

HEIDELBERG UNIVERSITY

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**The Limits of Knowledge  
and the Power of Bullshit**

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# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
<b>2</b>	<b>The Limits of Knowledge</b>	<b>2</b>
2.1	The Scientific Method . . . . .	2
2.1.1	Newton and Einstein . . . . .	4
2.2	The Burden of Proof . . . . .	5
<b>3</b>	<b>The Power of Bullshit</b>	<b>6</b>
3.1	Witchcraft . . . . .	7
3.2	Aliens . . . . .	9
<b>4</b>	<b>The Baloney Detection Kit</b>	<b>10</b>
<b>5</b>	<b>Conclusion</b>	<b>12</b>

# Chapter 1

## Introduction

Science is all around us. Every day in our lives we make use of its achievements, one way or another. Most of us don't even recognise that, however. We take many things as granted, but what too many people, even today, do not realise is this: Without science, none of us would have the standard of life we have today. To not know how important science is to our everyday lives is one thing, but not knowing about how science works on the most fundamental level is something different entirely. The scientific method should be common knowledge for every child, the fact that it is not even close to that, is shocking.

In an age where the internet in general became such a huge part of our lives, information is widely available for anyone who knows how to use Google, and thus also widely spread across various social media platforms, blogs, forums and the like. While this generally sounds like a good thing, problems arise when lies, hoaxes and made up 'facts', to just name a few, get mixed up with all that valuable information that is out there. Most of the time it is not obvious to tell if some information you came across is a fact or a lie. To be able to do that takes a very specific skillset that is very much akin to the aforementioned scientific method.

This report is largely based off of Carl Sagan's 1996 book "The Demon-Haunted World" [Sag97]. I will talk about what the scientific method actually is and why it should be taught to every child in school, why bullshit in the form of pseudo-science and baseless claims, among others, is so powerful and dangerous, and why the scientific method [...] *may be all that stands between us and the enveloping darkness.*

## Chapter 2

# The Limits of Knowledge

Knowledge is limited. Compared to what the universe has to offer in terms of knowledge, we know basically nothing. However, there are people not at all familiar with science and how knowledge is achieved, who assert that science claims to know everything. This is of course not true at all. Science has been wrong before and will be again in the future, but because it is based on logic and evidence, science has a built in error-correction mechanism. There might certainly be some scientists who claim to know more than they actually do, but this is not limited to scientists, it probably applies to most people on earth. Science itself is based on evidence, that much is obvious. For a scientific claim, a hypothesis, to be accepted it has to be proven right. The journey from a hypothesis to knowledge is called the scientific method. And in its basic form it should be taught to children from a young age, not to force them into pursuing science, but to teach them critical thinking so that they are able to evaluate information based on reason and logic.

### 2.1 The Scientific Method

Figure 2.1 shows a quick overview of the scientific method. However, one can not just put any hypothesis out there. The graphic already implies this, but a hypothesis needs to be falsifiable in principle via scientific experiments. It means that there exists a scientific way to disprove the hypothesis, should it be wrong. This is also the best way to actually get proof in favor of a hypothesis: If every experiment that tries to disprove it fails, the hypothesis becomes that much stronger. This is of course a never ending cycle. Even after a hypothesis has been accepted because it fit the observations that have been made, it still has to withstand constant attempts to expose its potential flaws and uncertainties.

Imagine a software that just had its version 1.0 released. It works for its intended purpose (hopefully), and achieves what the developer wanted it to do, but is it perfect? Of course not. It still needs constant maintenance and software updates to keep it working properly, maybe because the user base increased or new functionality has been added. All those things need to be kept in mind. Its the same

with science: There might be "bugs" that have not yet been detected or certain unexplored areas where the whole hypothesis fails to work. All those things need to be tested over and over again. This ensures improvement and may even lead to new discoveries in the long run.

To elaborate more on the diagram shown in Figure 2.1: Realistically speaking science doesn't work on that binary level of a hypothesis being either completely correct or incorrect. Usually there are many facets to a hypothesis, which makes it very possible that it can be correct on certain things, while being wrong on others. It is also very possible that some of those areas have yet to be explored, and as such could not have been labeled as either correct or incorrect yet. I will give a brief example of this in 2.1.1. As I've said earlier, even when a hypothesis seems to give correct results based on observations and is thus deemed to be correct, there needs to be a constant search for errors and flaws or, to put it more positively, improvements. It also needs to be pointed out that regardless of success or failure of a hypothesis, the results always need to be reported. In reality that is not always the case. The problem of only reporting positive results deserves an entire report on its own, likely much more than that, so I keep it at this brief mention.

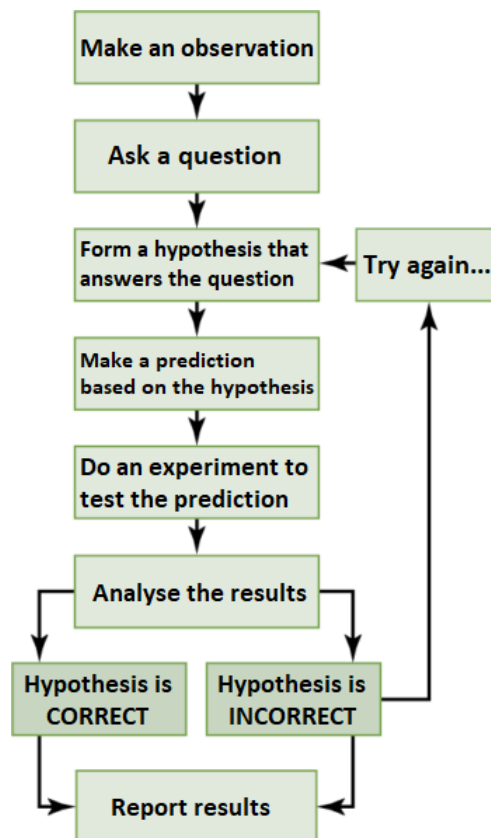


Figure 2.1: The Scientific Method

### 2.1.1 Newton and Einstein

When Isaac Newton found out how Gravity works it was considered a major breakthrough in the history of science. It still is, of course. Newtonian gravity works with great precision on our planet, and even in our solar system. As long as we don't approach extremely high masses and velocities close to the speed of light, Newtonian gravity works perfectly fine. For a long time it was thought to be working under all circumstances, because why shouldn't it? As it turned out, approaching the speed of light didn't bode well for Newtonian gravity: Its results were no longer coherent with observations, and thus a flaw in Newton's law of gravity has been found.

In the early 20th century, a few hundred years after Newton, Einstein gave the world his theory of general and special relativity. While it was as close as indistinguishable to Newtonian gravity under earthly circumstances as it gets, it gave astonishingly precise results for areas where Newtonian gravity was completely off. Admittedly Newton himself probably wasn't even considering that a mass close to the speed of light would behave so differently from when it simply fell down a tree. The reason Newtonian gravity is still taught in schools today is simple: It works. Compared to the theory of relativity, Newtonian gravity is much less complex while being comparably precise in most areas concerning our lives on earth. So it makes sense to still use it when the alternative would just make things way too complicated. It is however, a massive improvement from Newton and is a great example of why the scientific method is so greatly appreciated by scientists. And even though the theory of relativity predicted many things correctly, the search for flaws or errors within it never stops. Only then can improvements be made and errors corrected.

While there are centuries between the discoveries from Newton and Einstein the fact that it took as long as it did for Newton's laws of gravity to be improved to this degree shows, that the cycle of science never ends. With advances in technology and many other fields (also because of science) measurements get better or new ones are being made possible so that new discoveries can be made. The time it takes to improve a hypothesis is not important. The fact that science keeps trying, is.

Until a few years ago, one particular part about the general theory of relativity was still unproven and thus, unknown if it was true at all. Einstein predicted gravitational waves. Those are disturbances in the curvature of spacetime, generated by accelerated masses. Newton's laws of gravity didn't account for their existence. However, Einstein predicted those and not until 2015 were they directly observed, originating from the merger of two black holes. Until that moment it was unclear, but based on scientific evidence highly likely, if gravitational waves really existed, thus making one facet of Einstein's general theory of relativity unknown. Others were already proven right, but until observations are being made that (in)directly contradict predictions of the theory of relativity, it remains likely that its predictions (even those not yet confirmed) are true.

## 2.2 The Burden of Proof

Science requires proof, it is that simple. A direct consequence of this is that hypotheses need to be falsifiable. Now what exactly happens when someone makes a claim that has no way of being proven wrong, without giving convincing evidence? Figure 2.2 gives an example which highlights just how easy it is to make such claims. Carl Sagan once said something along the lines of *extraordinary claims require extraordinary evidence*, also known as the Sagan Standard. Simply put, claiming to have eaten ice cream the other day does not exactly require proof, while saying that someone can transform into a unicorn makes irrefutable evidence necessary. The Burden of Proof lies with the one making a claim, and not with people who doubt its legitimacy. A claim which relies solely on the basis of not being falsifiable is therefore completely useless. However, too many people still use this as their (basically only) "argument" of why their claim has to be true. Not being able to prove something wrong and it being true are two completely different things entirely.

This argument is often being used by deeply religious people when confronted with critical questions about their beliefs of the bible or god. It is also famously used by UFO enthusiasts: *You can't prove aliens have not visited us, therefore the strange light someone saw in the sky last night had to have been an UFO that has just kidnapped someone from their bed.* While there definitely is the possibility of extraterrestrial life, there is, as of yet, no compelling evidence of alien abductions, or their presence, at all. <sup>1</sup>

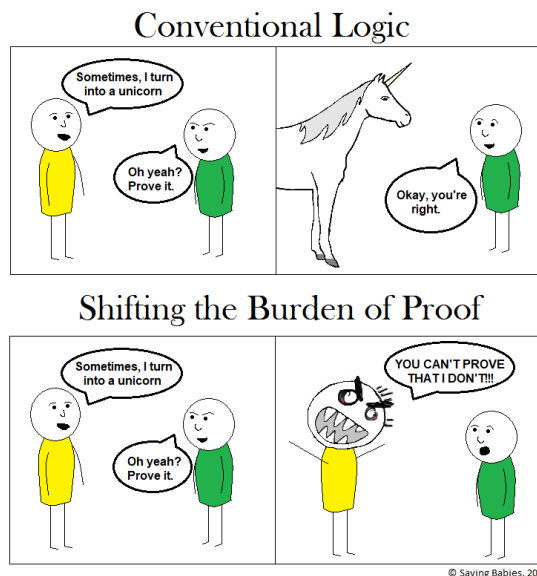


Figure 2.2: The Burden of Proof

<sup>1</sup>UFO enthusiasts think otherwise, as can be read in this exemplary article:  
<https://exemplore.com/ufo-aliens/FBI-Confirm-Aliens-Exist>

## Chapter 3

# The Power of Bullshit

What is Bullshit? In this context it means making claims based on nothing but belief, or consciously ignoring contradicting evidence for a hypothesis you really like. Everything considered, it includes everything from trying to avoid being thorough in research to willfully ignoring it. Considering what influence the media already had (back in 1996) and now even more so has, bullshit can't and shouldn't be ignored. Cover it with something the public likes to hear or is open to believe in at face value, and you suddenly have many people believing in hearsay. This can go as far as people ignoring scientific evidence that contradicts this 'opinion'. In recent decades and even more so today, the topic of climate change keeps the world more or less preoccupied. Scientific results make it pretty clear that we humans are responsible for the majority of climate change in the recent years. This is backed up by countless studies, scientific results, etc. In short: There is strong evidence for human made climate change. However, many people believe the exact opposite, even to the point where they smell a government conspiracy which aims to collect more taxes. What this comes down to is, what the title of this chapter already says: The Power of Bullshit. Why is it that Bullshit can convince many people without evidence, when science fails in doing the same, while at the same time having strong evidence to support its claims?

To further pursue this question, this next part goes back in time a few centuries. Roughly 500 years ago in Europe the church was executing 'witches' left, right and center. What this has to do with Alien abduction stories and UFOs is being explored in a subsequent part.



### 3.1 Witchcraft

Europe, a few centuries ago. The catholic church dominated the religious belief. Science was very much on the back foot. Considered an authority, the catholic church was what defined the truth for most people. Add to that their inability to read or write, let alone being able to read Latin (the only available language of the bible at that time). What we have now is a society that holds deeply religious beliefs and depends on the church as an authority to tell them what's right and what is not.

As a scientist, if you don't understand something, you research it. You try to explain it with means available to you, as best fits the data available. If that doesn't yield results that explain an observation sufficiently, you consider the matter unknown. You don't jump to conclusions and fabricate some wild explanations for it. But this is exactly what the church did.

*Microbiology and meteorology now explain what only a few centuries ago was considered sufficient cause to burn women to death.*

Extreme weather conditions, spreading sickness, unusual natural phenomena. All of this happens somewhere in the world, even today. This was no exception in 15th century Europe. Blamed for all of this, were witches. Offspring of sexual encounters between demons and humans, they used their powers to bring destruction or sickness upon the people. At least this was the explanation from the church for why this had been happening. Today we know that hallucinations or mental illnesses are real and (at least in the case of hallucinations) not exceptionally rare. So of course there would have been people 'confirming' those sexual encounters. Not long after, witches were arrested all over Europe. Their chances of survival: Basically zero. In case there was any evidence of their innocence (of whatever crime they may have been accused) it was explained away as a trick the devil played on them, so that no one would notice. Whatever the accused may have said in their defence was not accepted. Evidence in general was not needed. If accused of witchcraft, you were a witch. Plain and simple.

From there it got even worse. False confessions were being forced out of (mostly) women via torture, as well as "confirmations" of other witches in town. So as a result more and more witches were being arrested and executed, their number grew exponentially. In 1487 witchhunts became institutionalized after a document known as the *Malleus Maleficarum* ('The Hammer of Witches') was created (see Figure 3.1). Compiled 'research', mainly from scripture, this document explained what witches were and how to recognize them, what they were doing and why they needed to be punished. What may have been a real fear of the unknown and mystical powers once, quickly became a way of getting rid of people you really hated and got abused to the extreme. Once someone was accused of witchcraft, their life was over. With inquisitors showing up all over Europe, the main targets became wealthier women, since all their belongings were used to pay for anything

that involved their prosecution, imprisonment, and execution. What was left had been split up between the inquisitors and the church.

Now what is the bottom line of all of this? Based on assumptions made out of fear and lack of knowledge, countless people had lost their lives. They were systematically hunted down, first out of fear, later mostly for personal gain. If critical thinking would have been applied, all of this could have been avoided. But not only the lack of critical thinking was a problem. The fact that one main authority, the catholic church in this case, has played a major role in all of this also contributed heavily towards this mass murder, and likely has been the cause of this in the first place.

Surely now that we have advanced knowledge about our world and even beyond it, those myths and fabricated claims are a thing of the past? Not exactly. Even today pseudoscience and baloney are common, and while they don't cause any mass murders of the scale of witch-hunts anymore, they certainly shouldn't be overlooked.

The next part takes a closer look at one of those myths in particular.

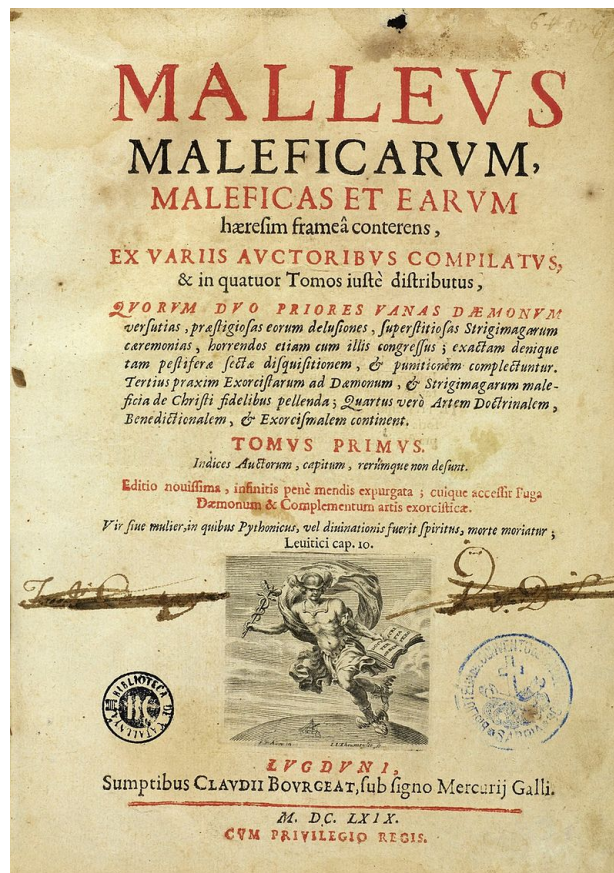


Figure 3.1: Malleus Maleficarum

## 3.2 Aliens

Does life outside of planet earth exist? Probably, some may even say likely, seeing how big the universe is and how many possibilities for life there can be. The next step is to ask about intelligent extraterrestrial life. The answer? The same as before. From there it is not hard to imagine how it would be if aliens really visited us. Would they be friendly or hostile? How do they look? How do they communicate? How did they manage to travel through space for such a long journey and how do they even know about us? All those questions and more come to mind when thinking about intelligent extraterrestrial life.

One answer is brought to us by science fiction. The genre got very popular during the 20th century, and aliens were pictured as the following: *Their heads are pear-shaped, bald, and large for their bodies. Their eyes are enormous, their faces expressionless and identical.*

Alien abduction stories sound crazy to most people, however, in the 20th century (and probably even today) many people were reporting such stories. They have allegedly been abducted by aliens in their sleep, experimented upon, forced to have sex and much more. One may think that if that were the case there would be some kind of ironclad evidence for this, maybe an alien failed the abduction and was taken prisoner, maybe their UFO crashed somewhere and killed the passengers. Maybe they even communicated with us directly. There are so many ways of proving alien abductions, yet none of it ever came to light.

Now what is more likely? The governments of the world collectively covering up the fact that the first contact has already happened and we are basically invaded and abused by aliens, that aliens are so advanced that there is no possible way for us to detect their presence other than the testimony of abductees, or that aliens have not yet visited us at all? The question of whether or not they exist in the first place wasn't even asked in this context. What makes all of this so intriguing is the amount of people that made those testimonies and how alike most of them are. Surely not every single one of them tries to trick us, there have to be at least some genuine experiences among those stories.

Hallucinations are real, mental illness is real, nightmares happen to all of us. In the early morning hours when we're neither fully awake nor asleep we can't always make out what is real and what is not. Combine this with the rise in popularity of science fiction and some people will 'experience' an abduction by aliens. Many of those will see these 'encounters' as they were: Nothing more than a bad dream or hallucination, their fantasy running wild. Others come forward with their stories, causing a snowball effect. More people will now join in and also tell their stories, some might invent extra details to spice things up a little.

Witch-hunts and alien abduction stories may have nothing in common on the surface, but they likely have the same cause. Carl Sagan hit the nail on the head:

*So in an age when traditional religions have been under withering fire from science, is it not natural to wrap up the old gods and demons in scientific raiment and call them aliens?*

## Chapter 4

# The Baloney Detection Kit

*What sceptical thinking boils down to is the means to construct, and to understand a reasoned argument and, especially important, to recognize a fallacious or fraudulent argument. The question is not whether we like the conclusion that emerges out of a train of reasoning, but whether the conclusion follows from the premises or starting point and whether that premise is true.*

This is how Carl Sagan described the Baloney Detection Kit in his chapter *The Fine Art of Baloney Detection*. It serves as a method to decide whether or not the presented argument or statement is logically sound and can be used to not only detect baloney, but also to improve arguments before they are being brought up.

A representative selection:

- Independent confirmation of the 'facts'.
- Think of multiple ways to explain a hypothesis. Then try to disprove each of those explanations. If an explanation survives, it has a good chance of being the right answer.
- Occam's Razor: Choose the simpler alternative between two hypotheses that explain data equally well.
- Perform control experiments: To test if a drug cures 20% of patients treated with it, there needs to be a control group that gets a placebo, to ensure the 20% are not just spontaneous remissions and the drug actually works.
- Separate variables: Taking two different pills to cure symptoms might help with a cold, but you will never know which of those pills was the cure (or maybe the combination of both?). Taking one at a time helps to determine the actual cure. Otherwise there is always a dependence on both pills instead of just one.

- A hypothesis needs to be at least in principle falsifiable. If that is not the case, then such a hypothesis has no value since no useful information can be obtained from it.

While this helps with constructing valuable arguments and detecting fallacious ones, this kit also provides valuable information on what not to do. A selection of examples of common fallacies people often fall into when arguing:

- Correlation does not equal causation: *A survey shows that more college graduates are homosexual than those with lesser education: therefore education makes people gay.*
- Observational selection, or: counting the hits and forgetting the misses *A state boasts of the Presidents it has produced, but is silent on its serial killers*
- Excluded middle: Only considering the two extremes in a continuum of possibilities, essentially ignoring most of the 'data'. *If you're not part of the solution, you're part of the problem.*
- Appeal to ignorance: What has not been proved false must be true, and vice versa. *There is no compelling evidence that UFOs are not visiting the Earth; therefore UFOs exist - and there is intelligent life elsewhere in the Universe.*
- Misunderstanding of the nature of statistics: *Roughly half the population of country X has below average intelligence.*
- *Ad hominem* [Latin: 'to the man']: Attacking the arguer and not the argument.

Knowing how to construct an argument and how to detect baloney is essential to critical thinking. However, this kit can be misused and applied out of context. It needs to be applied carefully and judiciously to be of value.

One example of misuse can be found when looking at the tobacco industry: Obviously, there is a statistical correlation between smoking and cancer. The tobacco industry admits as much, but claims that there exists no causal relation between the two. So far this is not entirely wrong: Just because two things are correlated, a causal relation is not at all guaranteed. A control experiment needs to be performed: Have the backs of mice painted with cigarette tar, and a control group of identical mice that have not been painted. If the control group stays healthy while the other group gets cancer, its safe to assume the correlation is indeed causal.

Presented with such evidence anyone who correctly applies the Baloney detection kit should admit to the causal relation.

The tobacco companies however, initiated a campaign to impugn the research findings, out of fear that their product wouldn't sell as much anymore.

## Chapter 5

# Conclusion

To put it in Carl Sagan's words:

*[...] better the hard truth, I say, than the comforting fantasy.  
And in the final tolling it often turns out that the facts are more  
comforting than the fantasy.*

At the end of the day, science is the best tool we have to discover and attain new knowledge and skills. Applying the Baloney Detection Kit, which in itself can be seen as a generalization of the scientific method, helps us determine the value of an argument or new information.

We humans have a desire for the mysterious. That's why so many of us rather believe that aliens are visiting us than accept what may very well be the easiest (and, according to Occam's Razor, the better) explanation: A hallucination or a daydream.

We need to actively strive toward a better future for humankind. One crucial step toward that goal is the teaching of the scientific method in schools. Every child should know what it is, when and how to use it and why it is so important. Nowadays the media has such a huge influence on most humans that it gets increasingly difficult to separate chaff from wheat, especially for those of us with little to none scientific education.

As this is largely based on Carl Sagan's *The Demon-Haunted World* it's only fitting to use the closing words of the book in this report:

*If we can't think for ourselves, if we're unwilling to question authority,  
then we're just putty in the hands of those in power. But if the citizens are  
educated and form their own opinions, then those in power work for us.  
In every country, we should be teaching our children the scientific method  
and the reasons for a Bill of Rights. With it comes a certain decency,  
humility and community spirit. In the demon-haunted world that we inhabit  
by virtue of being human, this may be all that stands between us  
and the enveloping darkness.*

# Bibliography

[Sag97] Carl Sagan. *The Demon-Haunted World*. Headline Book Publishing, 1997.  
ISBN: 0747251568.