

## Reply to creationwiki page “Pseudoscience in the American Journal of Physics”

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The [creationwiki](#) article above, by “Davidmihjn” (dated 14 January 2013) claims that my paper “Entropy and evolution” (*American Journal of Physics* **76** (11) November 2008, pages 1031–1033) is “irrational”. The twelfth paragraph (of thirteen in the article) describes why: My paper uses the microcanonical expression for entropy  $S = k_B \ln W$ , but “This is absurd because the Boltzmann constant [ $k_B$ ] comes from observations about atomic systems.”

In fact, living things are made up of atoms, so the microcanonical expression for entropy is perfectly reasonable and applicable. The suggestion that the Boltzmann constant applies only to “atomic systems” is also false. For example, black body radiation is not made up of atoms, yet the entropy of black body radiation of volume  $V$  and temperature  $T$  involves Boltzmann’s constant through

$$S = k_B^4 \left( \frac{32 \pi^5}{45 c^3 h^3} \right) VT^3.$$

(Here  $c$  represents the speed of light and  $h$  represents Planck’s constant.)

The above suffices to show why Davidmihjn’s critique is without substance. However, the article makes several other errors concerning thermodynamics and statistical mechanics, and as some of these errors are common misconceptions, it is worth pointing them out:

1. Claim: “Another basic variable is heat, which is what causes temperature to change.”

Fact: Heat is not a state variable. There are two ways to transfer energy into (or out of) a thermodynamic system – heat and work. Once the energy transfer happens, there is no way to distinguish whether the transfer happened through heat or through work. Furthermore, either heat or work might or might not cause temperature to change. For example, given a bowl of water and ice at equilibrium at atmospheric pressure and temperature 0 Celsius, addition of either heat or work will melt the ice and not raise the temperature.

2. Claim: Temperature and “average kinetic energy of molecules” are related through  $\langle KE \rangle = \frac{3}{2} k_B T$ .

Fact: This relation holds only for a classical monatomic gas of non-interacting point particles. For a classical diatomic gas of non-interacting molecules, the relation is instead  $\langle KE \rangle = \frac{5}{2} k_B T$ . For non-classical systems, and for interacting molecules, still other results apply.

3. Claim: “The second law of thermodynamics is that a gas will fill up the entire container it is in because that is the most probable distribution of gas molecules. It is possible, but improbable, for all of the molecules to be huddled in one corner of the container.”

Fact: The second law of thermodynamics applies to all equilibrium systems, not just gases. There is an easy way to make all the molecules huddle in one corner... simply decrease the temperature until the gas turns to a liquid. Or, consider a container of gas 50 kilometers tall with its base on Earth at sea level: most of the molecules will huddle at the bottom of the container, and the top will be near-vacuum.

4. Claim: “The second law does not apply to the evolution of stars.”

Fact: Thermodynamics, including the second law, is used on a daily basis by astrophysicists studying stellar evolution. See, for example, H. Kähler, “Stars with Given Entropy Distribution”, *Astronomy and Astrophysics*, **75** (1979) 207–213: “Entropy plays an important role for stellar structure and evolution: The structure of a spherical star in hydrostatic equilibrium (with specified mass and composition) is essentially determined by the run of entropy.”

5. Claim: “The second law only applies to systems of non-interacting particles or entities.”

Fact: The Clausius–Clapeyron relation demonstrates conclusively that the second law of thermodynamics applies at phase transitions. Phase transitions are caused by interactions between particles. Similarly, Schreinemakers’ Rule for invariant points in binary alloy phase diagrams follows from thermodynamics, and it has been tested extensively in highly-interacting systems. Clearly the second law *does* apply to systems of interacting particles.

HOWEVER, if it were true that “the second law only applies to systems of non-interacting particles or entities”, then the second law would not apply to living things, and hence the creationist canard that “the second law prohibits evolution” would be transparently false.

6. Claim: The second law does not apply to living things.

Fact: Le Châtelier’s Principle, which derives from the second law of thermodynamics, is fundamental to bioregulation. See, for example, [Creatine](#), [Phosphocreatine](#), and [ATP](#).

7. Claim: “entropy increases only for isolated systems not affected by outside forces or inputs.”

Fact: The entropy of a system affected by outside forces or inputs might decrease, remain constant, or increase.

8. Claim: “All these authors are making the same assumption — viz. that all one needs is sufficient energy flow into a closed system (or open system, where mass flow is allowed) and this will be the means of increasing the probability of life developing in complexity and new machinery evolving.”

Fact: None of the authors mentioned make the assumption that “all one needs is sufficient energy flow”. In fact, in the last paragraph of my paper I point out specifically that claims like the one above are irrelevant: “The second law of thermodynamics permits but does not require evolution. For example, the second law of thermodynamics holds on the Moon, yet biological evolution doesn’t occur there.”

## The relation between science and religion

In December 2013 I had an exchange with a man named David Roemer, who stated that he was the same as the [creationwiki](#) author “Davidmihjn”. When I pointed out the facts outlined above, he could find no fault with them. Yet he persisted in denigrating my work, not through any scientific fault, but because he claimed it was “atheistic propaganda”.

And this is the most common — and most poisonous — misconception of all. In reply I could mention how [Popes John Paul II and Benedict XVI](#) find evolution to be consistent with religion, or I could point out how 12,898 Christian [clergy](#) find evolution to be consistent with religion, or I could describe 31 statements in support of evolution by [religious organizations](#), or I could summarize the [brief essays](#) by thirteen scientists, philosophers, and clergy responding to the question “Does science make belief in God obsolete?” (in brief: only one answer is an unequivocal “yes”). But instead I will describe how I, as a Quaker, find evolution to be consistent with religion.

Everyone agrees that the theory of evolution is inconsistent with a literal reading of the “six days” creation story in Genesis 1:1–2:3. It is less widely known but equally true that a literal reading of the “six days” story is inconsistent with a literal reading of the “Adam and Eve” story in Genesis 2:4–2:25. For example, in the “six days” story God creates animals first, then several men and woman. In the “Adam and Eve” story, God creates one man first, then animals, then one woman. My interpretation of these inconsistencies is that we should take the Biblical stories as metaphors (as in great literature) rather than as dry literal fact (as in a telephone book). Biblical literalism denigrates the Bible by interpreting it in the same way that one would interpret a telephone book.

The stories in Genesis are paeans to the power and glory and majesty of God, they are not dull paleontology primers. Similarly, Psalm 23 is a celebration of God’s guidance, whereas a literal reading leads inevitably to questions like “How deep is the Valley of the Shadow of Death? What is the flow rate of the river running through it? Has it been nominated as a UNESCO World Cultural Heritage Site?” In short, a literal reading of the Bible *completely misses the point*.

According to Psalm 19, “the heavens proclaim the glory of God”. And indeed they do. The heavens proclaim a magnificent universe,  $13.798 \pm 0.037$  billion years old, full of microwave radiation, galaxies, clusters, stars, nebulae, and planets (1078 known to date); various and arresting and beautiful. At least one planet has life: 1.2 million cataloged species — far too many to have been discovered and named by one individual — varying from zebras to Sequoia to whales to gnats to Hallucigenia to Bdellovibrio to Sulfolobus. But even without life our planet is various and arresting and beautiful: crystals, lodestones, fluid turbulence, waterfalls, geysers, rainbows, clouds; 79 million cataloged chemical compounds, combinations of 92 naturally occurring elements, all made up of electrons, protons, and neutrons. Every day new scientific discoveries show that the glory we know at present is but a fraction of the full glory of God.

Most of this glory is undescribed in the Bible, for the excellent reason that the several authors of the Bible didn’t know it. Realizing the limits of their understanding, these authors never claimed that “the Bible proclaims the glory of God” just as today we don’t claim that “*Chemical Abstracts* proclaims the glory of God”. If we limit our understanding of God to the understanding presented in the Bible, we shortchange ourselves, we shortchange the Bible, and we shortchange God.