Laws of nature

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Plan

1. The accidental and the nomological
   - A case study: Bode's Law
   - Counterfactual support as indicator of necessity
2. Humean vs. non-Humean analyses
   - A Humean approach: best-systems analysis
   - Non-Humean approaches: Primitivism

What is a law of nature?

Central question:

Laws do important explanatory work (cf. the module on explanation) and are important in scientific practice (at least in some sciences)—but just what is a law?

- A law of nature is a true statement of some uniformity in nature, and it often is a universal statement.
- It must be confirmed a posteriori (which is why mathematical statements are not laws of nature).
- But it should not be merely true by accident or by definition, but hold with some sort of necessity.
- Without defining it (yet), we will call this necessity 'nomic necessity'.

Examples of laws of nature

- Boyle's law for ideal gases
- Galileo's law of free fall
- Newton's law of gravitation and his three laws of motion
- (Law of) natural selection
- Mendel's laws of heredity
- Chargaff's rules
- Coulomb's law in electrostatics
- Laws of thermodynamics
- Law of conservation of energy in physics
- Laws of conservation of matter, of constant proportion, of multiple proportion in chemistry
- (perhaps) Hardy-Weinberg or Lotka-Volterra in population biology
- Kleiber's law of metabolic scaling and other allometric laws in biology
- Law of superposition and Walther's law in geology
- Law of supply and demand in economics
- Weber-Fechner laws in psychophysics

The accidental and the nomological

- We need to distinguish generalizations that are accidentally true from laws.
- examples of accidental truth: 'All students present in the room are right-handed', 'All fruits in the garden are apples'
- examples of law: 'All gases expand when heated under constant pressure', etc
- In scientific practice, however, it is not always so easy to recognise whether a statement is accidental or nomological.

Example

Too see this, let us consider the intriguing case of Bode's law...

Bode's Law

Johann Elert Bode (1747-1826)

This latter point seems in particular to follow from the astonishing relation which the known six planets observe in their distances from the Sun. Let the distance from the Sun to Saturn be taken as 100, then Mercury is separated by 4 such parts from the Sun. Venus is 4+3=7. The Earth 4+6=10. Mars 4+12=16. Now comes a gap in this so orderly progression. After Mars there follows a space of 4+24=28 parts, in which no planet has yet been seen. Can one believe that the Founder of the universe had left this space empty? Certainly not. From here we come to the distance of Jupiter by 4+48=52 parts, and finally to that of Saturn by 4+96=100 parts.

Johann Elert Bode (1772). *Anleitung zur Kenntniss des gestirnten Himmels*.

Bode's Law

Law ((Titius-) Bode)

"The law relates the semi-major axis a of each planet outward from the Sun in units such that the Earth's semi-major axis is equal to 10:

$$a = 4 + n$$

where $n = 0, 3, 6, 12, 24, 48...$ *with each value of* $n > 3$ *twice the previous value."*

(http://en.wikipedia.org/wiki/Titius-Bode_law, ***accessed 16 October 2013)***

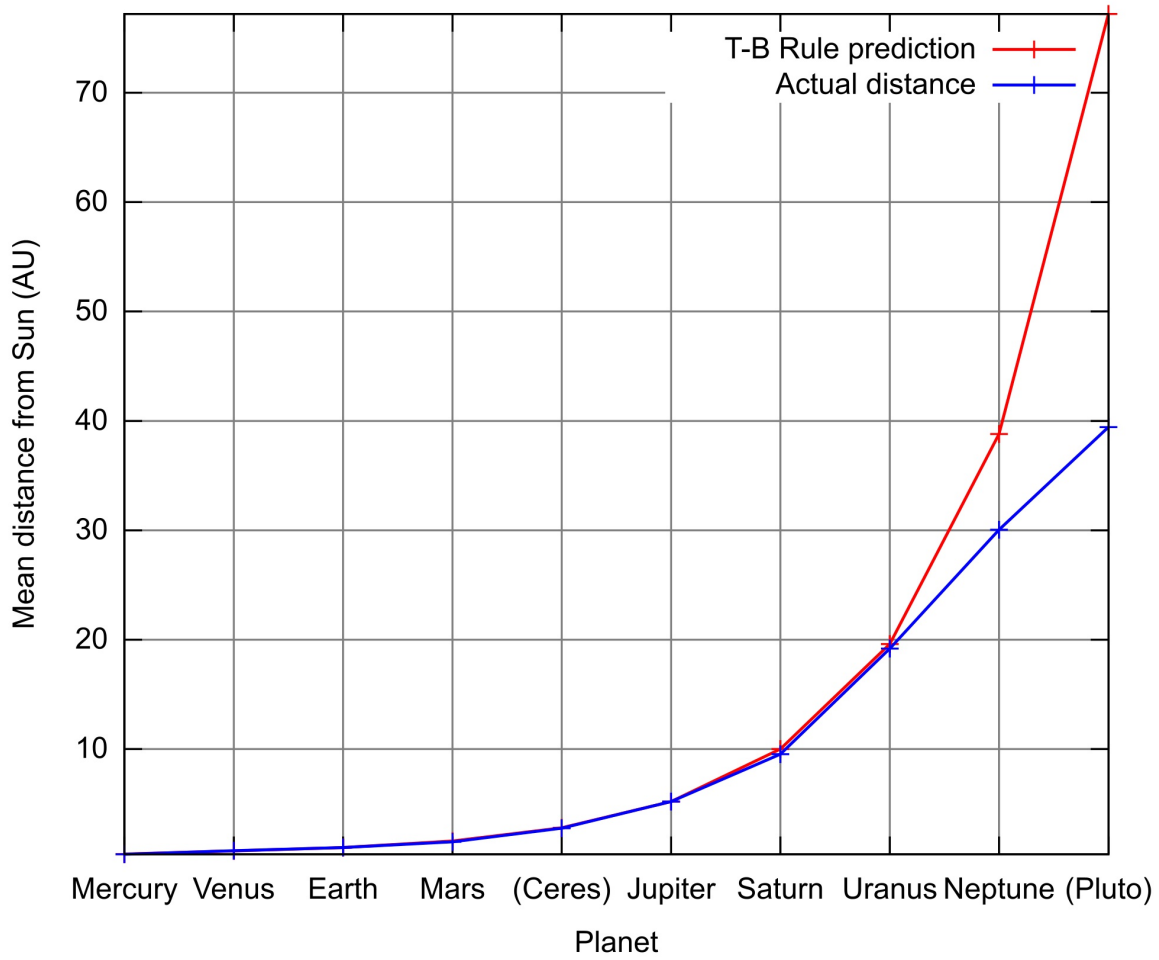
Bode's 'Law'?

- You might be inclined to dismiss this as pure coincidence...
- ... but then...
  - William Herschel discovered Uranus in 1781—at about a distance from the sun by $4 + 192 = 196$ parts!
  - And in 1801, Ceres is found at the location predicted by Bode, i.e., at $4 + 24 = 28$ parts

$\Rightarrow$ Triumph?

- Not quite...:
  - Neptune is discovered in 1846 at a location far off from where Bode's Law predicted (where, however, Pluto in found in 1930!).
  - And many objects other than Ceres are found in the Asteroid Belt, disrobing Ceres from status as planet.

Distances of planets in the Solar System



from Wikipedia at `http://en.wikipedia.org/wiki/Titius-Bode_law`

Nomic necessity as the mark of laws?

- Is the difference that accidental truths are about specific places (in this room, in the garden, in our solar system)?
- As we will see in two slides, this cannot be the difference, since there are universally true accidental generalizations without any such spatial (or temporal) restrictions. (And there are laws with such restrictions.)
- The difference is that laws (but not accidental statements) seem to have some sort of 'necessity', what we dubbed nomic necessity.
- Bode's 'law' does not have this necessity, so is not really a law. And: it is not even true!

Counterfactual support as a symptom of the necessity of laws

- Hempel: 'counterfactual support' is diagnostic of lawhood, but philosophically hard to capture
- second pass: a law is a true, exceptionless generalization describing a regularity in nature PLUS some additional, yet unspecified conditions, which capture this necessity and explain counterfactual support

Counterfactual support

Alex Rosenberg (2012). Why laws explain. In his *Philosophy of Science: A Contemporary Introduction*, Routledge: New York and London, 61-79.

Compare:

1. "All solid spherical masses of pure plutonium weigh less than 100,000 kilograms."
2. "All solid spherical masses of pure gold weigh less than 100,000 kilograms." (Rosenberg 2012, 63)

- Both statements seem true, but for very different reasons: their explanations both require laws, but only for (2), we must also include boundary or initial conditions, i.e., particular circumstances.
- In other words, only (1) would be true if counterfactual conditions obtained.

Counterfactuals

Definition (Counterfactual)

A counterfactual is a statement expressing what has not happened or is not the case—it is 'contrary to the facts'. Counterfactuals are often given in the form of conditional statements called counterfactual conditionals.

Example

If kangaroos had no tails, they would topple over.

- For a law to have 'counterfactual support' means that it reaches beyond what happens to be the case, i.e., it covers not just what is actual, but also what is possible or impossible.

Example

To return to the example on the previous slide, (1) has counterfactual support because it is impossible for there to be a large sphere of plutonium even if the actual facts in the universe had been different. But (2) does not have such support—there simply could have been more gold in the universe than there actually is.

Conditionals: 'If p, then q.'

Terminology

If ANTECEDENT, then CONSEQUENT.

Definition (Types of conditionals)

A counterfactual conditional is a conditional of which the antecedent is not true, expressing (in the subjunctive tense) what would be the case, if something were the case that is not. Their general form is 'if p had been the case, then q would have been the case'. An indicative conditional is a conditional of which the antecedent may or may not be true, expressing what is in fact the case, if its antecedent is in fact true. Their general form is 'if p was/is/will be the case, then q was/is/will be the case'.

On the difference between indicative and counterfactual conditionals

You can accept 'If Oswald didn't kill Kennedy, someone else did' as true, while rejecting 'If Oswald hadn't killed Kennedy, someone else would have' as false.

Adams, E. W. (1970). Subjunctive and indicative conditionals. *Foundations of Language* 6: 89-94.

A litmus test for lawhood: counterfactual support

Consider the following two counterfactuals, of which both antecedents (and both consequents) are false:

Compare

1. "If it were the case that the Moon is made of pure plutonium, it would be the case that it weighs less than 100,000 kilos." (Rosenberg 2012, 63)
2. "If it were the case that the Moon is made of pure gold, it would be the case that it weighs less than 100,000 kilos." (ibid., 64)

- The first counterfactual seems clearly true, while the second seems false.
- The first is supported by a universal truth about plutonium, but the second isn't supported by a universal truth about gold.
- But what underwrites this difference?
- Counterfactual support is indicative of lawhood—but this doesn't explain difference yet!
- The difference is to be found in nomic necessity (not in logical necessity!).

The causal connection—but not all laws are causal

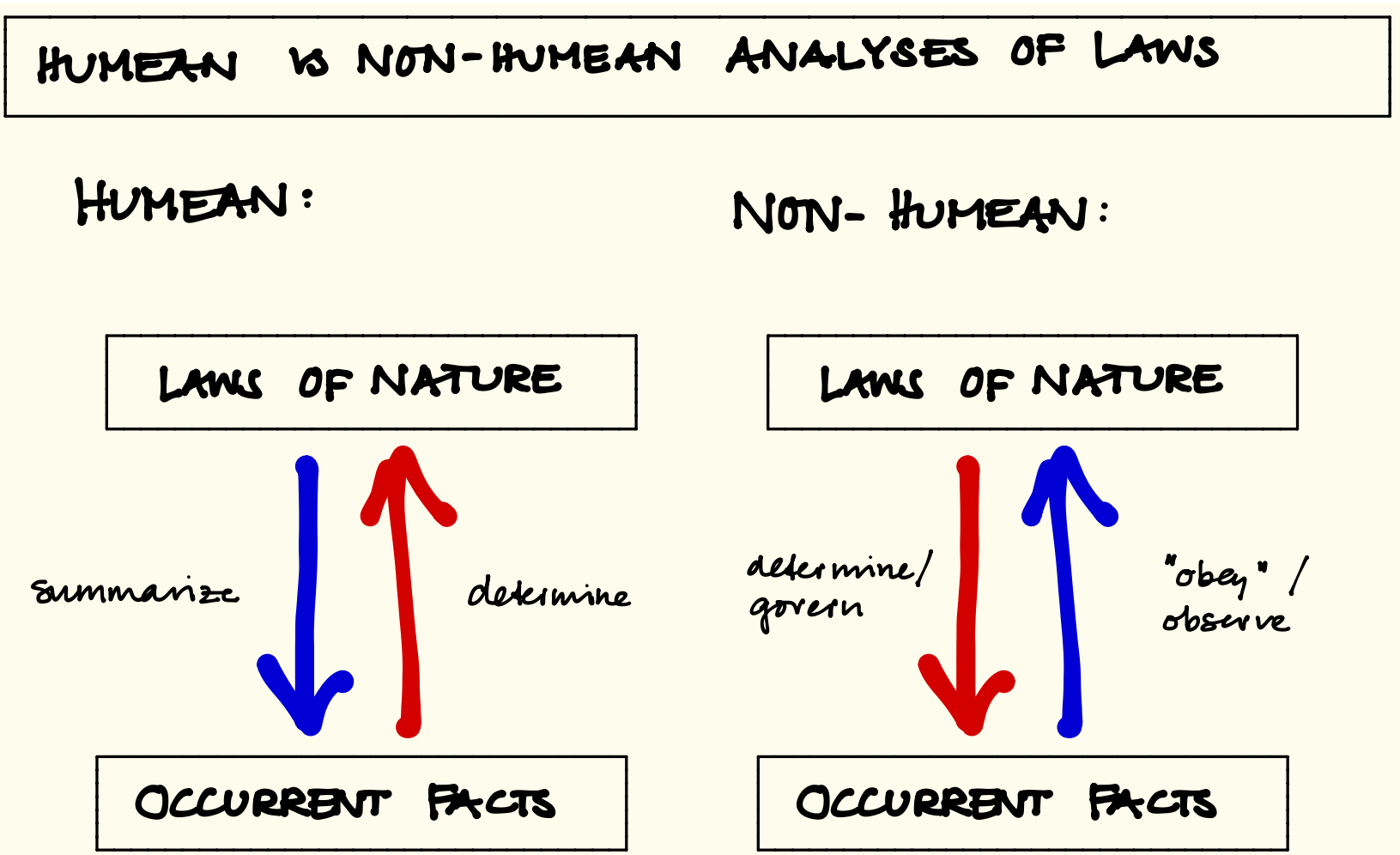
- Nomic necessity seems to be closely tied to causal connection we noticed before and which the logical positivists tried to avoid—it's metaphysics!
- But if it is something like this necessity which is responsible for the difference between explanatory laws and merely accidental generalizations, metaphysics cannot be avoided!
- However, not all laws are causal: e.g., laws describing radioactive decay capture statistical regularities ('After 2.6 years, half the nuclei of a sample of ^{22}Na have decayed'), but do not connect events by causality.

Two philosophical approaches to nomic necessity

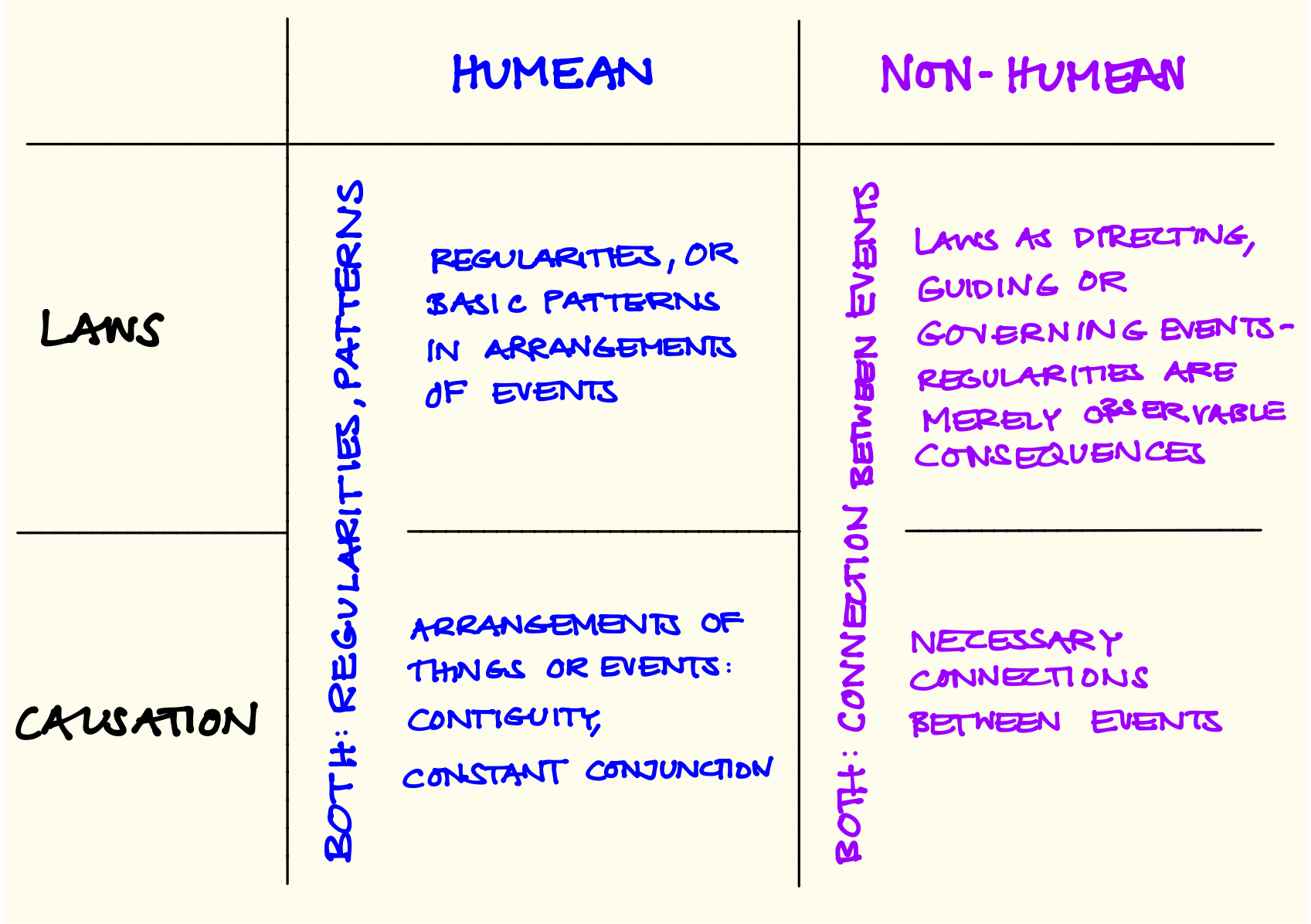
There are two basic connection in philosophy to analyse nomic necessity:

1. The governing conception ('non-Humean' approach):
   - Laws govern, produce, or determine events, they enforce the regularities they capture.
   - Laws are not reducible to events or patterns in the world; instead, they are fundamental.
   - Laws explain what happens.
   - examples: universalism, primitivism, dispositionalism
2. The Humean conception or approach:
   - Laws are descriptions or summaries of regularities or patterns in the world, which determine the laws.
   - Laws are not fundamental, but are reducible to events or patterns in the world.
   - What happens explains the laws.
   - example: best-systems analysis

Humean vs. non-Humean analyses



Humean vs. non-Humean analyses



Humean vs. non-Humean analyses

THE ROUGH GUIDE TO LAWS OF NATURE

HUMEAN (no 'necessary connections')

BEST SYSTEMS ANALYSIS

WHAT THERE IS:

MOSAIC OF LOCAL MATTERS OF PARTICULAR FACTS

(eg. distribution of point-particles in spacetime)

LAWS are AXIOMS or THEOREMS OF 'BEST' DESCRIPTION OF MOSAIC, i.e. BEST BALANCE BETWEEN SIMPLICITY AND STRENGTH.

NON-HUMEAN ('governing conception')

PRIMITIVISM

WHAT THERE IS:

LOCAL MATTERS OF FACTS (eg. initial configurations of particles in spacetime) + LAWS

LAWS are IRREDUCIBLE, PRIMITIVE POSITS.

DISPOSITIONALISM

WHAT THERE IS:

LOCAL MATTERS OF FACTS (eg. initial configurations of particles in spacetime) + DISPOSITIONS

LAWS derive from DISPOSITIONS WHICH INHERE IN OBJECTS.

in both cases: PRIMITIVE MODALITY

A Humean approach: best-systems analysis of laws

Position (Best-systems analysis)

A universal proposition is a law if and only if it is an axiom or a theorem in that true deductive system that best combines simplicity (e.g., least number of axioms) and strength (e.g., most informational content) (or, in the case of a tie, which is an axiom or a theorem in all 'best' systems).

- John S Mill, Frank Ramsey, David Lewis, John Earman
- metaphysically lean, Humean: doesn't require undetectable 'necessary connections'
- reduces nomic necessity to logical necessity
- allows for a link to counterfactuals: what we take to be true counterfactuals is given by our best theories
- gives a principled distinction between nomic and accidental generalizations:

The distinction between nomic and accidental according to the Humean:

If a universal proposition is an axiom or a theorem of a best system, then it is a law. If it is not, then it is an accidental generalization.

Problems

1. Main problem: What is simple? What is strength? These seem to be language-dependent, perhaps subjective criteria.
2. Generally, there will not be a shared maximum for both criteria $\Rightarrow$ needs balance between them. But how do we balance them?

Primitivism

Position (Primitivism)

Primitivism holds that (fundamental physical) laws of nature are ontological primitives, part and parcel of the fundamental ontology of the world. Thus, laws are irreducible, primitive posits.

Definition (Primitive notion)

A primitive notion is a concept that is not defined in terms of previously defined concepts and so cannot be reduced to something more fundamental, basic, or primary.

- Tim Maudlin, (related constraint approach: Emily Adlam, Eddy Chen)
- According to primitivism, what there is are local matters of fact (e.g. initial configurations of particles in spacetime) plus laws.
- metaphysically thicker: involves some form of 'production'
- allows for a link to counterfactuals: what we take to be true counterfactuals is given by the primitive laws
- gives a principled distinction between nomic and accidental generalizations:

The distinction between nomic and accidental according to the primitivist:

If a universal proposition is among the primitively given laws, then it is a law. If it is not, then it is an accidental generalization.

Problems

1. Identification problem: what is this mysterious, unanalysable 'lawhood'; how can it be detected or recognised?
2. Tyler Hildebrand (2013): wholly primitive laws cannot explain the uniformities in nature because "the primitive status of the law provides no reason to think that [a law] must describe (or otherwise give rise to) a natural regularity" (1)

Tyler Hildebrand. Can primitive laws explain?. *Philosophers' Imprint* 13 (2013): 15.

No laws: Nancy Cartwright

- Strictly speaking, there are no laws.
- We use laws to explain, approximately and in a simplified way, the behaviour of a thing to some approximation that results from its myriad dispositions, but ignores most of them.
- Objects have dispositions, i.e., properties that the object does not presently manifest, but which it would manifest in appropriate circumstances.
- Dispositions support counterfactuals.
- 'Nomic necessity' derives from the necessary connections between a disposition and its manifestation.