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Faith and science: two sides of the same coin?

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ABSTRACT: These are notes for a talk given at St. Mary's Wythall. The notes can be found on www.jpoffline.com.

Contents

1 Introduction

My talk will be divided into roughly two distinct, but interwoven, sections. Science, including cosmology and some of the latest results & the interface between science and faith.

The structure of the talk and aims:

- Discuss what the job of science is. What is science trying to do, in the broadest sense
- Outline some interesting interpretations of Genesis.
- What is the big bang theory and cosmology.
- Present some state-of-the-art results in cosmology: CMB, observations and simulations. Also discuss our best theoretical models
- What is the "God of the gaps"
- What observations of the natural world can be contradictory with an interpretation of Genesis

Word of warning: I am a scientist by trade and in parts I will be talking about theology. I will sometimes deliberately say things to challenge perceptions. Most of the time these will be parts of an argument, and so you will need to bear with me. Please don't immediately put up your guard.

1.1 Starting thoughts

Here are some starting points for thought that I commonly come across:

- Science is trying to do away with God
- People of faith shouldn't be thinking about how the universe works: "have faith", "well, God does it"
- Our understanding of reality is almost complete.

I will attempt to unravel the first two of these points as I go, but I will immediately respond to the last point. Frankly, its rediculous: our understanding of the natural world is nowhere near complete. And, frankly, neither is our understanding of the Bible. Thats not to say the laws of nature, or the "laws of God" keep changing, but we are still trying to understand them. Understand what language we should be using to describe them.

There are quite a few fundamental questions which we, as humanity, have grappled with for eons:

- Why is there something rather than nothing?
- How does the Universe behave?
- Why do we exist?
- Why does the universe *(a)* adhere to laws at all and *(b)* why this particular set of laws?

Science is one of the voices that will have an input into attempting to answer these questions. But it is by no means the only, or indeed necessarily the most important, voice.

Other "voices" include those of philosophy and theology. Many scientists are quick to dismiss philosophy; however, on philosophy, Nobel Laureate Sir Peter Medawar said "*There is no quicker way for a scientist to bring discredit upon himself and upon his profession than roundly declare – particularly when no declaration is called for – that science knows or soon will know, the answers to all questions worth asking, and that questions that do not admit a scientific answer are in some way non-questions to pseudo-questions that only simpletons ask and the gullible profess to be able to answer*".

Stephen Hawking, in his new book The Grand Design describes M-theory as a particular solution to some of these problems: "*Spontaneous creation is the reason there is something rather*

than nothing, why the universe exists, why we exist. It is not necessary to invoke God to light the blue touch paper and set the universe going". Here, Hawking is describing how the laws of physics allow for "spontaneous creation" of matter-energy from "nothing". An important point (which is the topic of many TV documentaries, books, and makes for great talks) is what Hawking (indeed, theoretical physicists in general) means by "nothing". They actually mean the *quantum vacuum*, which is anything (and everything) but empty, dull and nothing. When one zooms into the structure of atoms, inside nucleons, to very high energy scales the quantum vacuum comes into view. The quantum vacuum is what the universe looks like on the smallest possible scales, at the highest of possible energies. Inside the vacuum, particles are constantly being created and annihilated.

Hawking makes statements like "*Because there is a law of gravity, the universe can and will create itself out of nothing*". Hawking here appears to be stating that the law of gravity is present, precluding anything in the universe or indeed precluding the universe itself. In response to this, John Lennox said "*Nonsense is still nonsense, even when talked about by world famous scientists. Be careful about such statements: they are not statements of science. Even though the statement was made by a scientist, and one usually takes his word as authority, one must do so with care*"

1.2 What is science trying to do?

Science is the study of mechanisms in the Universe, from the quantum mechanically small to the astronomically large. Scientists merely recognize the patterns and regularities that are already present in the universe.

A scientific law describes the regularity of events, and a given law only holds under certain circumstances. For example, everything I know from my past experiences about throwing a ball upwards leads me to be able to *predict the future motion* of the ball once it leaves my hand after throwing it upwards. It is rather obvious that different physical conditions will make the ball move differently. I usually subconsciously take into account these different conditions, and correct for them. This allows me to predict the future of the ball. Nothing mystical about it.

However, if the ball interacts with something I didn't take into account (e.g. a buzzard flying in and knocking the ball off-course) then my prediction will fail. Of course, if the buzzard only causes a small amount of deviation, then my prediction wont be all that bad.

This is simple science: we take our past experience and use it to predict the future behavior of physical systems in particular circumstances. Again: a scientific law describes the regularity of events, and a given law only holds under certain circumstances. Science is descriptive and predictive, not creative.

1.3 The place of a creator in a scientific account

Let us consider the place that a creator has in a scientific account.

Let us construct a prototypical scientific account of a car. And let us take, for definiteness, a Ford (not just any car, a Ford GT40). Spend some time looking, poking, taking apart, and over time I will be able to provide a description of the car. I will understand how the car works. I will be able to assign function to its components: why that particular tube is there, in that particular place. I understand how to fix the car when it breaks. I can also assign a reason for why the car was created and invented in the first place: to take passengers from A to B or for pleasure in driving along scenic routes.

Nowhere, in that complete scientific account of a car, did I mention *or need to mention* Henry Ford. However, it is completely ridiculous to deduce from that account (or the way in which I gave the account) that Henry Ford does not exist.

The creator does not appear in the scientific account, but it is clearly ridiculous to deduce that the creator did not exist.

Good scientists should (and, mostly, do) realize this. C.S. Lewis put it like this: "*Book keeping, continued to all eternity could never produce one farthing*". Just because we are describing and cataloguing pieces of the natural world does not create any of it. One of (if not the) pioneer of our modern understanding of particle physics, Richard Feynman, commented "*That there exists rules to be checked at all is some sort of miracle*".

2 Genesis

Let us take a quick look at Genesis. Here are the first few verses of Genesis:

Genesis 1 [1]*In the beginning God created the heavens and the earth.* [2]*Now the earth was formless and empty, darkness was over the surface of the deep, and the Spirit of God was hovering over the waters.* [3]*And God said, "Let there be light", and there was light.* [4]*God saw that the light was good, and he separated the light from the darkness.* [5]*God called the light "day", and the darkness he called "night". And there was evening, and there was morning the first day.* [NIV] In the King James Version, Genesis 1:2 reads *And the earth was without form, and void; and darkness was upon the face of the deep. And the Spirit of God moved upon the face of the waters.*

The creation story, regardless of how you want to take it (literally, metaphorically, poetically) has some interesting flow and structure.

There are a few structures to point out. The first event "*created the heavens and the earth*" is not actually part of the creation week: it does not lie in the same "and God said... and there was evening and there was morning" rhythm. Jumping forwards a bit, this means that a literal reading of genesis allows for an "old" universe (which is what our current scientific models favour, over a "young" universe).

A day is begun by God speaking, and ends with an evening and morning. The passage outlines the ordering of creation:

1. Light and dark,
2. air and water,
3. land and sea,
4. Sun, moon and stars,
5. birds and fish,
6. animals and people,
7. rest...

The first three events separate the heavens and earth into sections, and the next set of three events fill these sections. (1) is filled by (4), (2) by (5), (3) by (6).

Another thing: God does not stop resting: there is no evening and morning on that 7th day.

Also, how was there an evening and morning (implying the setting and raising of the Sun) on days 1,2 and 3 before the Sun was created on day 4? Just something to think about.

This may seem an obvious point, but please keep it in mind for what I am going to say later on, but one of the main concepts that Genesis gets across is that the Universe had an origin. *It began.*

3 Some science

In this section we will briefly discuss some of the most recent and incredible observations, results and realizations of our universe. I will attempt to keep technical language to a minimum.

Simply define a few words (just so I don't get anyones back up!). The word *evolve* means to change in time. Thats it. Everyone evolves (gets older, moves around: evolve in space and time). Infact, imagine if we did know it: life would be rather boring.

Things that are alive also evolve, almost by definition.

3.1 The scale of the Universe

As I have already stated, science is the study of the universe from the very small to the very *very* large. I will mainly focus on the *very* large. Distances become so huge that our usual "unit" of distance (the metre, mile or kilometer) is simply useless. Instead, we will use something else to tell us about distances.

Recall: if a car travels at 40mph, then, in a single hour, it will travel 40 miles. So, if a car was to travel at that constant speed of 40mph, then in 5hours we would understand that the car would travel $40\text{miles} \times 5\text{hours} = 200\text{miles}$. What I mean, is that if the car goes at a known constant speed then we just need to quote how long the car has been travelling to obtain the distance the car has travelled.

For astronomy we do not use the constant speed of a car. Instead, we use light, which travels at a constant 300,000,000 metres in one second. This is incredibly fast. Light takes 0.13seconds to travel around the circumference of the earth.

It takes light 1.3 second to travel from us to the moon, which is the nearest of all the astronomical objects. The sun is futher away, and takes about 8 minutes for light to travel from us to the sun.

Light travel time to various solar system objects. Relative size of planets and stars. Distance to Andromeda in light years

Hubble deep field: contains over 3000 galaxies, observed an area of sky 1/10th that of the moon. Most galaxies are about 10billion years old in that image. The objects in the image a red because the universe has expanded so much since the light was emitted that the light has become stretched and has actually changed colour.

3.2 Cosmology

Current standard model: big bang, inflation, structure formation. These theories have testable predictions (an important property for any theory to have).

3.2.1 Big bang theory

The Big Bang piece of the theory was invented by Georges Lemaitre (a vatican priest) in the 1920's as a mathematical solution to Einstein's equations of General Relativity. Fundamentally, the big bang theory in its most widely accepted form is simply the name given to the initial singularity in the mathematics used to describe the universe (a singularity is a place where the equations divide by zero: 1/0: ill-defined). One of the corollaries of the theory (a corollary is another word for consequence) is that the universe is expanding: which means that the universe was much smaller in the past than it is today.

The big bang theory does not say that the universe is expanding from a point. We can not go to a place in the universe and state *this is where the big bang happened*. The big bang happened everywhere: everywhere is expanding from everywhere else. This may seem odd, but consider this analogy. Imagine blowing up a balloon with a bunch of paper stars stuck onto the surface. As the balloon is blown up the centre of expansion (the middle of the balloon) is not on the surface of the balloon, and everywhere on the surface is expanding away from everywhere else on the surface. When the balloon deflates (imagine getting very very small), everywhere on the surface

will eventually become the same location. In the same way, the 3D space of our universe can be thought of as being on the surface of some high-dimensional balloon.

It is worth saying that the big bang theory does not actually model what happened at the instant of the bang. Only that it happened. We have an understanding of what happened immediately after the big bang (to 10^{-36}seconds after the big bang). There are various models which allow for universes before the big bang. There are even alternative theories for the creation (for instance, the ekpyrotic scenario, where two or more sheets collide, converting their content to radiation "fire", and as they move apart they cool down). An important question which people are trying to grapple with (even working out how to ask the questions is difficult) is *what banged?*.

3.2.2 The cosmic microwave background

Another corollary of an expanding universe is that it was much hotter in the past than it is today. This is simple thermodynamics: compressing something will increase its temperature (plug the end of a bike pump with your thumb, pump and the end chamber will warm up; it is also how fridges work).

So in the past the universe was very hot. Infact, in the few hundreds of thousands of years after the big bang the universe was so hot it was a plasma. A plasma is a state of matter (like solid, liquid, gas) which can be imagined as a constant fire. The sun is a ball of plasma. An important property of plasmas is that they are opaque: light does not freely travel through plasmas. Light does, however, get caught up where the plasma is knotted and clumped up due to matter clumps.

What does this means for the universe in the plasma-like-state? Well, it would have been highly unpleasant to live in: just going outside the ambient temperature was 1000's of degrees Celsius. We also couldn't see very far (you cant see very far through the sun, can you?).

As the universe gets older it cools down, and eventually looses its plasma-like state. This means that the universe becomes transparent. All light that was caught up in the knots and clumps of the plasma is allowed to free-stream, to travel unimpeded. This light does, however, remember how it was clumped. Therefore, the light carries information about the structure of the universe in this very hot-state. Of course, the universe carried on evolving after this state (remember: evolve means to change in time), so whatever the universe looked like, whatever clumps and lumps of matter were in the universe at this time, acted as initial conditions (initial seeds) for what the universe would look like at later times.

This light that got released is called the *cosmic microwave background radiation*, or CMBR.

This may sound all very far-fetched (a universe which was opaque, like the sun, 1000's of degrees Celsius, light which remembers). But, what it does do is give us some testable predictions. If the idea is nonsense, then the things which it predicts should also be nonsense. I will now zip through some of its predictions, how we have gone about measuring them, and the outcome.

Temperature of the universe today First up, if the universe is expanding, and was very hot in the past, it should be much cooler now. If the universe was 1000's degC when it was 200,000years old, what is its temperature today, when it is 14billion years old? The prediction is

$$T = 2.725 \text{ Kelvin},$$

where 0K is absolute zero (0degC is 273K). This has been measured to one part in a million precision by many ground-based, balloon-based and space-borne telescopes. This temperature was first measured in the 60's by Penzias and Wilson in the USA, but it as been verified by many high precision instruments. Along the way about 5 Nobel Prizes have been awarded for the detection and high precision measurement of this ambient temperature of the universe.

The latest mission to measure this temperature is the Planck satellite, which was launched to a distance of 1.5million km away from the earth (the moon is only 360,000km away) and had to become the coldest thing in the entire universe. Manchester university had a large part in building some of the instruments on Planck, and Prof. Richard Davis was awarded an OBE due to his efforts and input on the projects.

Fluctuations in temperature Measuring the background temperature of the universe is all very well and good, but the big bang theory with a CMBR also has a prediction for what the fluctuations in temperature of the universe should be. This is like saying that the temperature in the room is about 21degC, but if I actually measure each location separately I will find that the temperature around light bulbs and people to be slightly higher. The big bang-CMB theory predicts what the temperature fluctuations of the universe should look like.

What this means is that there is a prediction for how many times one should find in the universe a temperature fluctuation of a give size: how may times should I expect to measure 1 or 2 or 100 μK above or below that background temperature. The difference in temperature between these hot and cold regions is of the order micro Kelvin (thats 0.0000001K). This requires spectacularly high precision (which is one of the reasons why Planck needed to be the coldest place in the universe).

The predictions were made, and first observed in the 1990's, earning Nobel Prizes by a satellite called COBE, and later by WMAP. Planck is the most recent mission whose goal is to measure the ripples in temperature in the universe.

The prediction and measurement agree spectacularly well.

Physically, these fluctuations in temperature correspond to the initial seeds of clumps of matter in the universe: structure in the universe began looking like this. Which leads me on to another prediction about the growth of structure in the universe.

Structure in the universe The CMBR encodes information as to what the universe looked like when it was 300,000years old. The universe obviously carried on evolving, getting older, expanding.

Gravity took hold of the universe and caused things to fall: an overdense region over there becomes more overdense over time. When matter collapses, structure forms.

If you've ever seen a plate of sand being vibrated, you'll have seen structure (clumps) form from the chaos. The universe is exactly like this.

We can take our CMBR snapshot of the universe from when it was in its infancy, 300,000years old, and combine it with how we think gravity works to produce a prediction for how the universe looks today (this is "just" a more sophisticated version of understanding how a ball bounces or predicting how a ball will fall). One of the predictions is how many galaxies we should see of each size in the universe, what the universe looks like on large scales and how the distribution of galaxies evolved as the universe grew older.

To actually test our predictions requires supercomputer simulations, coded up with our best models of physical processes (how black holes form, how stars are formed and die in supenovae) and also incredibly sensitive observations (which are able to take photos of galaxies which are billions of light years away), enabling us to build 3D maps of our universe.

There are many complicated details, but the main upshot is that our observations of the natural world, of the universe, agree with our predictions which were based upon this CMBR picture which was a consequence of the big bang theory.

3.3 Summary

So, to summarize the upshot of our standard model.

We have a theoretical ideas of the mechanisms which makes the Universe looks like it does (mostly, just gravity). These ideas are backed up by observations & simulations (e.g. make a Universe in a computer & see how well it matches our Universe). What this is does is it gives us confidence we are on the right track to understanding. This picture is very elegant (not some "random improbable sequence of events"). Being honest however, there are lots of things to iron out, but they tend to be minor details. For instance, our models seem to predict (or require the existence of) dark energy & dark matter. We don't have a good model for the origin of Big Bang. Infact we don't have a well-tested understanding of gravity which can be used on cosmological scales (this is the subject of my PhD thesis, and is a huge source of contention in the cosmology community). The standard model of cosmology gives a handle on the *how* of the Universe.

4 God of the gaps

In my opinion, the *god of the gaps* (I've deliberately used a lower-case "g") is a very large, and sometimes non-obvious trap which people fall into. Either, christians fall into the trap and end up limiting God, or non-christians think that christians believe in a god of the gaps. Let me explain first what a god of the gaps is.

God of the gaps is where god is used to plug the gaps in our knowledge. In the past we had large gaps in our knowledge and understanding of the natural world. There were may instances when "god" was invoked and used to explain away the gaps (god makes the planets go around, god makes the sun rise). There were so many gaps, and the gaps were so huge, that the god which was invoked was rather powerful and large and important. However, over time, our knowledge increased, which decreases the size of the gaps *and therefore of the god who fills them.* The god of the gaps is invoked as the solution to science problems, and becomes reduced when we, as humanity, becomes clever. The god of the gaps is a placeholder for human ignorance.

Whilst plugging the gaps in our scientific knowledge is not the usual reason most people believe in God today, I do think people do it anyway. Maybe not with why the sun comes up every morning, or why the planets go around the sun, and most definitely not why or how balls bounce. But maybe when talking about the origin or life, or the earth or the origin of the universe (just who was it that started the blue-touch paper?).

Let me make a point I made a while back: a scientific account can be complete without reference to a creator. And that the account exists does not mean that the creator does not exist.

I'm not really going to answer any of these questions, but it is designed to challenge preconceptions.

At what point is it ok to use "well, God does it" as a get-out clause or reason or placeholder for scientific understanding? A bouncing ball? Birth of a baby? Growth of a tree? Origin of earth, life, galaxies or the entire universe? At what point should I draw the line? Do I need to draw the line? Is it possible to give a complete scientific account of the universe without reference to a creator?

These thoughts should always be done with the mindset that "well, maybe at some point in the future we could scientifically understand this process". 500years ago it was "reasonable" to invoke god to make the planets move. Today it is not reasonable to use God as the only reason why planets revolve. Today we do not understand the origin of the universe. In 500 years time we may understand, and push god out of a hole in our understanding that he was plugging.

An alternative viewpoint, which I think I hold, is that God is intimately involved in everything, and that we can discover the mechanisms by which stuff happens in the universe. God is involved in making a ball bounce, in making trees grow, in the birth of a child, in the origin of the universe. But also, intertwined with this viewpoint, is that mechanisms can be found which describe the phenomena: gravity makes balls bounce, "biology" makes trees grow and babies born and some (not-yet-known) theory describes how the universe began.

5 Contradiction or mis-interpretation?

I want to point out from the beginning that I am fundamentally not talking about having a fallible bible: I am talking about a mis-interpretation of the bible.

A literal reading of genesis provides us with a "young universe" (actually, this discounts the note I made about God creating the heavens and the earth previously to the creation week). Our scientific understanding of the natural world leads us to believe that the universe is very old (of the order 14 billion years). Thinking about this clearly leads us to suppose that (at least one) of the following is true:

- Genesis is not literal. This then raises the issue: if Genesis isnt literal, then what is it trying to tell us?
- We chronically misunderstand the science. This does require a chronic misunderstanding: everything that we know and have tested leads us to think that the universe is about 14billion years old. Also, carbon dating leads us to the conclusion that the earth is "old". In response to comments like "carbon dating is not very accurate": this is true, but it does not get it wrong by millions of years.
- God's deceived us. The science is correct, but perhaps God placed fossils and star light there to confuse us. Infact, God must also have placed stars in their death-throws for us to observe today.

What we have come across, therefore, are two descriptions of reality which appear to be in contradiction. When this occurs one must begin to ask serious questions: have we interpreted the observations correctly? Have we read the bible correctly? Have we interpreted the bible in the way it was intended, or have we imposed some kind of preconcieved idea as to what the bible should say upon our reading? Have we actually understood the science properly?

See, thinking like this actually removes *contradictions* and replaces them with *mis-interpretation*. This concept has a historical precedent. Take, for example, the church's stance on our place in the Universe from the 1500's. They believed that the bible stated that the earth is at the centre of creation. When observations of the natural world were done, it was realised that we are not at the physical centre of creation. So, is this a contradiction or mis-interpretation?

Let us take also, some common phraseology from the bible: "*As far as the east is from the west*", "*To the ends of the earth*", "*Four corners of the earth*". We understand these not to be literal, to actually mean something more than a literal reading allows. The contradictions are replaced by mis-interpretation.

This happens a lot in science. Pre-1920 the scientific view was that the universe was eternal: it did not begin. *Steady state theory* was supported by almost every big-name at the time, including

Einstein. This idea was constructed psuedo-philosophically: how could the universe do anything on the grandest scales? What could possibly influence an object so massive? Einstein held on to this viewpoint so furvently that he modified his equations to make the universe static. Then, in 1929, Edwin Hubble pointed his telescope at the natural world, and discovered, by painstaking observations, that far away galaxies are receding from us faster than nearby galaxies. The upshot of this is that the universe is expanding, and thus is not static on large scales. In response to this observation, a priest named Georges Lemaitre discovered that the un-modified version of Einsteins equations allowed for a universe which behaved in exactly the way in which it was observed to behave. A down-side, however, was thet the solution that Lemaitre found also required the universe to be very small in the distant past. Infact, his solution predicted that the universe should be infinitesimally small (thats as small as it gets), and was effectively some sort of singularity (Lemaitre called it a *primordial atom*). This solution became ridiculed by the scientific community (Einstein said that Lemaitires mathematics may well have been correct, but his physics was "abominable"), and was nick-named the *big bang*.

However, more and more observation evidence stacked up in favour of Lemaitires model of the universe. Today, our standard model of cosmology includes this big bang as the origin of the universe. Notice that the "science" view was that the universe never began and the biblical view is actually that the universe has some beginning (indeed, the bible had been stating this for millenia). Would have been nice if some credit were given to the bible.

Anyway, the point I'm trying to make is this: our thoughts and observations about the universe were in contradiction. It was because our thoughts were mis-interpreting something that the contradiction arose.

Apparent contradictions are due to misunderstandings of (at least) one of the descriptions of the natural world we are using. One should be careful as to which description of reality one holds to be *a priori* true (and why). This goes for science and a given interpretation of the bible.

6 Final remarks

Choosing between science and creator as an explanation is nonsensical. We need both levels of explanation to give a complete description

Wayne Grudem: "*We should exercise care in speaking into issues that the bible does not clearly speak into. And when our observations of the natural world seem to conflict with our observations of scripture, we should look again at both, seeking to find where our limited and imperfect understanding of either could be wrong*"

Useful resources *God and Stephen Hawking* by John Lennox

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