



The Problem of Induction

How do we know what caused this?

Inductive Inference

Recall that inductive inference can be crudely represented as follows:

H predicts E

E

$\therefore H$

Inductive Inference

But we've also seen, when talking about IBE, that there's a lot more to it. It actually looks more like this:

A (auxiliary assumptions)

(H & A) predicts E

E

H is plausible

Alternatives to H aren't plausible, or don't predict E.

$\therefore H$

Theories 'transcend experience'

- As philosophers have noted at least since Leibniz, scientific theories go “beyond the data”.
- “... no observation or experiment, however extended, can give more than a finite number of repetitions”; therefore, “the statement of a law - B depends on A - always transcends experience.”

(Physicist Max Born, *Natural Philosophy of Cause and Chance*, 1949, p. 6)

‘meager input’ and ‘torrential output’

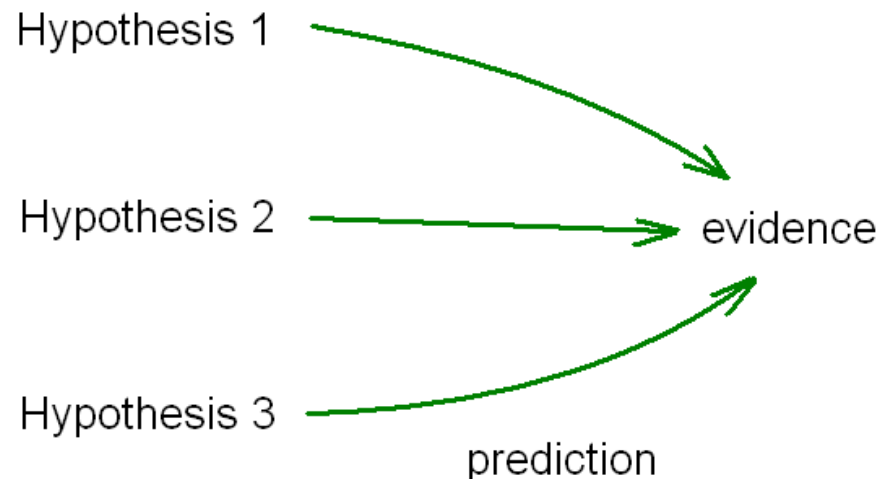
- Note also that theories don’t just go *a little bit* beyond the evidence that supports them.
- In terms of information content, theories have *infinite* content, as they can be used to predict infinitely many different observations. But the evidence we have is always *finite*.
 - Hence Quine (for example) talks of empirical evidence as a ‘meager input’, and the theories we produce as ‘torrential output’.
 - [Quine, “Epistemology Naturalized”. Originally published in *Ontological Relativity and Other Essays*, 1969.]

The underdetermination of theories by evidence

- This fact, that theories go far beyond experience, is often called “the underdetermination of theories by the evidence”
- It can also be called the “many possible causes” problem. Given any finite set of data, there are always many possible causes of the data that can be imagined.

The many possible causes problem

- For any observed data, we can imagine many possible causes of it.



Problem: If (say) three hypothesis all predict the observed data, then which hypothesis do you (inductively) infer *from* the data?

Empiricism

- At the same time, however, philosophers since Hume have (mostly) espoused *empiricism*, i.e. Francis Bacon's idea that **scientific laws and theories can be supported only by observation and experiment**.
- This creates what is called the 'problem of induction'. *As a matter of logic, how can experience support, to any substantial degree, claims that go massively beyond experience?*

Leibniz's rationalism

- Leibniz's 'solution' (*New Essays*, 1704) to this problem was to reject empiricism.

In other words, scientific theories are based on innate (or 'a priori') knowledge as well as observation.

(Recall how IBE uses 'plausibility' as well as data.)



Gottfried Leibniz, 1646-1716

Leibniz on Innate Knowledge

“Julius Scaliger used to call [innately known principles] ‘living fires or flashes of light’ hidden inside us but made visible by the stimulation of the senses, as sparks can be struck from a steel. We have reason to think that these flashes reveal something divine and eternal: this appears especially in the case of necessary truths.”

“... it is obvious that if some events can be foreseen before any test has been made of them, we must be contributing something from our side. Although the senses are necessary for all our actual knowledge, they aren’t sufficient to provide it all ...” (*New Essays*, Preface)

Common Rationalist Principles

Objective reality has a rational structure, so that reality is comprehensible.

1. The relation of cause and effect mirrors the relation of logical consequence.

- Effects can be logically inferred from their causes, i.e. from suitably complete descriptions of the total cause. (Or, at least, the probability of an effect is logically determined by the causes.)
- Every event has a cause. (Objects and events don't appear "from nowhere", spontaneously, all by themselves.)
- Exactly similar causes always yield exactly similar effects (or the same probabilities of effects)
- If a cause is symmetric, in a certain respect, then its effects (or the probabilities of effects) must also be symmetric, in the same respect.

2.The Separability Principle. The spatial and temporal parts of a system can be considered as individuals, and will behave independently of each other, unless they exert forces upon each other.)

3.The Locality Principle. Forces on a system can only be exerted by the immediate environment, not by distant objects, except indirectly via a chain of intermediaries.

4.The Markov principle. The past states of a system cannot act directly on future states, but only indirectly via the states at intermediate times.

5.Relativity principles. The laws of physics are the same in many (or even all) reference frames.

Objections to innate knowledge

1. People who've claimed to know things innately have often been wrong. E.g. Kant thought that Newtonian mechanics was known *a priori*, but unfortunately Newton mechanics was wrong!
2. If you're challenged as to how you know something, it's too easy to say, "I know it innately, so I don't need to provide any evidence for it". This kind of knowledge can't be publicly verified.
3. How would humans get *a priori* knowledge? Where would we get it *from*? There's no plausible answer.

Hume: Science isn't rational

- The Scottish Philosopher David Hume (1711-1776) was well aware that theories go far beyond experience, *but he was also firmly committed to empiricism.*

Hume reconciled these beliefs by holding that *science isn't logical*. Instead, we obtain scientific laws by a psychological mechanism that he called 'custom', and 'habit'.



What is ‘custom’, or ‘habit’?

- “... having found in many cases that two kinds of objects—flame and heat, snow and cold—have always gone together, and being presented with a new instance of flame or snow, **the mind’s habits lead it to expect** heat or cold and to believe that heat or cold exists now and will be experienced if one comes closer. This belief is the inevitable [i.e. psychological] result of placing the mind in such circumstances.
- That our minds should react in that way in those circumstances is as unavoidable as that we should feel love when we receive benefits, or hatred when we are deliberately harmed. These operations of the soul are a kind of **natural instinct**, which no reasoning or process of the thought and understanding can either produce or prevent.”

Appeal to the ‘uniformity of nature’?

- Hume focused on one kind of inductive inference: those that reason from past observations to future case.
 - E.g. coal burned in the past, so it will do so in the future
- Perhaps such inferences *can* be rational (contrary to Hume’s view) if we add a premise that “nature is uniform”.
- What do you think?

- E.g.

Coal burned in the past

Nature is uniform

∴ Coal will burn in the future

Appeal to the ‘uniformity of nature’?

- Hume’s response is to question: “How do you *know* that nature is uniform?”
- Could we know this from *experience*?
- No, says Hume. Experience could only tell us that nature was uniform *in the past*, whereas this inference requires knowing that nature *will continue* to be uniform, in the future.

Not even *probably* ...

But probable reasoning, if I have described it accurately, can't provide us with the argument we are looking for. According to my account, all arguments about existence are based on the relation of cause and effect; our knowledge of that relation is derived entirely from experience; and in drawing conclusions from experience we assume that the future will be like the past. So if we try to prove this assumption by probable arguments, i.e. arguments regarding existence, **we shall obviously be going in a circle**, taking for granted the very point that is in question.

Part 2

The problem of induction after Leibniz and Hume

Recap ...

Hume's argument:

1. Scientific theories massively transcend experience
2. All knowledge comes entirely from experience

∴ Science isn't rational

Is there an alternative to this conclusion?

1. Popper's falsificationism

“I hold with Hume that there simply is no such logical entity as an inductive inference ...

[However] I disagree with Hume's opinion (the opinion incidentally of almost all philosophers) that induction is a fact and in any case needed. I hold that neither animals nor men use any procedure like induction ...

The answer to this problem is ... we are justified in reasoning from a counterinstance to the falsity of the corresponding universal law.”

Popper, “The Problem of Induction”, 1953

Popper's falsificationism

- Popper says that inductive inferences are **impossible**, and **not needed in science**.
- In other words, Popper is prepared to give up the idea that we can ever rationally *believe* our theories, even to a limited degree.
- Instead, the best theories are merely ones that are falsifiable in principle, but not actually falsified (yet).

Don't we believe our best theories?

- The main problem with Popper's view is that scientists *do* seem to believe theories, at least with some degree of probability (that is often fairly close to 1). (“It turns out ...”, “We now know ...”)
 - And this often seems *justified*.
- Also, if scientific theories are to be applied to real-world problems, then we *need* to believe them.

2. Induction is IBE?

Can we say that induction can be understood as **inference to the best explanation**, which is rational and justified?

(We know that IBE is rational, since it can be demonstrated using Bayes' theorem, which is provable from the axioms of probability.)

$$\text{Strength}_K(H) = P_K(H) \times P_K(E|H), \text{ etc.}$$

Response

- Ah yes, but IBE itself relies on judgments about the “plausibility” of hypotheses, prior to the evidence.
 - From a Bayesian perspective, these are assessments of prior probability.
- And since they are synthetic judgments (i.e. “matters of fact”), and prior to the evidence, we are back to Leibniz’s “inner principles”, or Kant’s synthetic *a priori*.

How about Bayesian *empiricism*?

- What if one can assign values to the priors by *experience*?
- Bayesian empiricism says that the “priors” at any given time are based on *previous observations*.
- But there’s a kind of regress problem here, as Bayes’ theorem doesn’t allow probabilities to be determined by experience “all the way down”. It seems to require absolute priors.

E.g. what if we collect together *all* our evidence?

- Put *all* our evidence, that we have collected since the beginning of history, into one massive proposition E.
- Then, according to Bayesian methods, we should believe a hypothesis H if $P(H \mid E)$ is high.
 - Note that there is no '*K*' here, as we now have no background knowledge (since there is no experience prior to E).
- *But*, calculating $P(H \mid E)$ requires a value for $P(H)$, which is an absolute prior.

Goodman laws

- E.g. consider the following Goodman law.

**“Newton’s laws are followed up to April 5, 2023,
but after that <some other law> holds”**

What does *today’s* total empirical evidence E have to say about this law?

Are such laws *logically* impossible?

Do any purely logical principles (e.g. the probability axioms) render them *improbable*?

Appeal to past experience

1. We've never observed any such Goodman law to hold.

2. Standard, uniform laws have a great track record

∴ Goodman laws are improbable

- The argument is circular, says Hume (and Skyrms, Bonjour, etc.)

3. Evolution to the rescue?

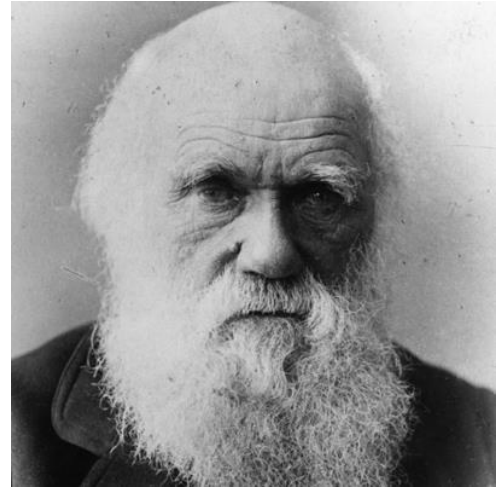
- Can we give an *evolutionary* explanation for the origin of (synthetic) *a priori* knowledge?
- Perhaps the beliefs we need to do science, such as the future being similar to the past, have been bred into us during our evolutionary history, by natural selection?

“... the mental requirements of the lowest savages, such as the Australians or the Andaman Islanders, are very little above those of many animals. How then was an organ developed far beyond the needs of its possessor? Natural Selection could only have endowed the savage with a brain a little superior to that of an ape, whereas he actually possesses one but very little inferior to that of the average members of our learned societies.”

Alfred R. Wallace *The Quarterly Review*,
April 1869.



- The cognitive tasks faced by hunter-gatherers seem rather different from those posed by (e.g.) evolutionary biology. Do we trust the intuitions of a hunter gatherer about evolutionary biology? (Or about quantum mechanics?)



“With me, the horrid doubt always arises whether the convictions of man’s mind, which has been developed from the mind of the lower animals, are of any value or at all trustworthy. Would any one trust in the convictions of a monkey’s mind, if there are any convictions in such a mind?”

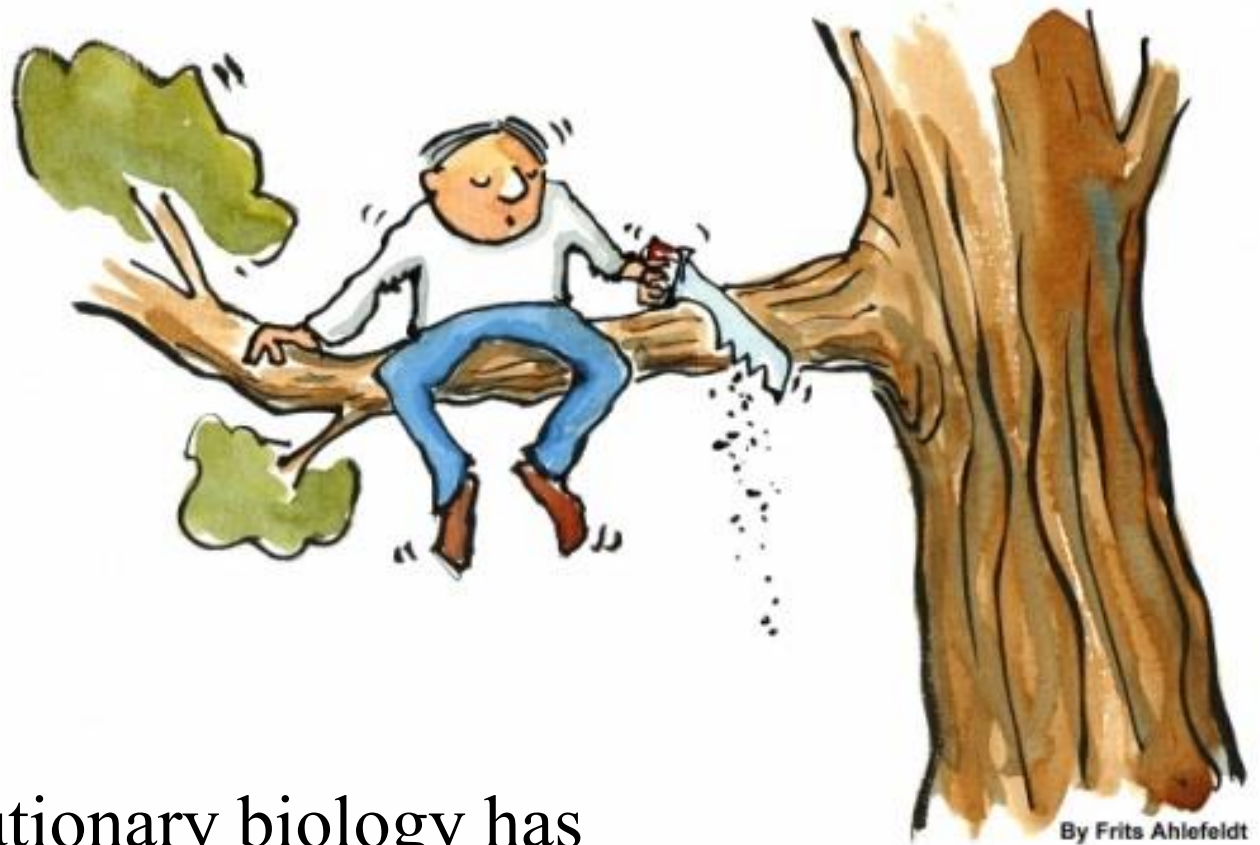
Charles Darwin, letter to William Graham, July 3rd, 1881.

- E.g. in the *Origin of Species* Darwin wrote things like:

“the simplicity of the view that each species was first produced within a single region captivates the mind.”

- Is a theory that captivates the mind of a primate *thereby* likely to be true?)

- One way to develop this argument notes that if natural selection has shaped our minds, over long ages, then this just increases the amount of past “experience” we have.
- In effect, we carry in our brains faint echoes of the experiences of innumerable remote ancestors.
- But if past experience gives no *logical* support to beliefs about the future, then adding more of it won’t help.
- This answer to the problem of induction is the basically the same as Hume’s, in that it provides only a *psychological explanation* for science, not a *logical justification*.



“Evolutionary biology has
shown conclusively that
science isn’t rational”

Part 3

A cautionary tale about Ockham's Razor, and the need for empirical adequacy

Are living cells *simple*?

- The expectation of a simple world has sometimes gone wrong.
 - A spectacular example of this is the case of living cells, when first observed (under a microscope).

Structureless
blobs of
protoplasm?



Many of these [simple cells], instead of emitting the broad lobe like pseudopodia of *Amæba*, have the faculty of sending out long thin threads of protoplasm, which they can again retract, and by the aid of which they capture their prey or move from place to place. **Simple structureless protoplasm as they are**, many of them fashion for themselves an outer membranous or calcareous case....

(Sir Norman Lockyer, *Nature*, 1879.)



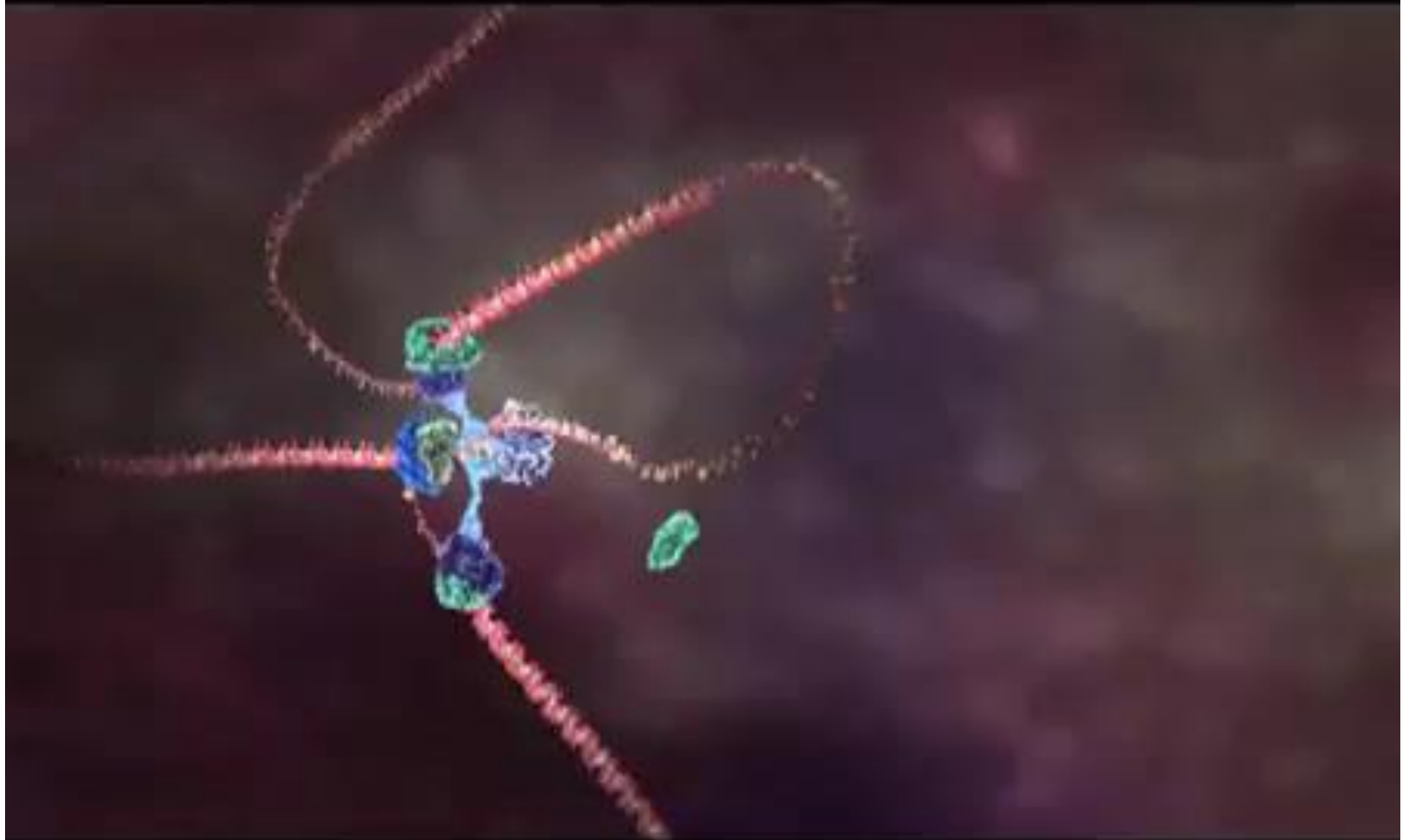
The American Cyclopedia, 1873.

“... They are not only the simplest organisms with which we are acquainted, but also the simplest living beings we can conceive of as capable of existing; and **though their entire body is but a single, formless, small lump of protoplasm**, and (each molecule of it being like the other) without any combination of parts, **yet they perform all the functions** which in their entirety constitute in the most highly organized animals and plants what is comprehended in the idea of life, namely, **sensation and motion, nutrition and propagation.**”

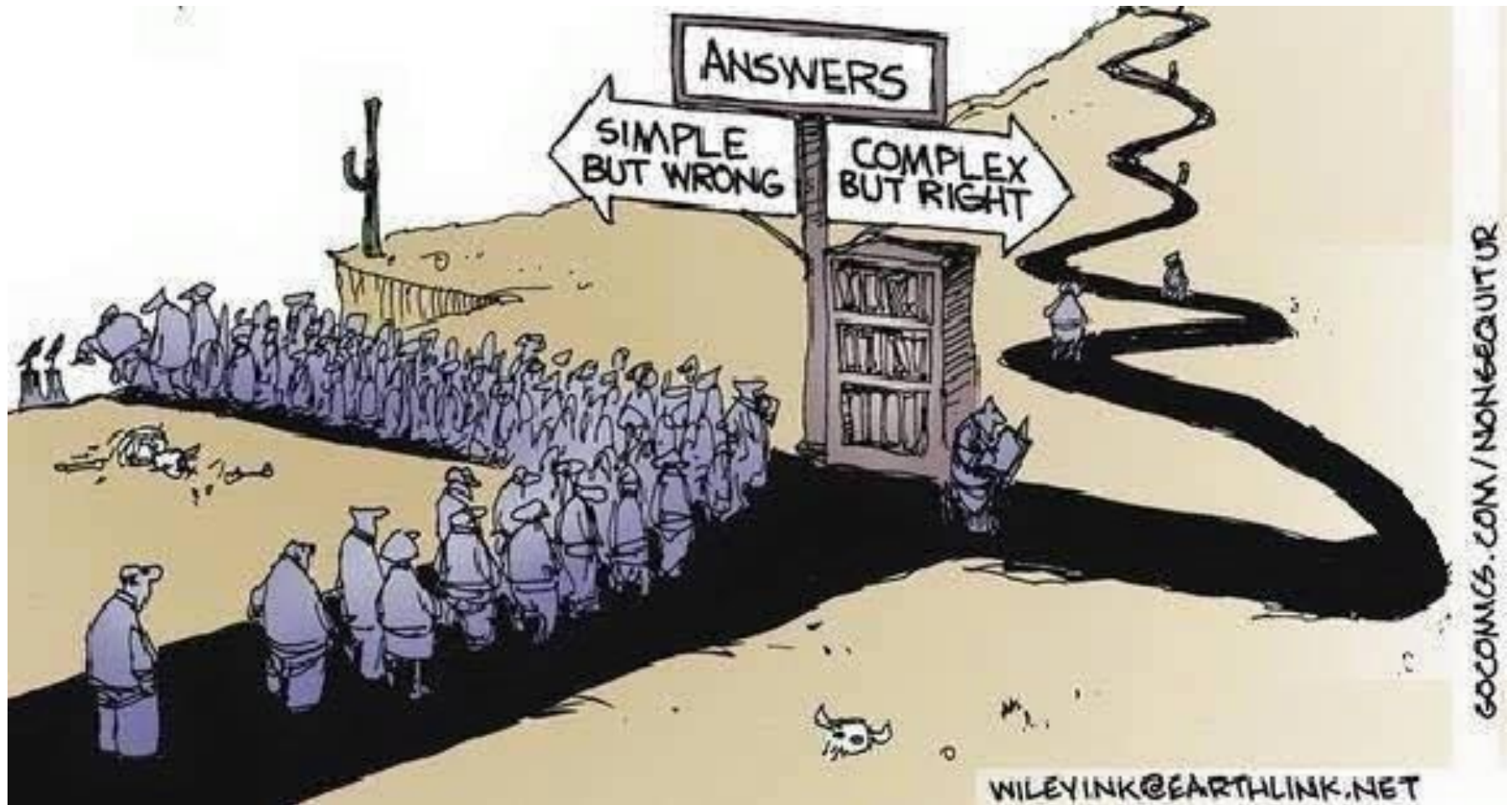


TRIPLE FACEPALM

Not even double facepalm can explain how much you fail



How does this fit with Ockham's Razor?



The need for *prediction*

- In hindsight, the idea of cells being simple seems crazy, in view of what they *do*.
- Surely the “structureless protoplasm” hypothesis **fails to predicts the data!** (“sensation and motion, nutrition and propagation”).
- If someone says, “my theory explains E”, then ask to see the *logical derivation* of E from their theory.
[C.f. Newton and the moon’s orbit.]

- The moral of the story is this:

It's all very well to expect simplicity, but *make sure that such a simple model is empirically adequate*. If it's not adequate, then a more complex model is needed.

Einstein:

“Everything should be made as simple as possible, *but not simpler.*”