Epistemology 3

MOT142A Q2

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Recap of last weeks topics

- Last week we looked at:
- arguments, truth, and validity
- truth tables, how to construct them, and how to use them to test the validity of arguments

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Recap of last weeks topics

- Few of you asked *why* we were looking at formal logic
- Aside from intrinsic value of logic (if there is any), there are two reasons:
  - Practical – a lot of employers look for critical thinking skills, and I’ve been told a number of consultancy firms actually include formal logic components on their application tests
  - Theoretical – we’ll deploy the skills we learned last week in understanding arguments about scientific knowledge in this week’s lecture and tutorials

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Aims for this week

- This week, we will consider:
  - Difference between *deduction* and *induction* more closely
  - The shortcomings of *inductive* reasoning, and how it features within science.
  - Falsificationism
  - The empirical cycle

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Recap on deduction

- Deductive reasoning is *truth preserving.*
- That is, when an argument is *deductively valid*, and the premises are *true*, we can be guaranteed that the conclusion is also true.
- In this way, we can reach novel truths, just by application of logical rules to truths we're already aware of.
- Mathematics exemplifies the greatest successes of the use of this model.

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Deduction vs. Induction

- Scientific reasoning, however, is much more reliant on inductive reasoning.
- Inductive reasoning is on far shakier ground.
- The truth of the premises, in an inductively valid argument, ***DO NOT*** guarantee the truth of the conclusion.

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Recap on deduction

- Deductive argument:
  - P1. All ravens are black.
  - P2. The next raven I see will be black.
- Inductive argument
  - P1. All ravens I’ve ever observed have been black
  - C. The next raven I see will be black.

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Deduction vs. Induction

- The truth of the conclusion is guaranteed by a deductively valid argument *and* the truth of the premises – that's what it is for an argument to be deductively valid.
- Not so for *inductive arguments.*
- While I might feel more assured of seeing a black raven, given the fact all previous ravens I've seen have been black, I **cannot guarantee** that the next one I see will be black.
- Instead, an inductively valid argument means the conclusion is ***likely***, given the truth of the premises.

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Deduction vs. Induction

- How might we *justify* inductive reasoning, then?
- Here's one possible method:
  - I use a lot of inductive reasoning in my day-to-day life all the time, and it's always served me well.
  - The sun has risen every day before today, and on this basis, I suppose that it will do tomorrow.
  - Every time I've eaten a meal, my hunger dissipates, and I suppose that pattern will continue, as well.
  - When I flick the light switch, the light comes on, and so on.
  - Given that inductive reasoning has always served me well in these circumstances, I can be assured that it will continue to do so.

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Deduction vs. Induction

- What do you think of this justification of inductive reasoning?
  - I use a lot of inductive reasoning in my day-to-day life all the time, and it's always served me well.
  - The sun has risen every day before today, and on this basis, I suppose that it will do tomorrow.
  - Every time I've eaten a meal, my hunger dissipates, and I suppose that pattern will continue, as well.
  - When I flick the light switch, the light comes on, and so on.
  - Given that inductive reasoning has always served me well in these circumstances, I can be assured that it will continue to do so.

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Deduction vs. Induction

- Problem of Induction
- We can’t justify inductive reasoning with inductive reasoning. To do so would be circular.
- Compare: Why *X*? Because *X*.

Deduction vs. Induction

- Why does the problem of induction matter?
- Well, it's hugely problematic, as inductive reasoning is at the cornerstone of scientific reasoning.

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Laws of Nature

- Laws of nature are, very simply, generalisations of the form ‘All Xs that are Fs, are also Gs’.
  - All metals are good conductors of electricity
  - All uranium-235 atoms have a half life of 703.8 million years
  - No massive entity can travel faster than the speed of light

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Laws of Nature

- Laws of nature are usually generalisations of the form ‘All Xs that are Fs, are also Gs’.
  - All metals are good conductors of electricity
    - All Xs that are Fs (metals) are also Gs (good conductors of electricity).
  - All uranium-235 atoms have a half life of 703.8 million years
    - All Xs that are Fs (uranium-235 atoms) are also Gs (have a half life of 703.8 million years).
  - No massive entity can travel faster than the speed of light
    - All Xs that are Fs (havers of mass) are also not-Gs (travel faster than speed of light).

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Laws of Nature

- Let's take one example:
  - All metals are good conductors of electricity

Laws of Nature

- How might we prove this sentence to be true?
  - All metals are good conductors of electricity
- Well, it might look something like this:
  - P1. Mercury is a metal, and mercury is a good conductor of electricity.
  - P2. Iron is a metal, and iron is a good conductor of electricity.
  - P3. Copper is a metal, and copper is a good conductor of electricity.
  - …
  - C. All metals conduct electricity well.

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Laws of Nature

‘All metals are good conductors of electricity’

- What is the problem with this picture?
- It’s always logically possible that we subsequently observe a novel *X* that is 1) a metal, and 2) is a *poor* conductor of metal
- The truth of our conclusion isn’t guaranteed by the truth of the premises
- Note: we can’t say that our theory says that such an X is physically impossible – the theory is the thing we’re trying to justify.
- Inductive reasoning then cannot guarantee the truth of the laws of nature

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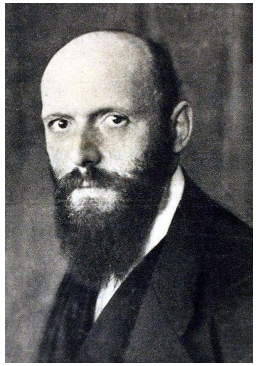
Verificationism



‘All metals are good conductors of electricity’

- The preceding discussion highlights the fatal flaw that exists within the *verificationist* project
- Verificationism is the philosophical project that states that a statement is only *meaningful* when we can empirically verify it
- Greatest exponents are widely known as the *Vienna Circle* (logical positivists)
- Main aim of the logical positivists was to rid us of statements of theology, metaphysics, ethics, etc., on the basis that they were meaningless
- As we can see, this criterion of meaningfulness is too stringent, in so far as it will undermine any universal generalisations
- We cannot verify universal generalisations, as there’s always the logical possibility that a counterexample exists – no empirical observation can verify such generalisations

Laws of Nature

- Since laws are at the cornerstone of science, what are we to do?
- It seems our main methodology in science is in grave jeopardy. If we have no justifiable methodology, why should we trust the knowledge science purports to produce?

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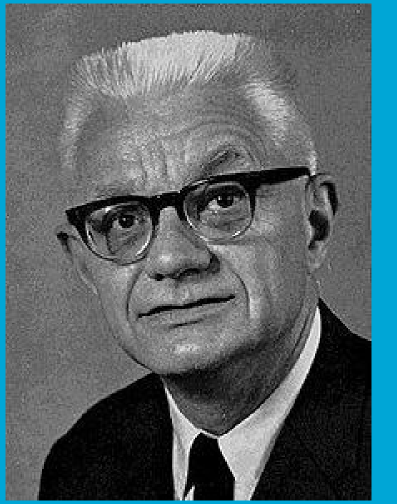

Hypothetico-Deductive Model

- Hypothetico-deductive model
- Proposed by Carl Hempel in the 1950s
- What is it? A proposed *description of the scientific method*
- The rough idea is this: scientific enquiry proceeds not by producing statements which we then justify inductively, but instead, by producing *falsifiable statements* that we can then test.
- Helps us understand also how *theories,* rather than just statements, might be falsified.

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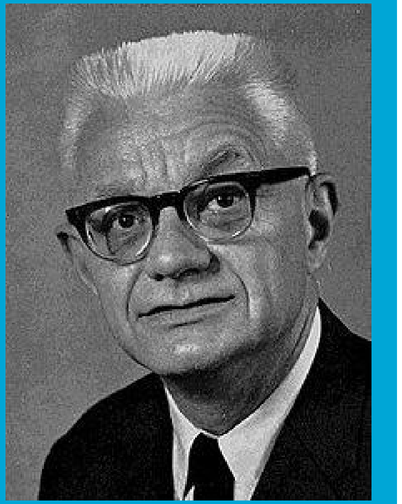

Hypothetico-Deductive Model

- Rather than try to justify the inductive inferences we make personally to reach laws, we simply bypass this part, and test the laws themselves *deductively*
- We treat those laws as hypothetical, and then test them

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Hypothetico-Deductive Model

- We test them using the following schema:
  - P1. If Theory T is true, then if condition C obtains, we can observe E to be the case.
  - P2. C obtains but E is not the case.
  - C. Theory T is false.

Hypothetico-Deductive Model

Consider the following example:

- Becher's phlogiston theory postulated the existence of a fire-like element, *phlogiston*, that was released by bodies during combustion.

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Hypothetico-Deductive Model

- We can apply the hypothetico-deductive model to Becher's theory
- Observation: when we burn steel wool, it gets heavier.
- For example:
  - P1. If phlogiston theory is true, then when we burn steel wool, we can observe that mass is lost by that steel wool by the release of phlogiston.
  - P2. We burn steel wool, but the steel wool *gains* mass.
  - C. Phlogiston theory is false.

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Hypothetico-Deductive Model

- For example:
  - P1. If Theory T is true, then if condition C obtains, we can observe E to be the case.
  - P2. C obtains but E is not the case.
  - C. Theory T is false.

- Is this deductive or inductive?
- Is this valid? How can we test?

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Hypothetico-Deductive Model

- For example:
  - P1. If Theory T is true, then if condition C obtains, we can observe E to be the case.
    - **(T -> (C -> E))**
  - P2. C obtains but E is not the case.
    - **(C & ~E)**
  - C. Theory T is false.
    - **~T**

T	C	E	T ->	(C -> E)	(C & ~E)	~T
1	1	1	**1**	1	**0**	**0**
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- Is this deductive or inductive?
- Is this valid? How can we test?

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Hypothetico-Deductive Model

- So, it’s *deductively* valid.
- What does the model help us do, then?
- It helps us establish *with certainty* that a statement (or body of statements, i.e., a theory) is false.
- This appears to put us on firmer footing – rather than relying on induction, which always carries the risk of being wrong, we’re instead utilizing deduction, which doesn’t carry the same risk.

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Hypothetico-Deductive Model

- What it still doesn't do, however, is help us establish that our scientific statements are *true.* We treat them as hypothetical.
- Still, proving falsity is useful.
- We are often faced with competing theories:
  - Relativistic vs. Newtonian Mechanics
  - Copernican vs. Ptolemaic models of the universe
  - Lamarckism vs. Darwinian theories of evolution
- As such, we have a methodology for establishing which of two competing theories is correct.
- The problem with this, however, is we're just left with 1 falsified theory, and 1 that hasn't yet been falsified. Neither are established as true.
- It's never the case that we can be sure that 1 of 2 theories is *definitely true.*

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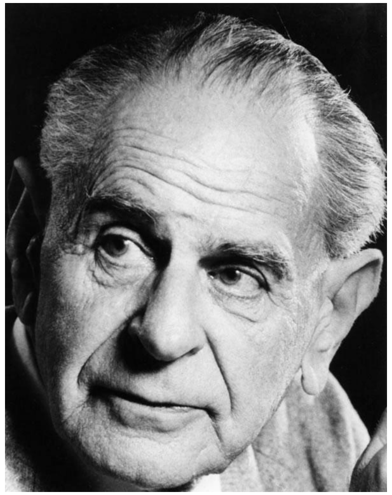
Falsificationism



- This idea proved quite durable.
- Karl Popper developed it further.
- Falsificationism says that we cannot (and should not) hope to *prove scientific statements and theories true*.
- Science, according to Popper, is just the process by which we eliminate statements by falsifying them; what we are left with, at the end, is science.
- We don’t know what the world is like, through science, we just know *what it’s not like.*

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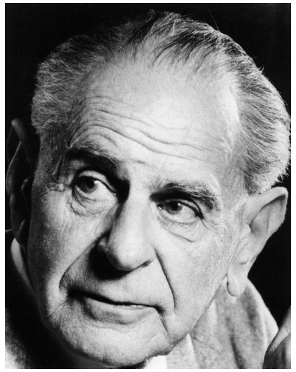
Falsificationism



- Falsificationism augments the hypothetico-deductive model by requiring that scientific theories be falsifiable.
- It provides a *criterion* for whether an activity is, or is not, science.
- As such, attempts to tackle *the demarcation problem;* tries to give an answer to the question of where the line is between science and pseudoscience

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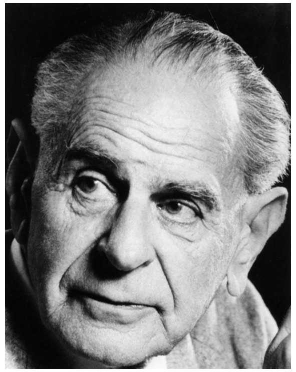
Falsificationism



- Popper's overall claim is that scientific theories must entail *falsifiable* predictions, or they are not scientific.

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Falsificationism

- Take for example, astrology.
- Quite an easy case; presumably we all believe it to be pseudoscience (if it even presents itself as science).
- Here’s my horoscope for today:
  - The hopes and goals of a group with which you're associated inspire you. You might make personal sacrifices in order to assure their success. These sacrifices are temporary, for you'll share in the group's good fortune. Personal success is also in the stars, but it may require disruptive change. Go with the flow and don't let self-doubt hold you back.
  - Good news for you guys!

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Falsificationism

- According to Popper, it’s pseudoscience, as this statement isn’t falsifiable.
  - No observation could be made, such that that observation would serve to demonstrate the falsity of that ‘prediction’
- Astrology makes such vague statements, that we can’t say whether or not the statement is true or false.
- Thus, astrology isn’t science.

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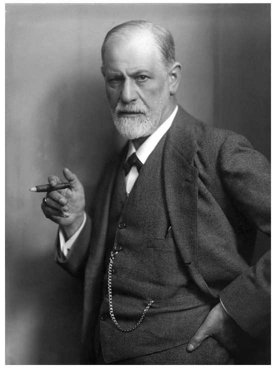
Falsificationism



- More usefully, perhaps, similar criticisms exist of what we might think of as more rigorous areas of study, such as psychoanalysis.
- There are very few falsifiable claims made by psychoanalysis (at least in earlier iterations).
- As such, Popper viewed it as pseudoscience.

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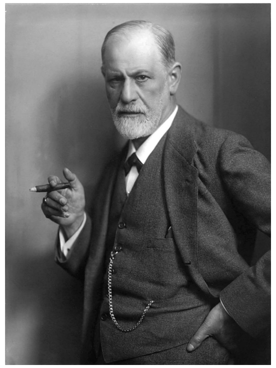
Falsificationism



- '…[E]very conceivable case could be interpreted in the light of Adler's theory, or equally of Freud's. I may illustrate this by two very different examples of human behaviour: that of a man who pushes a child into the water with the intention of drowning it; and that of a man who sacrifices his life in an attempt to save the child. Each of these two cases can be explained with equal ease in Freudian … terms. According to Freud the first man suffered from repression (say, of some component of his Oedipus complex), while the second man had achieved sublimation…

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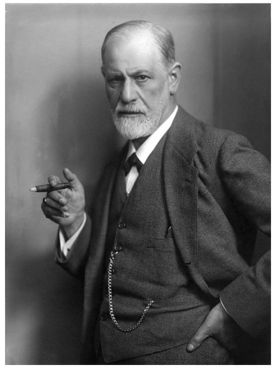
Falsificationism



‘I could not think of any human behaviour which could not be interpreted in terms of [the] theory. It was precisely this fact—that they always fitted, that they were always confirmed—which in the eyes of their admirers constituted the strongest argument in favour [of the theory]. It began to dawn on me that this apparent strength was in fact their weakness.’

(K. Popper, Conjectures and refutations, 1962)

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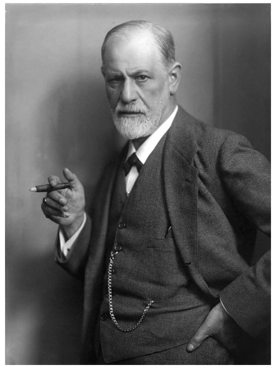
Falsificationism



If we consider this example, the theory is amenable to both *the man pushes the child in the water* (call it ‘A’) and *the man doesn’t push the child in the water* (i.e., ‘not-A’)

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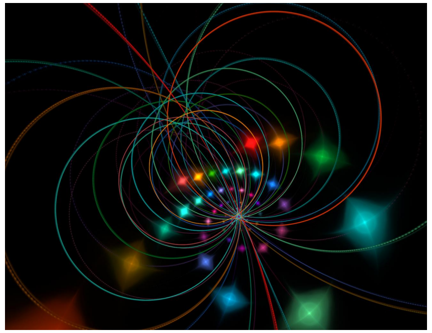
Falsificationism



- Trouble lurks, however
- A lot of credible theoretical physics (for example, String Theory) is, in principle, unfalsifiable (https://www.math.columbia.edu/~woit/wordpress/?p=533)
- A lot of the entailments of the theory are only testable in extreme conditions (energy levels unattainable in our current particle colliders)
- As such, might be viewed as unfalsifiable.
- Are physicists working on String Theory pseudoscientists?
- Even if you think they are, aren't they doing something more rigorous (i.e., this isn't the whole story to demarcation)?

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Falsificationism

- Another problem for falsificationism
- In practice, we rarely reject well respected theories on the basis of a falsifying example.

OPERA Experiment

- In 2011, researchers at the CERN-affiliated OPERA Experiment at Laboratori Nazionali del Gran Sasso (LNGS) reported that they had evidence that neutrinos travelled faster than light.

OPERA Experiment

- Neutrinos created at CERN were fired at a detector in Gran Sasso.
- The speeds recorded were in excess of the speed of light.

OPERA Experiment

- If correct, the findings would contradict relativity.
- Neutrinos have small, but nonzero mass.
- Theory of relativity – one of our most entrenched scientific theories – predicts that any entity with mass *cannot* travel faster than the speed of light.
- The findings, if confirmed, would irrevocably change our fundamental understanding of the world.

OPERA Experiment

- The findings were met with an enormous amount of incredulity in the scientific community.
- In the end, it was confirmed that a faulty fibre optic cable, and a clock oscillator that ran too fast, were to blame for the anomalous results.
- Once the experimental set up was corrected, it was confirmed that neutrinos travel within the margin of error for the speed of light.

OPERA Experiment

- Should we not have rejected special relativity, on the basis of the OPERA experiment?
- It seems we were entirely right to be sceptical of these incredible results, but Popper’s position is powerless to explain why.
- After all, no theory is verifiable. It’s just *not wrong*.

Falsificationism

- The relation between theory and prediction has not been represented accurately.
- The correct relation, in this case, might be something more like:
  - P1. If special relativity is true, and if there is no faulty wiring, then when we fire a neutrino, it will travel less than the speed of light.
  - P2. We fire a neutrino, but it travels faster than the speed of light.
  - C. Special relativity is false.
- More generally:
  - P1. If theory T is true, and if assumption A is true, then if condition C obtains, effect E is observed.
  - P2. Condition C obtains, but effect E is not observed.
  - C. Theory T is false.

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Falsificationism

- This formulation, however, is invalid:
  - P1. If theory T is true, and if assumption A is true, then if condition C obtains, effect E is observed.
  - P2. Condition C obtains, but effect E is not observed.
  - C. Theory T is false.

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Falsificationism

T	A	C	E	(T&A)	->	(C->E)	C & ~E	~T
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Falsificationism

- Adjust the schema appropriately
- This formulation, is valid:
  - P1. If theory T is true, and if assumption A is true, then if condition C obtains, effect E is observed.
  - P2. Condition C obtains, but effect E is not observed.
  - C. Special relativity is false, **or assumption A is false.**

Falsificationism

T	A	C	E	(T&A)	->	(C->E)	C & ~E	~T v ~A
1	1	1	1	1	**1**	1	**0**	**0**
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Falsificationism

  - P1. If theory T is true, and if assumption A is true, then if condition C obtains, effect E is observed.
  - P2. Condition C obtains, but effect E is not observed.
  - C. Theory T is false, or assumption A is false.
- The problem with this second formulation, however, is that we’re no longer required to accept the falsity of T.
- As a result, we could always build in assumptions that we could ‘rest the blame’ on, so to speak.
- That is, we could lay the fault for the failed prediction with the assumption, rather than the theory.

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Falsificationism

- And in many cases, these assumptions won’t be as ridiculous. For example:
- According to Newtonian mechanics, two objects *a* and *b,* if released at the same time from the same height, will hit the ground at the same time.
- That is, unless any wind resistance that slows their fall.
- If there is no atmosphere, a feather and a cannonball will fall at the same speed.

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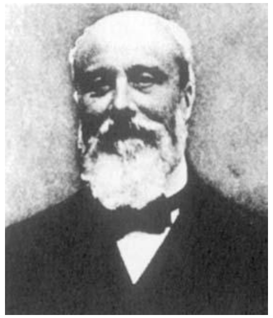
Falsificationism

- If we plug this into the theory:
  - P1. If **theory T** (*Newtonian Mechanics*) is true, and if **assumption A** (*air resistance doesn't slow the fall of objects* a *and* b) is true, then if **condition C** (*we drop objects a and b from the same height simultaneously*) obtains, **effect E** (*objects* a *and* b *hit the ground at the same time*) is observed.
  - P2. **Condition C** obtains, but **effect E** is not observed.
  - C. **Theory T** is false, or **assumption A** is false.

Falsificationism

- The problem here, however, is that, in other circumstances, we can build in whatever assumptions we want (that we can blame for the failure of the predicted effect to occur)
- Those assumptions may grow increasingly outlandish
- Imagine for example, someone claims they are amazing at football, and who comes up with increasingly tortured excuses for why, when you see them play, they're rubbish.
- Though it might be obvious to us, there's no non-arbitrary criteria for us to use that says that the theory (that they're good at football) is false, rather than the assumption (the fact that they got up too early, have a headache, sun got in their eyes, etc.)

Duhem-Quine

- This problem is closely related to the Duhem-Quine thesis
- The idea is: it’s impossible to test a hypothesis in isolation
- What you *really* do, is test the hypothesis, *in conjunction with* a background corpus of knowledge
- When the hypothesis isn’t borne out in observation, it’s impossible to tell which of the two – hypothesis, or background assumptions – have been falsified.
- To see this, switch ‘assumption A’ for ‘background knowledge’ in our previous schema

Falsificationism

- In summary, then, significant problems exist for falsificationism.
- It does however represent progress over the inductive/verification model of science.
- That said, it has enduring popularity, so much so that it's probably accurate to say it's the received view amongst contemporary scientists.

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The Empirical Cycle

- It’s a model of how science actually proceeds.
- Should bring together the multiple elements we’ve looked at in today’s lecture.
- Now, you’ll be able to point out the multiple flaws that occur within this picture.

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Empirical Cycle

- Experimentation/Observation (Phase 1)
- Generation (Phase 2)
- Prediction (Phase 3)
- Observation (Phase 4)
- Evaluation (Phase 5)

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The Empirical Cycle

- *Experimentation/Observation* (Phase 1)
  - "there is the taking in of unsolicited facts, things that come to be known by just looking around and observing the world or by 'toying' with experimental set-ups in a laboratory, out of curiosity, or things observed accidentally while doing experiments aimed at other matters."

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Empirical Cycle

- *Generation* (Phase 2)
  - "This first observational phase is followed by a reasoning phase: laws, theories, mechanisms are proposed that would account for the observed facts, unify them in some respect or explain them."
  - What form of reasoning is going on here? Deductive or inductive?

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Empirical Cycle

- *Prediction* (Phase 3)
  - "Next, there comes another reasoning phase: once the laws, theories or mechanisms are articulated, consequences are derived from them, predictions concerning other facts that we must expect to obtain in particular circumstances if we are right about the theories and mechanism"
  - What form of reasoning *here?* Inductive or deductive?

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Empirical Cycle

- *Observation* (Phase 4)
  - “This… is followed by another phase of activity: this time a meticulous search for the circumstances in nature in which the predicted fact should be observable, or the careful construction of an experiment aimed at creating these circumstances in a laboratory, terminating in a record of what was actually observed.”
- Is there any *reasoning* going on in Phase 4?

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Empirical Cycle

- *Evaluation* (Phase 5)
  - "This second empirical phase is followed by another reasoning phase, a phase of evaluation: given our observations, and the extent to which they match or fail to match the predictions derived from the proposed law or theory, what is the status of the latter? Can we go on to consider itas satisfactory accounts of nature's ways, perhaps even as being true, or must we drop it?"

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Empirical Cycle

- Toy example:
  - I look around me, I notice that **all Fs** I've seen **are also Gs** (*experimentation/observation*).
  - From this, I develop the theory **'all Fs are Gs'** (*generation*)
  - Someone comes along, hears about my theory, and notices that my theory entails **the F that they know about must also be a G**. (*prediction*)
  - They go and check **whether their F is also a G** (*observation*)
  - They confirm that **the F is indeed a G**, and my theory isn't falsified (*evaluation*)

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Next week (final week)

- We’ll consider the question of whether or not we should believe our best scientific theories are *true* or not

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