) Others had examined this question as well. Louis Bernard Guyton de Morveau (1737–1816) published his *Dissertation sur le phlogistique* in 1772. He had investigated all of the calcinable metals, and 'had confirmed in experiments of exceptional precision and care that metals *increased* in weight when they were roasted in air' (emphasis in original).[7] He proposed that in this case phlogiston had a 'levity'; thus, when the metals gave up their phlogiston, they became heavier.

Antoine-Laurent Lavoisier

French scientist Antoine-Laurent Lavoisier (1743–1794) became skeptical of phlogiston, at least partly because of dissatisfaction with Guyton de Morveau's 'absurd'[8] explanations. He reperformed many of the classic experiments himself, although being more precise in his measurements and more exact in his overall approach than the original experimenters had been. In 1775 he read the first[9] of a series of papers before the French Academy of Sciences, developing a new hypothesis: 'dephlogisticated air' was itself responsible for combustion, and there was no such thing as phlogiston. He was very clear that his theory was revolutionary; it was 'directly contrary to the theory of Stahl'[10] and 'the system of Stahl will be found to be shaken to its foundations'.[10]

Today we know 'dephlogisticated air' as *oxygen*, and of course we accept his idea as true. Oxygen is of course required for both combustion and respiration, and heated metals absorb it (Priestley's *precipitate per se* is today known as mercuric oxide). Rust, also known as iron oxide, is similarly understood today as being the result of the iron being 'oxidized' (combined with oxygen). 'Inflammable air' is now known as hydrogen. Today we understand combustion in general to be a process whereby oxygen combines with other elements in the material, sometimes producing various gases and other times solids, several forms of energy.

Lavoisier did not stop until he had completely overturned the foundations of chemistry in his day. Among other things, his *Traîte elementaire de chimie*, published in 1789, replaced the four ancient 'elements' with 33.[11] Also, 'The language of chemistry', Lavoisier now felt, had to be transformed to go with his new theory, and he undertook a revolution in nomenclature, too, replacing the old, picturesque but uninformative terms—like butter of antimony, jovial bezoar, blue vitriol, sugar of lead, fuming liquor of Libavius, flowers of zinc—with precise, analytic, self-explanatory ones. If an element was compounded with nitrogen, phosphorus, or sulfur, it became a nitride, a phosphide, a sulfide. If acids were formed, through the addition of oxygen, one might speak of nitric acid, phosphoric acid, sulfuric acid; and of the salts of these as nitrates, phosphates, and sulfates. If smaller amounts of oxygen were present, one might speak of nitrites or phosphites instead of nitrates and phosphates, and so on. Every substance, elementary or compound, would have its true name, denoting its composition and chemical character, and such names, manipulated as in an algebra, would instantly indicate how they might interact or behave in different circumstances'.[12] Laviosier's insights were so powerful that the old paradigm of phlogiston was completely swept away.

Lavoisier's new hypothesis was not immediately embraced by all of his peers. The phlogiston theory had been the dominant paradigm for almost 100 years, and it was based on philosophical views that had been in place for over a millenium. But his challenges to the phlogiston theory were substantial, and he pointed out that the advocates of the phlogiston theory (known as 'Phlogistians') had many inconsistencies in their explanations: for example, how could wood *lose* weight when phlogiston was lost, but metal *gain* weight when phlogiston was lost? In his *Mémoires de Chimiel* (believed to have been written in 1792 and published posthumously in 1805) he complained:

> ' … chemists have turned phlogiston into a vague principle, … which consequently adapts itself to all the explanations for which it may be required. Sometimes this principle has weight, and sometimes it has not; sometimes it is free fire and sometimes it is fire combined with the earthy element; sometimes it passes through the pores of vessels; sometimes these are impervious to it; it explains both causticity and non-causticity, transparency and opacity, colours and their absence, it is a veritable Proteus changing in form at every instant.'[13]

Lavoisier had much better explanations. For example, he had reperformed Boyle's tin heating experiment, but unlike Boyle, he weighed the tin and the flask together, before and after the heating. He observed that, even after the heating, the combined weight had not changed. Once he opened the flask, air rushed in, and *then* the tin gained weight. Therefore, he concluded, the tin was absorbing oxygen from the air, and this accounted for the weight gain. Many of Lavoisier's contributions to science were due to his insistence on precise quantitative measurements—this emphasis was unusual until that time, and lent great empirical weight to his arguments.

The Phlogistians did not give up easily to the Antiphlogistians, and they pointed out problems with Lavoisier's ideas as well. However, Lavoisier refined and corrected his hypothesis over time, and the Antiphlogistian case became stronger. As the debate progressed, more and more Phlogistians became Antiphlogistians. Eventually, the Antiphlogistians won, with Priestley (a Phlogistian to the end) mourning in 1796:[14]

> 'The old system is entirely exploded … I hardly know of any person, except my friends of the Lunar Society at Birmingham, who adhere to the doctrine of phlogiston; and what may now be the case with *them*, in this age of revolutions, philosophical as well as civil, I will not at this distance answer for.'

Comparing phlogiston to evolution

So how is this relevant to us today? The phlogiston theory lasted for over 100 years. For most of that time, all the prominent scientists believed it. It seemed to explain so much. But it was *wrong*. Although many today would laugh at the phlogiston theory as being hopelessly naive, nevertheless it is in many ways better than the ruling paradigm of our time: evolution. Let's compare the two:

- Phlogiston accumulated a large body of evidence over time. When this evidence was re-examined, much of it was shown not to support the idea after all, causing scientists to abandon the theory. Not so with evolution—as earlier 'evidence' for evolution has been subsequently disproved, this has not seemed to affect anybody's faith in the idea. For example, most of the 'evidence' for evolution that was presented in the 1925 Scopes trial has since been thrown away (e.g. Piltdown Man,[15] horse evolution,[16] embryonic recapitulation ,[17] etc.). It doesn't seem to matter that the 'evidence' is always changing.
- Phlogiston was discarded by many scientists because they saw that many of its predictions were not upheld by new experiments and data. Not so with evolution—for example, Darwin acknowledged that the fossil evidence for his theory was lacking, and admitted that it was 'the most obvious and serious objection which can be urged against the theory'.[18] He placed his faith in the 'extreme imperfection of the geologic record',[18] expressing confidence that the evidence would be found later. Today, after more than a century of tireless digging, the evidence still hasn't been found—but rather than acknowledging the tremendous problem this poses, some evolutionary paleontologists claim that this *lack* of fossil evidence for evolution is, instead, evidence for a certain version of evolution.[19,20] Similarly, in astronomy we see that the measured Cosmic Microwave Background is only about 10% of that required by the big bang inflation model—nevertheless, this is claimed to support the model![21]
- Phlogiston was also discarded by many scientists because they grew uncomfortable with the increasingly *ad hoc* explanations that were necessary in order to preserve the theory against the growing body of evidence. Not so with evolution—we often see situations where it is preferable to make up implausible stories than to question evolution. For example, we see stars whose orbits are unstable (over billions of years anyway) within their parent galaxies. Rather than accepting the possibility that the galaxies are young, evolutionists would rather invent 'dark matter' instead (an invisible, undetectable material that's surrounding each galaxy and galaxy cluster).[22,23] There's also 'dark energy': a mysterious unknown force operating on the entire universe, which is necessary to keep the big bang model viable.[24] Other serious problems with the big bang have had to be repaired with the 'inflation' hypothesis[25]—the idea that soon after the big bang, the Universe suddenly increased its rate of expansion to more than the speed of light, then a little while later suddenly slowed down again. How solid is *this* idea? Even its proponents admit: 'What drove inflation? Nobody knows'.[26] We see that phlogiston was rightly thrown out when it became necessary to spin tales to explain away the evidence, yet sadly we see this same sort of story-telling appear perfectly respectable today in evolutionary thought.

Conclusion

Phlogiston, although obsolete as a scientific idea, nevertheless has much to teach us today. We see that just because an idea seems to explain a lot of things, and is believed by all the prominent scientists of the day, who all proclaim it to be the ultimate explanation of how things work, does not necessarily mean that this idea won't be thrown onto the garbage heap later.

There's no reason why this shouldn't be as true of today's evolutionary theories as it was of phlogiston. As creationists, we are often mocked because 'the majority of scientists believe in evolution.' Even if that is true, it's irrelevant. As a paradigm, phlogiston was perceived to be just as powerful then as evolution is today, yet it was completely uprooted and destroyed in a few short years.

(We even see that evolution is actually on shakier ground than phlogiston was. Why then has it not been overthrown yet? Because, unlike phlogiston, the creation/evolution issue is a spiritual battle as well as a scientific one. A godless society will fight tooth and nail to reject any possibility of responsibility towards a creator. If alternative explanations don't match the evidence, then so be it—anything is preferable to the truth.)

Phlogiston teaches us to resist trusting the majority's opinions, just because they are held by the majority. We see that those opinions can change in an instant. On the other hand, the Bible is the Word of the Creator of Heaven and Earth. It has been the same from the beginning, and its truth remains ... today and forever.

References

1. E.g. the title of Ref. 3. A brief biography was published in *Creation* **12**(1):22–23, 1989. Also available at <www.answersingenesis.org/home/area/magazines/docs/v12n1_boyle.asp>.
2. Gillispie, C.C. (Ed.), *Dictionary of Scientific Biography*, Charles Scribner's Sons, New York, Vol. V, pp. 574–575, 1975.
3. As quoted in Sootin, H., *Robert Boyle: Founder of Modern Chemistry*, Franklin Watts, USA, p. 91, 1962.
4. Stahl, G.E., *Zymotechnia Fundamentalis*, Halle, 1697.
5. As published in the second volume of his *Experiments and Observations on Different Kinds of Air*, J, Johnson, London, 1775. Gillispie, Ref. 2, Vol. VIII, p. 75.
6. Gillispie, Ref. 2, Vol. III, p. 156.
7. Sacks, O., *Uncle Tungsten, Memories of a Chemical Boyhood*, Alfred A. Knopf, New York, p. 108, 2001.
8. Sacks, Ref. 7, p. 109.
9. Lavoisier, A-L., *Mémoire sur la nature du principe qui se combine avec les metaux pendant leur calcination, et qui en augmente le poids* (Memoir on the nature of the principle which combines with metals during their calcination and which increases their weight); read before the Academy, 26 April 1775; a revised version was published in the Academy's *Memoires* in 1778. Available in English translation at <//webserver.lemoyne.edu/faculty/giunta/lavoisier.html>.
10. Lavoisier, A-L., *Mémoire sur la combustion en général* (Memoir on Combustion in General); presented to the Academy in 1777, available in English translation at <//webserver.lemoyne.edu/faculty/giunta/lavoisier1.html>.
11. More precisely, the 33 elements corrected the 55 that Lavoisier had earlier proposed in his *Méthode de nomenclature chimique* (1787). Gillispie, Ref. 2, Vol. VIII, p. 80.
12. Sacks, Ref. 7, p. 112.
13. *Encyclopaedia Britannica*, 11th Edition, **4**:35, 1911.
14. Priestley, J., *Considerations On The Doctrine Of Phlogiston And The Decomposition Of Water*, 1796. Available at <//webserver.lemoyne.edu/faculty/giunta/phlogiston.html>.
15. Now acknowledged to be a deliberate fake—a human skull with an orangutan jaw, stained to look old.
16. Sarfarti, J., The non-evolution of the horse, *Creation* **21**(3):28–31, 1999. Available at <www.answersingenesis.org/horse>.
17. Grigg, R., Fraud rediscovered, *Creation* **20**(2):49–51, 1998. Available at <www.answersingenesis.org/fraud>.
18. Darwin, C., *The Origin of Species By Means Of Natural Selection Or The Preservation Of Favored Races In The Struggle For Life*, Random House, Inc., New York, p. 406, 1993.
19. Batten, D., Did creationists 'hijack' Gould's idea? *TJ* **16**(2):22–24, 2002. Available at <www.answersingenesis.org/gould2>.
20. Batten, D., Punctuated equilibrium: come of age? *TJ* **8**(2):131–137, 1994. Available at <www.answersingenesis.org/punc>.
21. Hartnett, J., Cosmologists can't agree and are still in doubt! *TJ* **16**(3):21–26, 2002. Available at <www.answersingenesis.org/cosmologies>.
22. DeYoung, D.B., Dark matter, *CRSQ* **36**(4):177–182, 2000. Available at <www.creationresearch.org/crsq/articles/36/36_4/darkmatter.html>.
23. Oard, M. and Sarfati, J., No dark matter found in the Milky Way galaxy, *TJ* **13**(1):3–4, 1999.
24. 'The biggest problem with this idea is that no one has any idea what dark energy is. "So far, all we've been able to do is name it," says Turner. "It could be the energy associated with nothing, or the influence of hidden spatial dimensions".' Sincell, S., The 8 greatest mysteries of cosmology, *Astronomy*, June 2001, p. 46.
25. There are actually a number of inflation models today. 'Physicists have suggested different models to describe the inflating universe, but all the solutions are mathematical conveniences *with no particular physical basis*. "All the theories of inflation amount to proof that we don't have one good theory yet," says Fermi National Accelerator Laboratory astrophysicist Edward W. "Rocky" Kolb.' Sincell, Ref. 24, p. 49, emphasis added.
26. Sincell, Ref. 24, p. 49. Even Alan Guth, the inventor of inflation, has admitted, 'Although the basic idea still looks very attractive [because the big bang is invalid otherwise], we don't know the real details of inflation or the mechanism that drives it.' Nadis, S., Cosmic inflation comes of age, *Astronomy*, April 2002, p. 30, material in brackets added.

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