opening extract from

Why is Snot Green?

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Introduction

This is a book about science, and it's a book about answers. The answers to so many of those crazy questions you may have once thought about . . . but then never quite got around to asking. And that's what science is all about: unanswered questions.

Too often, people are put off reading about science because they think it's too hard to understand, or just too boring to bother with. 'Besides', they say, 'science doesn't have all the answers.'

They're right. It doesn't.

But it does, I think, have some of the very best questions.

'What is Space made of?'

'Do spiders have ears?'

'What do people taste like to sharks and tigers?'

'Will evil robots take over the world one day?'

At the Science Museum, children and adults ask us questions like these every day. If we know, we'll try to answer, or help people to figure it out for themselves. Yet very often the answer just leads to another question. 'But why *is* that?' they say. 'How do you *know* that?' is another favourite. This leads to more explanations and even more questions. And that's how science works – we keep asking questions.

The main reason why science is such a useful way of thinking about things is that we're never happy just to say 'I don't know' and leave it at that.

If we don't know, we *want* to know – and we'll keep on asking questions until we find out.

So if you think science is too hard or too boring – you've just been asking the wrong questions. Now let's have some fun with some of the good ones.

Lost in Space

The universe can be a pretty dizzying place.

It was born in an almighty explosion of energy. It's so massively, hugely, immensely enormous that it's almost impossible to imagine how big it really is. Within it, there are spinning planets, burning suns, icy comets and vast clouds of floating dust and rock. Planets, moons and asteroids whip round each other like cosmic dance partners. Stars are born, stars die and stars collapse into mysterious black holes in Space.

But why did it turn out that way?

Where is it all headed?

Are we all alone in it?

And come on – how big could it really be?

Want to find out? Then read on . . .

How big is the universe?

Big. Proper big. Crazy big. Billions of times bigger than the biggest thing you can imagine.

I don't know about that – I can imagine some pretty big stuff . . .

OK, let's give it a go. Let's imagine the size of the universe. Probably best to start small and work up – so let's start with something fairly big – the Earth. The Earth is about *8,000 miles* wide. If you drove a tunnelling car straight through the middle,* you'd get to the other side in about 5½ days, going non-stop at an average motorway speed of 60mph.

That doesn't sound so far.

Right – it's not. So let's try a longer journey. Say, from here to the Moon. The Moon doesn't go round us in perfect circles – it gets closer and further away from us at different times of the month. But, on average, it's about *240,000 miles* away. It would take about 168 days to get there in a 60mph flying space-car. Even with rocket propulsion, the *Apollo* astronauts took about three days to get there (and it was a real squash in their spacecraft).

Similarly, the journey from the Earth to the Sun is about *93 million miles* so would take about 176 years by space-car. To get right across our galaxy, the Milky Way, it would take about a million billion years (or 1,181,401,000,000,000 years to be more precise) to make the journey of *621 million billion* (or 621,000,000,000,000,000) miles.

So what does that tell us?

* You can't, of course – see *Could you dig your way through the Earth to Australia?* (page 54) if you're not sure why. But imagining this will help us get our heads around even bigger scales.

That a space-car would be cool, but at 60mph it'd be pretty rubbish for getting about the place?

Yes. Quite.

That, and that the galaxy is pretty huge in itself – let alone the universe. I'm running out of space to put all the zeros after the numbers here.

All right – what if you had a space-car that could go at the speed of light?

Now we're talking. The speed of light is about 670 million mph, so a car that fast could do about *6 thousand billion miles* (or 6 trillion miles) if it kept driving, non-stop, for a whole year. We call this distance a *light year*, and it's much more useful for measuring the huge distances – between stars and across galaxies – that we've been talking about. For example, the Milky Way is about 100,000 light years across, so it'd take 100,000 years for our souped-up, super-fast, light-speed car to cross it. Still way too long to manage, but easier to imagine, maybe.

Go on, then – how big is the whole universe?

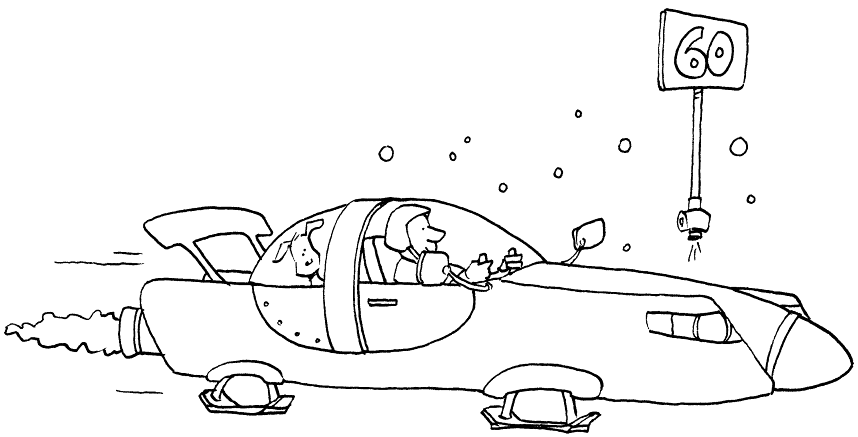
Well, we can only measure the universe as far as we can see it. With the best telescopes we have, that's about *15 billion light years* (or *90 billion trillion miles* – I won't even bother trying to write that out with zeros) in every direction. So at the speed of light, it'd take at least *30 billion years* to cross it. That's about 2 billion years longer than the age of the universe itself.

Ah. So it's big, then?

Like I said: *crazy* big. And that's just the bit we can see. Beyond that, we know it extends even further, because the light from the stuff we can see at the 'edge' has taken 14 billion years to reach us, and the universe has expanded quite a bit since then! It might even curve back on itself, like the sea does as you sail round the globe. If that was the case, you could circle the universe and end up back where you started from.

Now that would be cool.

Yes, it would. But all your friends would be many billions of years older. So even if they were still around, they probably wouldn't know what cool was any more. Bummer.



What is Space made of?

Well, it's not just 'nothing'. Space is, at the very least, filled with gases spread out very, very thinly. It also bends – and possibly rips – so it must be made of something . . .

But Space is, well, *space*, isn't it? No air, no gravity . . .

Well, not exactly. Gravity is actually everywhere in Space.

Its pull becomes *weaker* the further you move away from one particular source – like a planet – but it's still there.

And while it *is* true that there's no air in Space, there are other things spread around it. It's only because the stuff is spread out so thin, and Space is so big, that we can't detect it very easily.

So what is this 'stuff'?

Mostly hydrogen and interstellar dust left over from the Big Bang.

How much of it is out there?

Well, there's billions of tonnes of it, but it's spread so far and wide across the universe that you won't find more than one atom per cubic centimetre of Space in most places.*

You've probably been told that gases spread out to fill their containers, right? Well, if there's nothing else in the container, then they do. In this case, the container – the universe – was empty and is now at least 180 billion trillion miles wide. Spread over this distance, even billions of tonnes of material can look like virtually nothing. It just depends on how hard you're looking for it. It's a bit like Marmite on

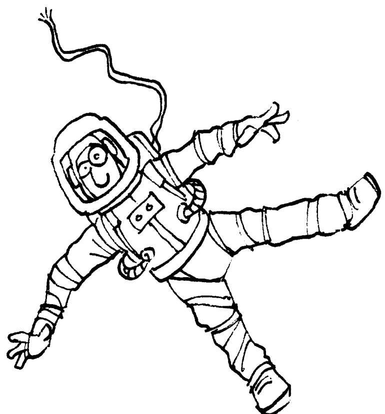
* See *How big is the universe?* (page 4) to get a better idea of just how big that is.

toast: spread it thinly enough and only the real Marmite-haters will detect it. (You can try that one for yourself.)

OK . . . so rather than say 'there's nothing in Space', you could say 'there's *almost* nothing in Space' instead?

Exactly. That will not only be more accurate, but it will also freak people out. Which is always fun.

Top 10 things to do in Space



1. Float
2. Drift
3. Hover
4. Do somersaults
5. Spill some milk – and catch it again
6. Play zero-gravity football
7. Try to hit the Moon with a frisbee
8. Draw a halo above your head with toothpaste
9. Wonder where your spaceship went
10. Panic

Why do planets bother going round the Sun?

Because the Sun's gravity pulls planets round it, preventing them from whizzing off into Space. But despite this, the planets are still gradually inching away from the Sun over time.

Yikes. That doesn't sound good. I thought we'd just go round and round the Sun forever.

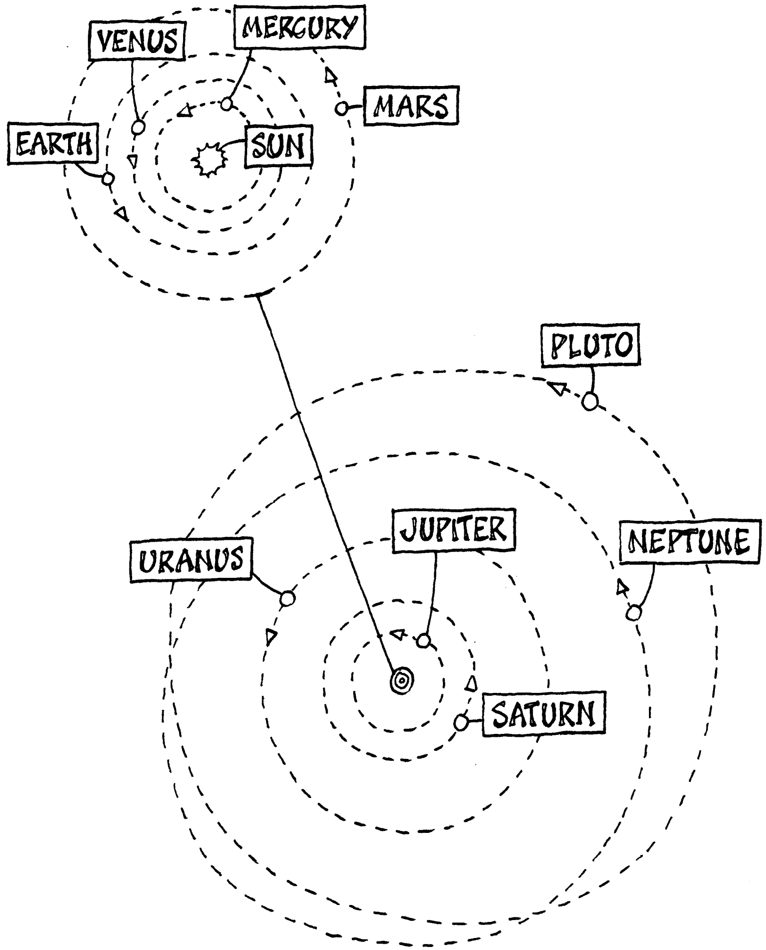
I'm afraid not. We're getting a tiny, tiny bit further from the Sun with each lap we do round it. The Earth gets about 1.5cm further away from the Sun every year.

Why's that, then?

It's all to do with how gravity works. A very clever scientist called Isaac Newton explained how gravity works over 300 years ago. If, like me, you can't read Latin and lots of maths gives you a headache, it basically goes like this:

- everything attracts everything else
- the bigger the things are, the bigger the pull
- the closer together the things are, the bigger the pull
- the force that causes this attraction is called gravity.

Now, the Sun is by far the biggest object in the solar system so it pulls everything else towards it. That includes planets, comets, asteroids – everything.



Hang on a minute – so why don't the planets all just get pulled right into the Sun?

That's because the planets all formed from chunks of stuff that were already circling the Sun to begin with. When the solar system began, these chunks clumped together to form planets and settled into regular circuits (or *orbits*) round the Sun. Closer to the Sun, all the icy bits got vaporized, so we ended up with the small rocky planets – Mercury, Venus, Earth and Mars. Further away, it was cool enough for gas to hang around, so we got the gas giant planets – Jupiter, Saturn, Uranus and Neptune.

You forgot Pluto.

No, I didn't. Most astronomers don't count it as a real planet these days. There are a whole lot of small Pluto-sized objects out there beyond Neptune, and these (it has been decided) aren't planets either.

Oh.

Anyway – as I was saying – the planets have settled into more-or-less fixed orbits round the Sun. They don't get pulled right into it because they still have some circling speed (or rather, *momentum*)* left over from when they were just baby chunks of planet (or planetesimals, as they're called). It's like they're excitable puppies on a long leash – they're trying to whizz off into Space but the Sun's gravity keeps pulling them round it instead.

So why are they gradually getting away from it, then?

Because the Sun is burning up its fuel and, in doing so, it's shrinking. As it gets smaller, the strength of its pull on the planets decreases.

* See *If the Earth spins round once a day, what started it spinning?* (page 24) for details.

Doesn't that mean we're going to fly off into Space and freeze?

Well – do you want the good news or the bad news?

The bad . . .

Before any of this happens, the Sun will swell up into a Red Giant star and frazzle the Earth anyway.

Ouch. OK – the good . . .

It'll take a while, so there's a good chance we'll be able to hop planets (or preferably solar systems) beforehand.

Wahey!! Better get cracking on those spaceships, then?

Yep. Time's a wastin' – only got about 4.5 billion years left.

Why do stars twinkle?

Because we're looking at them through the murky veil of our atmosphere. From outside it, they look clear, steady and bright.

You mean . . . stars don't twinkle? All those nursery rhymes – they lied to me!

Well, you could see it that way. The shifting brightness and shape that we see is actually caused by churning gases in our atmosphere, which we have to look through in order to see the stars. Outside the atmosphere, the light from the stars is more constant and even, so there's no 'twinkle'. From down here, though, they do *seem* to twinkle. So they weren't really lying. Whoever they are.

Fine. If they don't twinkle, what do they do, then?

They burn. They burn fiercely for billions of years. Then, when they die, some can explode with enough force to sweep up 1,000 suns – leaving nothing but a vast, deadly hole in Space behind them.

OK, that sounds cooler than 'twinkle'. Tell me more.

Are you sitting comfortably? Good. Then let's begin . . .

Once upon a time there was a cool cloud of gas. It was pretty dense, but all its gas-cloud mates thought it was cool, and everybody knew that one day it would become a star. There it was, minding its own business, doing whatever gas-clouds do, until finally it collapsed. Under the pull of its own gravity, it crunched up on itself really tightly and got hotter and hotter, starting a chain reaction and turning