

John Keble was Professor of Poetry at Oxford. The Christian Year, from which this excerpt is taken, was published in 1827.

Humour from the Web
ANIMAL POEMS

NEWS BRIEFS..... (From the Internet)

- * T. rex demoted to scavenger
- * The stars in the visible universe are not quite overcountable
- * Glow in the dark fish
- * Oldest known fossil of modern human found
- * Move over Hubble for the world's most powerful telescope
- * Feeling miserable? It is probably the metapneumovirus
- * Music goes way back
- * The humble sponge first invented fibre optics
- * Battery power from a bottle

Spot the Fallacy
DUBIOUS TESTIMONIES AND POST HOC ERGO PROPTER HOC
.....(Mike L Anderson)

* Feature article *
THE SECOND LAW OF THERMODYNAMICS IN THE CONTEXT OF THE
CHRISTIAN FAITH
.....(Allan Harvey)

"Now we address the context in which the 2nd law arises in creation arguments. The usual argument goes something like this: "The 2nd law says everything tends toward increasing entropy (randomness and disorder). But the evolution of life involves the development of great complexity and order. Therefore, evolution is impossible by the 2nd law of thermodynamics." While it sounds simple, there are major flaws in this argument that render it worthless."

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<http://members.aol.com/steamdoc/writings/thermo.html>
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Wisdom from the Past

FIFTEENTH SUNDAY AFTER TRINITY

John Keble

Consider the lilies of the field, how they grow.
St. Matthew, vi.28.

Sweet nurslings of the vernal skies,
Bathed in soft airs, and fed with dew,
What more than magic in you lies,
To fill the heart's fond view?

In childhood's sports, companions gay,
In sorrow, on Life's downward way,
How soothing! in our last decay
 Memorials prompt and true.

Relics ye are of Eden's bowers,
 As pure, as fragrant, and as fair,
As when ye crowned the sunshine hours
 Of happy wanderers there.
Fall'n all beside--the world of life,
How is it stained with fear and strife!
In Reason's world what storms are rife,
 What passions range and glare!

But cheerful and unchanged the while
 Your first and perfect form ye show,
The same that won Eve's matron smile
 In the world's opening glow.
The stars of heaven a course are taught
Too high above our human thought:
Ye may be found if ye are sought,
 And as we gaze, we know.

Ye dwell beside our paths and homes,
 Our paths of sin, our homes of sorrow,
And guilty man where'er he roams,
 Your innocent mirth may borrow.
The birds of air before us fleet,
They cannot brook our shame to meet -
But we may taste your solace sweet
 And come again to-morrow.

Ye fearless in your nests abide -
 Nor may we scorn, too proudly wise,
Your silent lessons, undescried
 By all but lowly eyes:
For ye could draw th' admiring gaze
Of Him who worlds and hearts surveys:
Your order wild, your fragrant maze,
 He taught us how to prize.

Ye felt your Maker's smile that hour,
 As when He paused and owned you good;
His blessing on earth's primal bower,
 Ye felt it all renewed.
What care ye now, if winter's storm
Sweep ruthless o'er each silken form?
Christ's blessing at your heart is warm,
 Ye fear no vexing mood.

Alas! of thousand bosoms kind,
 That daily court you and caress,
How few the happy secret find
 Of your calm loveliness!
"Live for to-day! to-morrow's light
To-morrow's cares shall bring to sight,
Go sleep like closing flowers at night,
 And Heaven thy morn will bless."

Humour from the web

ANIMAL POEMS

THE RABBIT

Anonymous

The rabbit has a charming face:
Its private life is a disgrace.
I really dare not name to you
The awful things that rabbits do.
Things that your paper never prints -
You only mention them in hints.
They have such lost, degraded souls
No wonder they inhabit holes;
When such depravity is found
It can only live underground.

IF YOU SHOULD MEET A CROCODILE

Anonymous

If you should meet a Crocodile
Don't take a stick and poke him;
Ignore the welcome in his smile,
Be careful not to stroke him.
For as he sleeps upon the Nile,
He thinner gets and thinner;
And whene'er you meet a Crocodile
He's ready for his dinner.

FLEAS

Anonymous

Adam
Had 'em.

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- * T. rex demoted to scavenger
Many paleontologists now think that the symbol of ferocious predation, Tyrannosaurus rex, may have been like a vulture - entirely a scavenger. Several lines of evidence are pointing them to this conclusion. Its large size would have made it fairly slow. Its arms were too small for catching prey. Its jaw structure was more suited to bone crushing than tearing flesh. The olfactory lobes of the brain were very large- just as we see in vultures. Other paleontologists believe it was more like a hyena - a scavenger that also preyed on the

infirm.

www.24hourmuseum.org.uk/nwh_gfx_en/ART17662.html

* The stars in the visible universe are not quite overcountable

Astronomers from the Anglo-Australian Observatory in New South Wales have recently arrived at the most accurate estimate of the number of stars in the visible universe - 7×10^{22} . This is roughly ten times the number of grains of sand on Earth. They divided the sky into transects and estimated the number of stars in a single strip. They multiplied this number by the number of transects. The brightness of galaxies and star clusters were used to estimate the number of stars they contained.

www.space.com/scienceastronomy/star_count_030722.html

* Glow in the dark fish

For the child that has everything, now there is a glow in a dark pet. A genetic engineer from the National Taiwan University took a gene from a jellyfish and added it to the genome of the Zebra fish. His purpose was to make the internal organs of the fish more visible for researchers. A local aquarium supply company quickly saw the commercial potential. Now orientals can buy "Night Pearls" - probably for the price of a gem.

www.bbc.co.uk/science/genes/gene_safari/wild_west/glowing_gallery2.shtml

* Oldest known fossil of modern human found

A new subspecies of modern human, called *Homo sapiens idaltu*, has been found in Ethiopia. Dated at between 154 000 and 160 000 years old, the find is adding to the growing acceptance of the Out-Of-Africa theory. The fossils help to fill a gap between pre-human species (300 000 years ago) and the previous oldest modern human (100 000 years ago). The fossils show evidence of a burial ritual and so are the oldest indication of human culture.

www.abc.net.au/science/news/stories/s877478.htm

* Move over Hubble for the world's most powerful telescope

Scientists have figured out how to use massive gas clouds in space as a "magnifying lens" for a radio telescope. The clouds bend the radio waves much as glass bends light. The problem is that the space lens is moving around, is bumpy (the gas varies in density) and the observer won't keep still (the earth is also moving). The result is that it takes a year to factor in all the variables and take a picture. But it does give astronomers the opportunity to view some of the most distant and mysterious objects in the universe - such as the Black Holes inside quasars with unprecedented resolution. The images from the new telescope have a resolution of 10 microarcseconds - that's 2000 times better than Hubble.

www.abc.net.au/science/news/stories/s829460.htm

* Feeling miserable? It is probably the metapneumovirus

The metapneumovirus was discovered only two years ago.

Researchers now realise that it is the extremely common cause

of such ailments as colds in adults and coughing, congestion, and wheezing in children. While the bug is medically largely insignificant, microbiologists are very interested in it as an evolutionary success story.

<http://www.sacbee.com/24hour/healthscience/story/1000466p-7025771c.html>

* Music goes way back

Animal-bone flutes made by Neanderthals have been recently found in France. The instruments are remarkably fine-sounding and sophisticated and as much as 53 000 years old.

Anthropologists already knew from the universality of music in human cultures that it must be very old. Biomusician Patricia Gray and colleagues suggest that music predates the human race since whale and human music have so much in common despite diverging 60 million years ago. Just like humans, whales sing in key, have similar ranges in song length, mix pure and percussive tones in similar ratios and have similar structures in overall form.

<http://www.sciam.com/article.cfm?articleID=0006255F-8BAA-1C75-9B81809EC588EF21>

* The humble sponge first invented fibre optics

If you are dazzled by the high-tech world of fibre-optic cables, then the "Venus flower basket" should leave you flabbergasted. This sponge produces glass fibres that are as thin as a human hair, conduct light better and are more flexible than man-made fibres. The sponge fibres can even be tied in a knot without breaking. Scientists are studying the sponge to find out its secrets. Biomimetician (an engineer who studies biological systems to apply the principles to technology) Geri Richmond says "We can draw it on paper and think about engineering it but we're in the stone age compared to nature."

Battery power from a bottle

Engineers have devised a way to make ethanol power a battery. The ethanol combines with oxygen in the air to produce carbon dioxide, water and energy which is directly converted to electricity. The chemical reaction is catalysed by cheap, biodegradable, enzymes instead of expensive metals. They also can be recharged in seconds. In an emergency, the battery can be topped up by an alcoholic beverage. But what if the emergency is that you have run out of beer?

www.sciencedaily.com/releases/2003/03/030325072337.htm

Spot the Fallacy

DUBIOUS TESTIMONIES AND POST HOC ERGO PROPTER HOC

Mike L Anderson

Fred Basset slips off his master's chair straight after being told to get off.

"Did you see that," exclaims his master. "He obeyed

immediately!"

"Oh, no, I didn't!" thinks Fred. "I was just on the point of getting off before he spoke."

Fred's master is too eager to find evidence of his authority in the home and has fallen for the fallacy called false cause or *_post hoc ergo propter hoc_*. The name is Latin and means 'after this therefore because of this.' Philosophers have pointed out since David Hume that just because two events follow each other in sequence does not necessarily mean they are causally connected (1).

Uri Geller used the fallacy very effectively. He put on shows in which he instructed his television audience to fetch any watches that have stopped. He tells them to hold the watches firmly in their hands while he will try to fix them with just the power of his mind. Telephone lines became jammed with excited callers proclaiming that their watches had been fixed. Geller won over many converts this way.

True, the watches were fixed straight after Geller furrowed his brow. But, does this prove that his mental activity started the watches? To think so is to commit *_post hoc ergo propter hoc_*. It will spoil his fun, but let's bring some cold logic to bear on the incident. Perhaps warm hands did the fixing. Perhaps they caused the metal cogs to expand and become unstuck. Perhaps Geller's show is now history because most people have switched to using digital watches!

The fallacy commonly comes up in discussions about health. I recall one over a certain unregistered health practitioner (who was subsequently prosecuted by the state). Angela was planning a visit because "her methods work." "What makes you so sure," I asked?

Jan interjected very dramatically. "You take the product (making a hand motion as if taking medicine), you get better - voila - it works."

Privately, I wondered how my medical researcher friends would have responded to this. Here they are rigorously testing drugs to ensure their efficacy and safety at great cost when they could have just asked any Tom, Dick or Sally! Jan had seen too many soap advertisements on TV. Actually, it is a conceit, a trivialisation of the complexity of the human body and an insult to the Creator to think that just anyone can evaluate a medication. Her argument is a classic *_post hoc ergo propter hoc_*. It takes serious research to try to determine whether improvement is due to a specific medication rather than some other cause. The fallacy is also potentially dangerous. The National Council Against Health Fraud reported evidence that "vitamin/mineral self-dosing is not benign or necessarily healthful (2)." Angela took my explanations to heart, cancelled her appointment, and probably saved herself a bundle of money and potential damage to her health.

The fallacy can also be spiritually dangerous. In Jesus' day a certain tower of Siloam happened to fall on eighteen people. Apparently, people felt that the tragedy followed and therefore must have been caused by specific sin. Jesus had to

disabuse them of this notion and false complacency. "do you think," He says, "they were more guilty than all the others living in Jerusalem. I tell you, no! But unless you repent, you too will all perish" (Luke 13:4-5).

Pastor Clinton Macomber says (3) that faith causes salvation. He claims this on the basis of Romans 10:9-10: "That if you confess with your mouth, "Jesus is Lord," and believe in your heart that God raised him from the dead, you will be saved. For it is with your heart that you believe and are justified, and it is with your mouth that you confess and are saved." But this is giving too eminent a role to our part in salvation. Ephesians 2:8-9 is emphatic: "For it is by grace you have been saved, through faith--and this not from yourselves, it is the gift of God." Faith precedes salvation but is not the cause of it. Faith satisfies a necessary condition, not a sufficient cause. The sufficient cause is grace.

Some testimonies make the mistake of taking the particular human circumstances surrounding ones conversion as normative for all conversions. A person comes to Christ through a certain denomination and then gives that denomination a greater role in his salvation then is theologically warranted. Another person is baptised by a human at the time of her conversion and then thinks that baptism is necessary for salvation. This is to dilute the causal primacy of the Cross. Like Fred Bassett's master we may be inclined to overemphasise human authorities, but in salvation that authority belongs to God.

Notes

1. Copi, I.M. (1972) Introduction to Logic. The MacMillan Company, New York. p. 82-83.
2. NCAHF News, September/October 1992, Volume 15, Issue #5, <http://www.ncahf.org/nl/1992/9-10.html>
3. <http://pleasantplaces.org/Building a Spiritual Church/Centrality of Faith/Need of Faith.htm>

* Feature article *

The Second Law of Thermodynamics in the Context of the Christian Faith

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Introduction

This essay was written in response to questions that came up on the Science and Christianity mailing list touching on issues of entropy and/or the second law of thermodynamics. I found myself writing the same things repeatedly to straighten out various misconceptions. So, I have written something between a personal essay and a FAQ on the topic. Since this is written from my personal viewpoint, I will start by stating my background and personal convictions which cannot help but influence what I write.

I have a Ph.D. in Chemical Engineering (UC-Berkeley, 1988), specializing in "Molecular Thermodynamics," which combines classical and statistical thermodynamics to describe the thermophysical properties of fluids. I then did two years of postdoctoral work, more or less in Chemical Physics, followed by four years in private industry. I am now with the Physical and Chemical Properties Division of the National Institute of Standards and Technology in Boulder, Colorado. [Nothing I say here should be construed as representing NIST or the US Government.] I do not consider myself a specialist specifically in the second law, but my overall expertise in thermodynamics is sufficient to shed light on the relevant issues.

I am an evangelical Christian. I believe the Bible to be entirely trustworthy in conveying God's messages. Where people get into trouble is when, for example, they take the message of Genesis 1 (that God created everything, including us) and try to read it as something it is not (i.e., a science text). I get annoyed at the silly arguments of "creation science," but what is more annoying is when non-Christians see those arguments and get the false impression that such issues (rather than Christ) are what Christianity is all about. I do believe that God created everything, but how and when and to what extent that involved his sovereignty over "natural" processes are secondary questions that should not divide the church.

Finally, I should add that God has given me a passion for truth. Truth in all things, since all truth is God's truth. I therefore welcome correction or constructive criticism on this document.

What are the Laws of Thermodynamics?

First, we need a few definitions. In thermodynamics, we must refer to a clearly defined system. Textbooks commonly consider the system to be the contents of a box-like container. But we could also define it to be a specific cubic meter of the atmosphere above Phoenix, or the Earth (provided we define the boundary precisely), or my left kidney. Everything in the universe that is not a part of the system is the surroundings. Systems are divided into three categories: an isolated system can exchange neither matter nor energy with its surroundings, a closed system can exchange energy but not matter, and an open system can exchange both energy and matter. The Earth, for example, is an open system, but might be considered closed if one neglected meteors, space probes, etc. It is not an isolated system because, among other things, it receives radiant energy from the Sun. [NOTE: this categorization is not universally used; in particular it is not uncommon to hear an isolated system as defined above described as "closed."]

The first law of thermodynamics, also known as the law of conservation of energy, states that the total energy of any system remains the same, except to the extent it exchanges energy with its surroundings. This exchange can be in the form of heat transfer (perhaps by placing a hot body in thermal contact with the system) or work (perhaps by compressing the system via a piston). This gets modified a little for matter/energy conversion (important if the system

is the Sun), but it is basically the simple idea that energy is never created or destroyed.

The second law is trickier. There are many statements of it; perhaps the simplest is that it is impossible for there to exist any process whose only effect is to transfer energy from a system at a low temperature to one at a higher temperature. In other words, heat flows downhill. The 2nd law is also formulated in terms of entropy, a well-defined quantity in terms of heat flows and temperature. Another statement of the 2nd law is that, for any isolated system, the entropy remains the same during any reversible process and increases during any irreversible process. The 2nd law also places bounds on the entropy change in a non-isolated system in relation to the temperatures of the system and the surroundings and the amount of energy leaving or entering it, but it is important to note that a system can experience a decrease in entropy if it is exchanging energy with its surroundings. The 2nd law is ultimately a statement about heat flows, work, and temperature, and also about the direction of time. It states that, as time goes forward, the overall effect is for energy to dissipate from hot things to cold things.

The third law concerns changes in entropy as the temperature approaches absolute zero, and indirectly can be used to show the impossibility of attaining absolute zero. It does not come up in the contexts of concern in this essay.

For those who want to learn more, I recommend *The Second Law*, by P.W. Atkins, Scientific American Books, New York, 1994. This is a well-written popular introduction to the subject. The reader is cautioned, however, that Atkins has a bias toward metaphysical naturalism which sometimes leads him to extrapolate from the science to unfounded metaphysical conclusions. If you can ignore the philosophy and stick to the science, you will learn a lot from his book. A good exposition at a higher technical level is given in the introductory chapters of *Entropy*, by J.D. Fast, McGraw Hill, 1962. [NOTE: Fast's classic work should not be confused with a book of the same title written around 1980 by notorious gadfly Jeremy Rifkin.] Of course any college textbook on thermodynamics will cover these topics.

A Brief History of the Second Law

Some of the following information is adapted from Ira N. Levine, *Physical Chemistry*, McGraw-Hill, 1978. Something that was roughly the 2nd law was stated by French engineer Sadi Carnot in 1824 with regard to the efficiency of steam engines. [Carnot may also have been the first to postulate the 1st law, but he never published that and got no credit until long after his death.] Carnot's work was almost universally ignored, but was rediscovered (and stripped of its tie to the pre-1st-law "caloric" theory of heat) in the 1840's. Around 1850 came the first rigorous statements of the 2nd law by William Thomson (Lord Kelvin) and Rudolph Clausius. It was Clausius who first defined the quantity entropy and coined the word (from a Greek word meaning "transformation"). He made the often-quoted brief statement of the first and second laws: "Die Energie der Welt ist Konstant. Die Entropie der Welt strebt einem Maximum zu."

[rough translation: The energy of the world (more properly, an isolated system) is constant. The entropy of the world strives toward a maximum.] Maxwell made his contributions a little later, followed by Boltzmann. Their main contributions here were in tying things to the concept of molecules (including the science of statistical mechanics, which they basically invented though Gibbs brought it to maturity), which was not a part of the thinking of people like Kelvin and Clausius.

The Second Law and Creation

Now we address the context in which the 2nd law arises in creation arguments. The usual argument goes something like this: "The 2nd law says everything tends toward increasing entropy (randomness and disorder). But the evolution of life involves the development of great complexity and order. Therefore, evolution is impossible by the 2nd law of thermodynamics." While it sounds simple, there are major flaws in this argument that render it worthless.

The Earth is Not an Isolated System

It is only in isolated systems that entropy must increase. Systems that can exchange energy with their surroundings have no such restriction. For example, water can freeze into ice (becoming more ordered and decreasing its entropy) by giving up heat to its surroundings (this increases the entropy of the surroundings, of course). In the case of the Earth, the Sun is a major source of energy, and the Earth also radiates energy into space. One consequence of thermodynamics is that, when energy comes from a "hot" source (like the Sun) and is output to a "cold" reservoir (like space), it can be used to do work, which means that "complexity" or "order" can be produced. The main point is that, for a non-isolated system, an increase in "complexity" (to the extent one can connect that concept with the thermodynamic entropy, which is far from straightforward for living creatures) does not necessarily indicate a violation of the 2nd law. A good example is the development of a human fetus into an adult; this is the production of a more thermodynamically complex system but involves no violation of the laws of thermodynamics.

It is worth mentioning here that the usual reply to creationists that "the second law doesn't apply to non-isolated systems" is not quite correct. The second law always applies; in fact, it was originally developed for non-isolated systems (the working fluid of a heat engine). The key point is that it is only in isolated systems that the second law takes the simplified "entropy must increase" form. For non-isolated systems, the second law still applies as a statement about heat flows and temperatures, just not in the form used in creationist arguments.

An Internal Inconsistency

Some creationists assert that advanced (especially human) life represents a decrease in entropy which violates the 2nd law, and they therefore invoke intervention by God, who is outside the laws of thermodynamics. They also, however, generally assert that this particular "intervention" stopped with the creation of man, and that (with the exception of the occasional miracle) God has allowed things to develop in

accordance with the laws of thermodynamics and other physical laws since then.

These two assertions are, however, mutually inconsistent. The reason is that the thermodynamic entropy is strictly an additive quantity. If the 2nd law has not been violated as the number of humans grew from two to 6 billion, it is ridiculous to assert that it was violated in the comparatively minuscule change from zero to two. If we say that the first two humans represented a violation of the 2nd law, the logical conclusion would be that God must be continually intervening in violation of the 2nd law in order to increase the number of humans on Earth. While God is certainly capable of this, there is no evidence to suggest that such violations are happening as complex life forms like humans reproduce and increase in number. [NOTE: All this is not to say that God's creation of human life was not miraculous. My only point is that the specific assertion that the existence of human life in and of itself violates the 2nd law is unfounded.]

What About the Universe?

An occasional creationist response to the first flaw mentioned above is to say that, while the Earth is not an isolated system, the universe as a whole is. However, this does not help the argument they are trying to make. Astrophysicists, using data such as the cosmic background radiation, have verified that the universe has obeyed the second law of thermodynamics very well since the time of the big bang. The 2nd law predicts that something small and hot should become larger and colder, and that is just what has happened. The existence of some ordered life in a little corner of the universe like ours is a drop in the bucket - when the whole system is considered (which one must always do in thermodynamics), there is no violation of the second law in the development of the universe.

So what about "before" the inception of the universe? Can it be said that bringing into existence the hot, pointlike early universe from nothing was a violation of the 2nd law? While that argument has a certain appeal, and I believe the creation of the universe to have been miraculous, I think a 2nd-law argument is inappropriate here as well. The 2nd law is an attribute of the physical universe, describing how systems go with time. Modern physics tells us that the physical universe is not just space but also contains time as a fundamental dimension. The process by which all that came to be is not something that can be addressed by the laws (including the laws of thermodynamics) characterizing the resulting universe.

What About Information Theory?

Since their arguments do not work in terms of thermodynamics, some anti-evolutionists turn to information theory, which contains a quantity called "entropy." While I am no expert in information theory, I can offer some relevant comments.

As a preliminary, we must talk about the definition of entropy from statistical physics. This definition is mostly due to Boltzmann, and is even engraved on his tombstone. He defined the entropy of a system in terms of the number of different states available to it. So, for example, the

expansion of a gas into double its original volume at constant temperature would represent an increase in entropy, because each molecule would have twice as much volume (and therefore twice as many "states") accessible to it. It is this definition that causes entropy to be thought of in terms of "disorder," because a highly ordered system like a crystal has fewer available states. Boltzmann's identification of this quantity with the thermodynamic entropy is now universally accepted.

More recently, a field has arisen called information theory. This deals with, among other things, quantifying the "information content" of various systems. Some of the results of information theory resemble the results of statistical physics, so much so that in certain well-defined conditions a quantity can be defined that is labeled "entropy" and that obeys something analogous to the 2nd law. While the identification of the information entropy with its thermodynamic counterpart is controversial, it is plausible enough to be taken seriously.

So some creationists, recognizing that their argument fails for the thermodynamic entropy, assert it in terms of the information entropy, which talks about things related to "complexity" and "disorder." It still doesn't work. First, there are real problems, without satisfactory solutions thus far, in quantifying the information entropy of living things. Someday this may be do-able, but right now science is not sufficiently well-developed to make definitive statements with regard to information entropy and life. Second, the first flaw mentioned above still applies in that the systems under consideration are not isolated. This means that, even if one can apply a "second law" to them, it will not be in the simple "entropy must increase" form valid for isolated systems. Finally, I can mention that, contrary to statements one finds in the creationist literature, cases are known in which genetic "information" (by some reasonable definition of the term) in living creatures can increase via natural processes.

What about "Energy Conversion Mechanisms"?

A few of those invoking the 2nd law to oppose evolution have recognized the isolated system problem, and responded by saying that for work and structure to be produced in a system, it is not enough to have energy flow, one must also have an "energy conversion mechanism." This statement is actually correct, but it does not help the anti-evolution cause. The biochemistry of life is full of such mechanisms (a more standard name is "dissipative structures"). Photosynthesis is one example, as are other pieces of the biochemistry of the cell. With these structures in place (in other words, once life exists), there is then no obstacle from the standpoint of thermodynamics to the evolution of more and different life.

One might, of course, ask about the origin of these dissipative structures. This is a legitimate question, though not really one of "evolution" (which normally refers to the development of life from other life) but instead one of "abiogenesis." Whether or not the biochemistry of life could arise "naturally" is one where the evidence is not so clear, and legitimate arguments can be made here. However, at this

level the arguments are primarily about plausibility of chemical mechanisms rather than thermodynamics (and those who use them should not say their position is based on thermodynamics), so they are outside the scope of this essay.

Other Abuses of the Second Law

A common misuse of the 2nd law occurs in connection with events that are highly improbable. An example is the hypothetical origin of life from normal chemical processes, which has been compared to unlikely occurrences such as the assembly of a 747 by a tornado passing through a junkyard. That may or may not be an appropriate analogy, but it is definitely mistaken to assert that, simply because it is ridiculously unlikely, the scenario would represent a violation of the 2nd law. The important point is that, while violations of the 2nd law are highly improbable (this improbability is the essence of the 2nd law in the statistical-mechanical formulation), not every improbable event is a violation of the 2nd law. For example, if I flipped a coin 1000 times and came up "heads" each time, it would be highly improbable but would not violate any laws of thermodynamics.

Finally, there is the use of "entropy" in situations where thermodynamics is simply not relevant. One hears entropy invoked as an explanation for everything from my messy desk to the decline of society. That is tolerable and perhaps even useful as a metaphor; certainly there is some similarity between the "decay" and "disorder" in these situations and the thermodynamic consequences of the 2nd law. But we must not mistake metaphor for real physical law. To do so can lead to false and even harmful conclusions, such as when "relativity" is invoked to argue against the idea of absolute right and wrong.

The Second Law, Evil, and the Fall

My final topic is the occasional identification of entropy with "evil" or "death," an identification often accompanied by the assertion that the 2nd law is a consequence of the Fall. I believe that this is wrong for several reasons. [NOTE: I am neutral with regard to the literalness of the Biblical account of the Fall. I am open to the idea that it is a figurative account of mankind's collective rejection of God's authority. For simplicity, this section uses terminology that presumes the literal interpretation. But the arguments are not significantly affected if one takes a less literal view.]

First, I believe the identification of the 2nd law with "evil" is a consequence of some of the misconceptions mentioned above. We identify God (and therefore good) with "order," but mistakenly identify the ungodly "disorder" in the world with the thermodynamic entropy. Certainly entropy is a factor in some of the world's "disorder," such as the degradation of the environment. But gravity, electromagnetism, and the 1st law are all involved as well, and there are no grounds for assigning any special "evil" role to the 2nd law. Calling the 2nd law evil because it is involved in, for example, the decay that accompanies physical death is as unfounded as calling gravity evil when somebody falls off a cliff.

Second, the physical evidence strongly indicates that, like all God's other physical laws, the 2nd law has been operating since creation. Entropic processes are involved in the burning of the Sun and other stars (many of which emitted the light we see today longer ago than the 6000-20,000 years ago usually assigned to the Fall), and would have been involved as Adam and Eve walked, ate and digested their food, etc. Assuming there were flowers in the garden, it is the 2nd law that allowed Adam and Eve to smell them (again speaking against the concept that entropy is inherently evil). While it is not impossible that God had an entirely different set of physical laws in place before the Fall, such speculation is not supported by any scientific or Biblical evidence.

Third, we need to deal with Romans 8.18-23, which talks about (in the context of the final fulfillment of the Kingdom) how "the creation itself will be set free from its bondage to decay and obtain the freedom of the glory of the children of God" (v. 21, NRSV). The "bondage to decay" is sometimes taken to refer to the 2nd law. That interpretation is at best incomplete. The Bible teaches (cf. Rev. 21) that, when all is said and done, God will throw out the current physical laws and create something that transcends all the limitations we now know. So while the "repeal" of the 2nd law may be a part of what the passage refers to, it is at most only a small portion of a much greater transformation. As to when the "bondage to decay" began, the passage says nothing to suggest it began with the Fall. Some of it, in fact, seems to imply that this bondage has been an aspect of creation from the beginning.

There may be an additional logical (and theological) fallacy at work in those who attribute the 2nd law to the Fall. The (faulty) line of reasoning goes something like, "Since the 2nd law will not exist in God's final Kingdom [that may or may not be the case], it must not have existed before the Fall." This simply does not follow. Nowhere in the Bible does it suggest that the final Kingdom will simply be a restoration to pre-Fall conditions. Instead, it is pictured as something brand new and infinitely more glorious than what Adam and Eve experienced in the Garden.

With all that said, I should add that I do believe that the Fall has consequences. The primary result, of course, is our separation from God and resultant need for salvation. But Scripture does teach (Gen. 3.17) that there was also some negative consequence for our surroundings. I do not deny that, in some sense, the ground (and maybe even all of creation) is "cursed" because of our sin (I lean toward viewing that as our relationship to the environment being corrupted by sin). What I do deny is that the 2nd law of thermodynamics is any more a part of that curse than is gravity or any of the other physical laws God has crafted for His creation.

Final Thoughts

I used to think about entropy childishly. When I was about 20 and a fairly new Christian, I even wrote a poem called "The Second Law" in which I invoked entropy to explain decay of the human soul, of human society, and of Christ's church. [I

later saw a "Life in Hell" cartoon listing "Entropy" as a topic about which all bad poets must eventually write.] Since then, I have learned more about thermodynamics and about God. I know how alluring the simplistic entropy arguments sound. But God calls us to truth, and that sometimes requires abandoning simplistic concepts.

My main purpose here is to dissuade my fellow followers of Christ from pursuing incorrect arguments based on a lack of understanding of the second law. One might ask whether it is really important for Christians to think about entropy in a mature manner. For many, it probably isn't. But for those who engage in apologetics, and for those who might find themselves defending the faith to those who are scientifically literate, I think it is important for three reasons.

The first is that, by abandoning these errors, we can focus more effectively on legitimate arguments for the faith. While I do not subscribe to the notion that one can arrive at Christianity through pure reason, I do believe that it is reasonable in all respects. With regard to origins, there are reasonable arguments that the universe and human life did not come about through random Godless chance. But none of these arguments is based on thermodynamics, and it can only confuse the issues and obscure God's truth when the 2nd law is inappropriately dragged in.

The second reason is the special responsibility to truth we have as people of God. There is no room for falsehood in God's kingdom, even in the defense of the Gospel. We should be diligent in our efforts to avoid bearing false witness, whether the victim is our next-door neighbor or Ludwig Boltzmann. Worldly politicians or marketers may say "I don't mind using a little falsehood as long as it helps persuade my audience," but that is unacceptable for a Christian. We who serve the God of truth should make a special effort to cleanse our words of all falsehood.

Finally, there is the Christian witness to the world. A small but not insignificant segment of the world is scientifically literate. It is tragic that many think of Christians only as "those people with the crackpot arguments about a young Earth and entropy" and do not even consider the Gospel because they think it requires them to believe things they know to be as silly as a flat Earth. The myth that Christianity is for stupid people is widespread, and part of the blame must rest on some Christians. This harm to our witness will only be overcome if Christians refocus their message on central truths (like the fact that God created everything) rather than trivial side issues (like how He did it), and repudiate those arguments (like the misuse of the 2nd law) that are simply incorrect. Many will still reject and belittle Christ and those who follow Him. But if the world is going to laugh at us, let it at least be for a central doctrine like the Cross or the Resurrection, or for our insistence on loving everybody, not for mistaken pseudoscientific arguments on peripheral issues.

Disclaimer: The views expressed in this essay are the opinion of the author of this essay alone and should not be taken to

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