

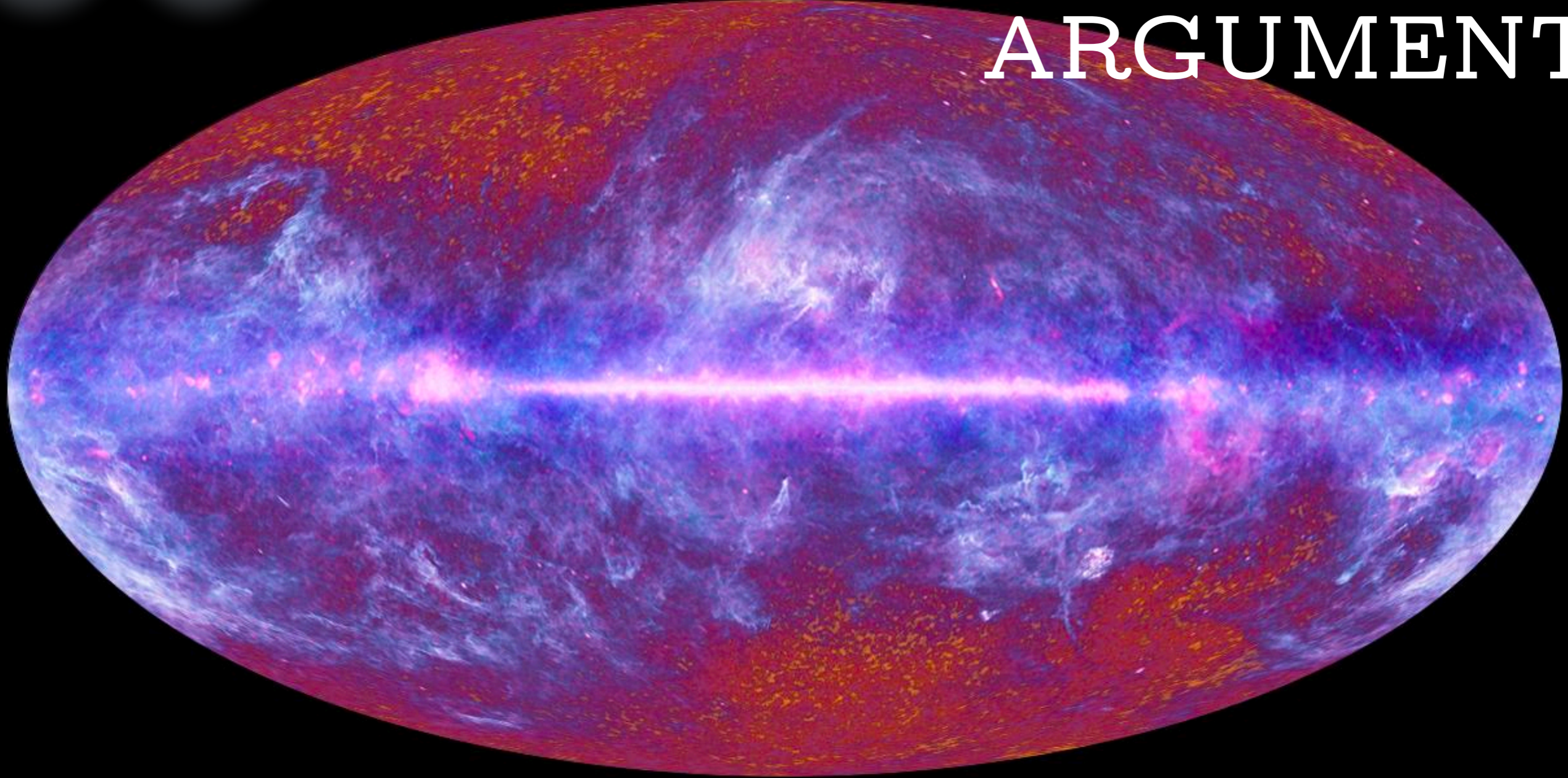
# THE FINE- TUNING ARGUMENT

Bayes'  
theorem

the argument

fine-  
tuning of the  
universe

objections



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Suppose that I have an opaque jar with some number of ping pong balls in it. You know that the jar either has 10 ping pong balls in it or 1000 ping pong balls in it. In either case the balls are numbered sequentially.

You think that the two possibilities are equally likely.

Suppose that we pick a ball at random. It is #3. Does this favor one hypothesis over the other?

It seems to favor the 10 ping pong ball hypothesis, since that hypothesis makes it more likely that #3 will be picked (rather than some number higher than 10).

But how much? How likely should I think that it is that the jar has 10 ping pong balls in it, vs. 1000?

Suppose someone offered you 40:1 odds that it is the 10-ball jar — so you win \$40 if it is the 1000 ball jar, and lose \$1 if it is the 10 ball jar.

Should you take the bet?

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Before we drew the ball, we thought that each theory had a 0.5 probability of being correct. This is called the theory's **prior probability**.

We also know something else. We know how likely each theory predicts it to be that we draw the #3 ball.

We know that the 10-ball theory says that there is a 0.1 probability that the #3 ball will be drawn. The 1000-ball theory says that there is 0.001 probability that this ball will be drawn.

This is a claim about what is called **conditional probability**. This is the probability that something will happen if something else is true. What we seem to know here is the probability of the evidence (e) conditional on the hypothesis (h). We write that like this:

$$Pr(e | h)$$

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So we know the prior probability of the hypotheses, and the probability of the evidence given the hypothesis. What we **want** to know is this:

$$Pr(h | e)$$

This is the probability of the hypothesis given the evidence. It tells us how likely we should take the hypothesis to be, given the evidence we have observed.

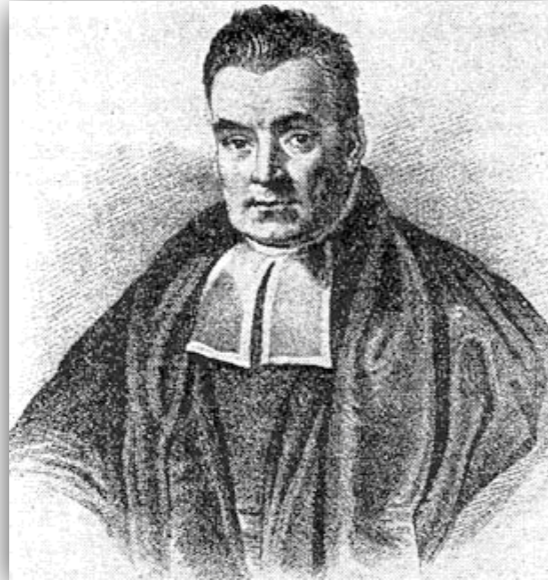
How can we do this?

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How can we do this?

One way to answer these questions employs a widely accepted rule of reasoning called “Bayes’ theorem,” named after Thomas Bayes, an 18th century English mathematician and Presbyterian minister.

To arrive at the theorem, we begin with the following definition of conditional probability:

$$P(a|b) = \frac{P(a \& b)}{P(b)}$$

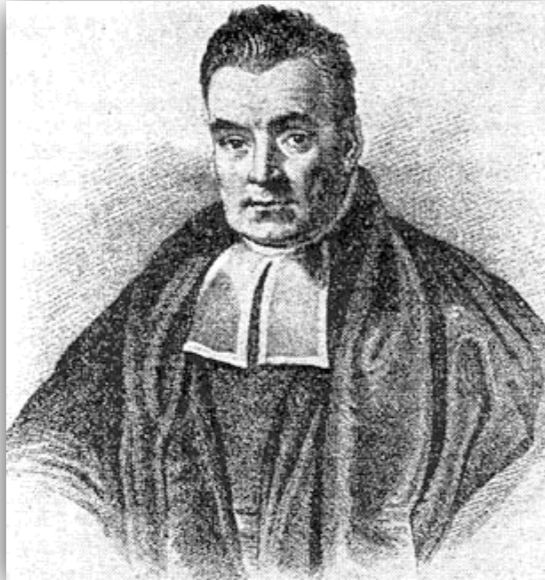
This says that the probability of  $a$  given  $b$  is the chance that  $a$  and  $b$  are both true divided by the chance that  $b$  is true.

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This says that the probability of  $a$  given  $b$  is the chance that  $a$  and  $b$  are both true divided by the chance that  $b$  is true.

Why might this be true? Intuitively, the idea is this. Take all of the chances that  $b$  could be true, and look at how many of them  $a$  is also true in. Divide the situations in which both  $a$  and  $b$  are true by the total number of situations in which  $b$  is true — and that will tell you how likely it is that  $a$  will be true if  $b$  is. And that just is  $Pr(a|b)$ .

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$$P(a|b) = \frac{P(a \& b)}{P(b)}$$

Using this definition of conditional probability, we can prove the following:

Bayes' theorem

$$P(h|e) = \frac{P(h) * P(e|h)}{P(e)}$$

(You can see the proof [here](#).)

And this does **exactly** what we wanted in the case of the urns and the ping pong balls. It tells us how to take some prior probabilities and the probability of the evidence given the hypothesis and lets us figure out how likely the hypothesis is, given the evidence.

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## Bayes' theorem

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And this does **exactly** what we wanted in the case of the urns and the ping pong balls. It tells us how to take some prior probabilities and the probability of the evidence given the hypothesis and lets us figure out how likely the hypothesis is, given the evidence.

Let  $h$  be the 10 ball hypothesis, and let  $e$  be the event of ball #3 being picked. Then it looks like

$$P(h) = 0.5$$

$$P(e|h) = 0.1$$

How about  $P(e)$ ? Well, we know that the probability of the #3 ball being picked on one hypothesis is 0.1, and on the other hypothesis it is 0.001; and we thought that these two hypotheses were equally likely to be true. So it seems that we should take the average, which gives us

$$P(e) = 0.0505$$



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$$P(e) = 0.0505$$

This gives us all the information we need to plug into Bayes' theorem:

$$P(h|e) = \frac{0.5 * 0.1}{0.0505} \approx 0.99$$

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## Bayes' theorem

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$$P(h|e) = \frac{0.5 * 0.1}{0.0505} \approx 0.99$$

So, there is about a 99% chance that the urn has 10 balls in it.

You should have demanded better odds than 40:1!

This illustrates the fact that peoples' intuitive judgements about probability are often incorrect. Bayes' theorem is enormously useful in helping us to figure out what the chances are of some hypothesis being true, given some new evidence.

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Here is a more real life example. Suppose that you go to the doctor for a routine cancer screening. You know that 1% of people in the population have cancer. You know that the test detects cancer 80% if the time that it is present (and so misses it 20% of the time). You also know that the test sometimes throws up false positives; in 10% of cases in which the person does not have cancer, the test gives an incorrect positive result (and in the other 90% it gets it right).

You test positive. What are the chances you have cancer?

Again, Bayes theorem tells us:

Bayes' theorem

$$P(h|e) = \frac{P(h)*P(e|h)}{P(e)}$$

$$P(h | e) = \frac{0.01 * 0.8}{0.107} \approx 0.075$$

So, about a 7.5% chance. Why is this?

In a population of 1000, 8 people will get a correct positive test for cancer. (2 will have cancer, but the test will miss it.) Of the 990 people who do not have cancer, 99 will get false negatives. So many more people get false negatives than are correctly diagnosed with cancer. Most likely, you are one of them!

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Enough about probability (for now). Let's turn now to some results from contemporary physics which will be important to the argument which follows.

A first question: what does the theory provided by physics include?

“The standard model of physics presents a theory of the electromagnetic, weak, and strong forces, and a classification of all known elementary particles. The standard model specifies numerous physical laws, but that's not all it does. According to the standard model there are roughly two dozen dimensionless constants that characterize fundamental physical quantities.” (Hawthorne & Isaacs, ‘Fine-tuning fine-tuning’)

These “dimensionless constants” will be our focus.

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These “dimensionless constants” will be our focus.

One such constant is the cosmological constant, which measures the energy density of empty space.

The cosmological constant is just a number which (as far as we know) could have different values consistent with the laws of physics.

One thing that the standard model of physics gives us is a measure of how likely it is, given the laws of the nature, that the fundamental constants (like the cosmological constant) would fall in a certain range.

We can make certain plausible assumptions about what it would take for life to have evolved. For example, if there were nothing but hydrogen, it is hard to see how life could have evolved. If there were no planets, it is hard to see how life could have evolved.

Given assumptions such as these, we can look at what the standard model of physics tells us about how likely it is that, for example, the cosmological constant has a value which would permit the evolution of life.

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“Physicists have determined the (approximate) values of the fundamental constants by measurement. (There's no way to derive the values of the fundamental constants from other aspects of the standard model. Any quantities that could be so derived wouldn't be fundamental.) Still, the underlying theory favored some sorts of parameter-values over others. ... Physicists made the startling discovery that -- given antecedently plausibly assumptions about the nature of the physical world -- the probability that a universe with general laws like ours would be habitable was staggeringly low.”

Contemporary physics tells us that the conditional probability of the cosmological constant having a life-supporting value, given the laws of nature, is very low.

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Contemporary physics tells us that the conditional probability of the cosmological constant having a life-supporting value, given the laws of nature, is very low.

We should emphasize just how small we take the life-permitting parameter values to be according to the physically-respectable measures. “Small” here doesn’t mean “1 in 10,000” or “1 in 1,000,000”. It means the kind of fraction that one would resort to exponents to describe, as in “1 in 10 to the 120”. The kind of package that we have in mind tells us that only a fantastically small range is life permitting.

The claim is that, according to current physics, the probability of the cosmological constant falling in a life-supporting range, given the laws of nature, is  $\frac{1}{10^{120}}$ .

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The claim is that, according to current physics, the probability of the cosmological constant falling in a life-supporting range, given the laws of nature, is  $\frac{1}{10^{120}}$ .

Let's now ask how to turn these facts about current physics and probability theory into an argument for the existence of God.

Much as we considered two different hypotheses about the number of balls in the urn, so we can consider two different hypotheses about the origins of the universe.

Let the **design hypothesis** be the hypothesis that the universe was created by an intelligent designer.

Let the **non-design** hypotheses be the hypothesis that the universe was **not** created by an intelligent designer.

Let **life** be the claim that life exists.



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Let the **design hypothesis** be the hypothesis that the universe was created by an intelligent designer.

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Let **life** be the claim that life exists.

Then what do we know about the relevant probabilities? Consider first the probability of life conditional on non-design.

Our discussion above suggests that this probability should be tiny. The reason is that, according to current physics, the probability of the physical constants being in a life-permitting range is tiny and, if the constants are not in a life-permitting range, there is no life. So that suggests:

$$Pr(\text{life} \mid \text{non-design}) = \frac{1}{10^{120}}$$

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$$Pr(\text{life} \mid \text{non-design}) = \frac{1}{10^{120}}$$

It seems at least reasonably plausible that, if the universe were created by an intelligent designer, that designer would make it the case that the fundamental constants are such as to permit life. Just to pick a number, let's suppose that

$$Pr(\text{life} \mid \text{design}) = 0.5$$

What we want to know is: what are the probabilities of our two hypotheses, conditional on our evidence?

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$$Pr(\text{life} \mid \text{non-design}) = \frac{1}{10^{120}}$$

$$Pr(\text{life} \mid \text{design}) = 0.5$$

What we want to know is: what are the probabilities of our two hypotheses, conditional on our evidence?

Bayes' theorem

$$P(h|e) = \frac{P(h)*P(e|h)}{P(e)}$$

This is what Bayes' theorem is for. But to apply that theorem, we need two other pieces of information: the probability of the evidence, and the prior probability of the two hypotheses.

Let us suppose that we are perfect agnostics, so that

$$Pr(\text{non-design}) = 0.5$$

$$Pr(\text{design}) = 0.5$$

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$$Pr(\text{life} \mid \text{non-design}) = \frac{1}{10^{120}}$$

$$Pr(e \mid \text{design}) = 0.5$$

$$Pr(\text{life} \mid \text{design}) = 0.5$$

$$Pr(\text{design}) = 0.5$$

Bayes' theorem

$$P(h|e) = \frac{P(h)*P(e|h)}{P(e)}$$

How about  $Pr(e)$ ?

Well, we know that **life** is close to 0 conditional on non-design, and 0.5 conditional on design. So let's approximate and say that

$$Pr(\text{life}) = 0.25$$

(Really, this number should be very, very slightly larger than 0.25.)

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$$Pr(\text{life} | \text{non-design}) = \frac{1}{10^{120}}$$

$$Pr(\text{life} | \text{design}) = 0.5$$

Bayes' theorem

$$P(h|e) = \frac{P(h)*P(e|h)}{P(e)}$$

$$Pr(e | \text{design}) = 0.5$$

$$Pr(\text{design}) = 0.5$$

$$Pr(\text{life}) = 0.25$$

With this information in hand, figuring out the probability of the non-design hypothesis given our evidence is a matter of just plugging in the numbers.

$$Pr(\text{non-design} | \text{life}) = \frac{0.5 * \frac{1}{10^{120}}}{0.25} = \frac{2}{10^{120}}$$

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$$Pr(\text{non-design} \mid \text{life}) = \frac{0.5 * \frac{1}{10^{120}}}{0.25} = \frac{2}{10^{120}}$$

This is the probability of the non-design hypothesis being true, given that the cosmological constant is in the life-permitting range.

It is difficult to think about numbers as large as the denominator of this fraction.

But to give you some idea: the odds of winning Powerball are about 1 in 300 million. Now consider the odds of winning Powerball one trillion times in a row.

Call that a “super Powerball.”

Now consider the odds of winning a super Powerball one trillion times in a row.

Call that a “super duper Powerball.”

Now consider the odds of winning a super duper Powerball one trillion times in a row. The odds of this happening are about  $1 / 10^{44}$  — so much, much higher than the odds of the universe being life-permitting by chance.

This means that if you simply take the physics at face value, and begin by assigning a probability of 0.5 to the non-design hypothesis, you should think that the chances of the non-design hypothesis being true are vastly lower than the chances of winning a super duper powerball a trillion times in a row.

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This means that if you simply take the physics at face value, and begin by assigning a probability of 0.5 to the non-design hypothesis, you should think that the chances of the non-design hypothesis being true are vastly lower than the chances of winning a super duper powerball a trillion times in a row.

By contrast, the probability of the design hypothesis is very close to 1. It is, in fact, 1 minus the very small number we were just discussing:

$$Pr(\text{design} \mid \text{life}) = 1 - \frac{2}{10^{120}}$$

This is about as close to certainty as it is possible to get.

So far we have not written this out as a premise/conclusion argument.  
But it would not be hard to do so.

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## THE FINE-TUNING ARGUMENT

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  2.  $Pr(\text{life} | \text{non-design}) = \frac{1}{10^{120}}$
  3.  $Pr(\text{design}) = Pr(\text{non-design}) = 0.5.$
  4. Bayes' theorem.
  5.  $Pr(\text{design} | \text{life}) \approx 1. (1,2,3,4)$
  6. Life exists.
  7.  $Pr(\text{design}) \approx 1. (5,6)$
  8. If the universe was created by an intelligent designer, then God exists.
- 
- C.  $Pr(\text{God exists}) \approx 1. (7,8)$

This looks like a powerful argument for the existence of God. It is notable that it seems to use no especially controversial philosophical assumptions, like the Principle of Sufficient Reason.



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How might someone object to this argument? I want to look at four different angles of attack.

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### The 'god of the gaps' objection

There's a long history of arguments that God is needed to explain some natural phenomenon - to fill in some 'gap' in our knowledge. But science always eventually provides the missing explanation.

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Consider, for example, the fact that for centuries the most popular argument for the existence of God was that the 'argument from design,' which held that God was needed to explain the existence of complex organisms like us. But then Darwin's theory of evolution provided a purely naturalistic explanation of how complex organisms came to be. And that more or less spelled the end of the traditional argument from design.

In reply, it is worth asking what premise of the argument this objection is supposed to be an objection to. Let's have a look.

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The fine-tuning argument is simply not of the form "we can't explain X, so God must exist to explain X." None of its premises say anything about anything being inexplicable without God.

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The fine-tuning argument is simply not of the form “we can’t explain X, so God must exist to explain X.” None of its premises say anything about anything being inexplicable without God.

The closest we get is probably premise (2), which says that a certain fact is very improbable if there is no intelligent designer. But that is not an anti-scientific claim; it’s a claim based on contemporary physics.

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### **The convinced atheist objection**

The hypothesis that an intelligent designer exists is really, really unlikely in the first place, so premise (3) is false.

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## The convinced atheist objection

The hypothesis that an intelligent designer exists is really, really unlikely in the first place, so premise (3) is false.

Our initial statement of the argument assumed that there is a 0.5 prior probability of the claim that the universe was created by an intelligent designer. But of course not all will agree to that; imagine that an atheist claims that there is only a 1/1 million chance that the design hypothesis is true. Will that matter?

Not really. The problem is that the number  $10^{120}$  is so **big**. Changing the initial probability from  $1/2$  to  $1/10^6$  has no serious effect.

What if the atheist is **certain**, so that the prior probability of the design hypothesis is 0?

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### Skepticism about physics

The physics is wrong (or at least might be).

This would target premise (2) of the argument.



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## Skepticism about physics

The physics is wrong (or at least might be).

This would target premise (2) of the argument.

Here is the idea. Contemporary physics makes two claims of interest to this argument. The first is a claim about what the laws of nature are. The second is the claim that **if** those are what the laws of nature are, then the probability of the constants being in a life-permitting range is almost 0.

But physicists are fallible, and our best physical theories have been disproven in the past. So it is at least possible that one of the two claims above is false. Premise (2), by contrast, just assumes that both claims of contemporary physics are true.

Suppose we think that there's a half chance that contemporary physics is significantly enough on the wrong track that one of the above claims is true. How might that affect the argument?

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Suppose we think that there's a half chance that contemporary physics is significantly enough on the wrong track that one of the above claims is true. How might that affect the argument?

Well, suppose (for simplicity) that in scenarios in which current physics is wrong, it turns out that the true physical theory is one according to which the chances of the constants falling in a life-permitting range is

not  $\frac{1}{10^{120}}$ , but some significantly higher number, like  $1/2$ .

Then how would we calculate the probability of life given non-design? We would have two possibilities to consider, the one in which current physics is on the right track and the one in which current physics is on the wrong track. We already know that

$$Pr(\text{life} | \text{non-design and current physics is on the right track}) = \frac{1}{10^{120}}$$

We are supposing that

$$Pr(\text{life} | \text{non-design and current physics is on the wrong track}) = \frac{1}{2}$$

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Well, suppose (for simplicity) that in scenarios in which current physics is wrong, it turns out that the true physical theory is one according to which the chances of the constants falling in a life-permitting range is

not  $\frac{1}{10^{120}}$ , but some significantly higher number, like  $1/2$ .

Then how would we calculate the probability of life given non-design? We would have two possibilities to consider, the one in which current physics is on the right track and the one in which current physics is on the wrong track. We already know that

$$Pr(\text{life} | \text{non-design and current physics is on the right track}) = \frac{1}{10^{120}}$$

We are supposing that

$$Pr(\text{life} | \text{non-design and current physics is on the wrong track}) = \frac{1}{2}$$

Since we are also supposing that these possibilities are equally likely, we can get the probability of life given non-design by averaging them, to get

$$Pr(\text{life} | \text{non-design}) \approx \frac{1}{4}$$

## THE FINE-TUNING ARGUMENT

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1.  $Pr(\text{life} | \text{design}) = 0.5$
  2.  $Pr(\text{life} | \text{non-design}) = \frac{1}{10^{120}}$
  3.  $Pr(\text{design}) = Pr(\text{non-design}) = 0.5.$
  4. Bayes' theorem.
  5.  $Pr(\text{design} | \text{life}) \approx 1. (1,2,3,4)$
  6. Life exists.
  7.  $Pr(\text{design}) \approx 1. (5,6)$
  8. If the universe was created by an intelligent designer, then God exists.
- 
- C.  $Pr(\text{God exists}) \approx 1. (7,8)$

$$Pr(\text{life} | \text{non-design}) \approx \frac{1}{4}$$

This probability is massively higher than the probability assumed by premise (2). This change would thus sufficiently weaken the argument. It still might be enough to push an agnostic into theism; but it's not enough to move an atheist who is pretty sure of their position.

$$Pr(\text{life} | \text{non-design}) \approx \frac{1}{4}$$

This probability is massively higher than the probability assumed by premise (2). This change would thus sufficiently weaken the argument. It still might be enough to push an agnostic into theism; but it's not enough to move an atheist who is pretty sure of their position.

It is worth emphasizing that, for this objection to do much to weaken the argument, one has to think that current physics is screwed up in some pretty fundamental ways.

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Let's look at one last objection:

### **The multiverse objection**

There are very many — perhaps infinitely many — distinct universes, which can have different fundamental physical constants.

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## The multiverse objection

There are very many — perhaps infinitely many — distinct universes, which can have different fundamental physical constants.

Surely, this objection goes, if there were enough universes, then no matter how improbable it is that one of them would have constants that fall in the life-permitting range, it is not so improbable that some would. This would then be a way of rejecting premise (2) of the argument.

Our situation would then be somewhat analogous to the position of someone who wins the lottery. The odds of **that** person winning the lottery were very small; but if enough people buy tickets, it is not so improbable that someone wins.

It would be unreasonable for the winner to infer that the lottery was rigged in her favor; just so, it would be unreasonable for us to assume that our universe was designed.

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It would be unreasonable for the winner to infer that the lottery was rigged in her favor; just so, it would be unreasonable for us to assume that our universe was designed.

So the key question is: do we have good reason to think that the multiverse hypothesis is true?

A first point to note: it would be very surprising if this hypothesis were true. For, if it is, there are very many — perhaps infinitely many — other universes, each as real as ours, in which some near-duplicate of you exists. There is, for example, very likely one in which there exists some being with a qualitatively identical history to you who differs from you only in that she or he scratched his nose one second ago.

This does not show that the multiverse hypothesis is false; the universe might be strange, and science repeatedly shows us that it is. But it does suggest that the multiverse hypothesis is not one that we should believe without argument.



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This does not show that the multiverse hypothesis is false; the universe might be strange, and science repeatedly shows us that it is. But it does suggest that the multiverse hypothesis is not one that we should believe without argument.

One might think that the very facts used in the fine-tuning argument can be used to support the multiverse hypothesis. For consider the following argument:

### A Bayesian argument for the multiverse

It is very, very improbable that our universe is the only one and, just by chance, the constants came to be set in such a way as to make life possible. But if there were many many universes, it would not be very improbable that one would be life supporting. So, the fact that our universe is life-supporting is strong evidence in favor of the multiverse hypothesis.

But, while this reasoning sounds plausible, consideration of parallel cases shows that something has gone wrong.

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But, while this reasoning sounds plausible, consideration of parallel cases shows that something has gone wrong.

### A Bayesian argument for many dice rollers

I am sitting in my office, and I pick up 12 dice and decide to roll them. I roll all sixes. Amazed, I think to myself: there must be lots of people rolling dice in Malloy Hall right now. After all, what are the odds that someone rolls 12 sixes in Malloy in the case where there is just one person rolling dice?

This would be terrible reasoning; the fact that I rolled all sixes, however improbable, is not evidence for the existence of many rollers. What has gone wrong?

## A Bayesian argument for many dice rollers

I am sitting in my office, and I pick up 12 dice and decide to roll them. I roll all sixes. Amazed, I think to myself: there must be lots of people rolling dice in Malloy Hall right now. After all, what are the odds that someone rolls 12 sixes in Malloy in the case where there is just one person rolling dice?

One diagnosis is that we need to distinguish between two pieces of evidence we might have:

E1. I rolled  
12 6's.

E2. Someone  
in Malloy  
rolled 12 6's.

The existence of many rollers would make Evidence 2 more likely. Would it make Evidence 1 more likely?

If not, then it looks like Evidence 2, but not Evidence 1, provides evidence for the many rollers hypothesis. Since in our imagined scenario what I possess is Evidence 1, my inference that there must be many rollers was illegitimate.

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But now compare this to the case of the multiverse.

E1. This  
universe has  
life-  
permitting  
constants.

E2. Some  
universe has  
life-  
permitting  
constants.

Which of these, if either, does the multiverse hypothesis make more likely? Only E2, it seems. But it looks like E1 is the evidence we have; so it looks like the probability of our evidence conditional on the multiverse hypothesis is not higher than the probability of that evidence conditional on the single universe hypothesis.

Could one object that we also have E2 as evidence, and say that **E2 is evidence for the multiverse?**

But if that were legitimate we could do the same thing in the many rollers case -- and we know that that is a mistake.

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Summing up: it appears that, if we have good reason to believe the multiverse hypothesis, this would be bad news for the fine-tuning argument.

But it also seems that the fact that our universe is life-supporting is not itself evidence for the multiverse hypothesis. So the key remaining question is: do we have any good reason to believe in the multiverse?

This is a question very much in dispute — though the dispute is as much among physicists as philosophers. Some physicists think that there is physical evidence in favor of the multiverse hypothesis. Others think that the very idea of physical evidence about universes distinct from our own makes little sense.

Here — as in other cases — we have an example in which philosophical reasoning and scientific theory are intertwined.

What seems clear is that if (1) there is just one universe and (2) current thinking about the fundamental constants in physics is on the right track, then the fine-tuning version of the design argument is a powerful argument for the existence of a designer of the universe.

## Appendix: Proof of Bayes' theorem

Remember our definition of conditional probability:

$$P(a|b) = \frac{P(a\&b)}{P(b)}$$

Using this definition, we can prove Bayes' theorem as follows:

### Derivation of Bayes' theorem

1. $P(a b) = \frac{P(a\&b)}{P(b)}$	def. of conditional probability
2. $P(b a) = \frac{P(a\&b)}{P(a)}$	def. of conditional probability
3. $P(a b) * P(b) = P(a\&b)$	(1), multiplication by '='s
4. $P(a\&b) = P(b a) * P(a)$	(2), multiplication by '='s
5. $P(a b) * P(b) = P(b a) * P(a)$	(3),(4)
C. $P(a b) = \frac{P(b a)*P(a)}{P(b)}$	(5), division by '='s

To go back to the main lecture, click [here](#).

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