5 Laws of nature

5.1 Laws that govern: a modern notion

The idea that laws **govern** nature is relatively modern and still widely held.

- It does not appear in ancient Greek, Roman or Far Eastern thought, but likely arose in the medieval world with the interaction of various religious, philosophical and legal ideas.

For essentialists, however, laws do *not* **govern** (they are not prescriptive) but merely **describe** how things must behave given their essential natures.

- An analysis of natural kinds, then, is fundamental to any analysis of laws.

5.2 The hierarchies of natural kinds

There are three sorts of natural kinds. Each is hierarchically ordered:

i. Natural kinds of **objects** and **substances**.

- Eg. all chemical compounds → all halides → all chlorides → common salt.

ii. Natural kinds of **events** or **processes**.

- **Causal interactions** are discontinuous and instantaneous, distinguishable at various levels of generality (eg. chemical reactions).
- **Energy transfer processes** are continuous and temporally extended[4].

iii. Natural kinds of **properties** and **structures** (facts about the intrinsic natures of things).

- **Dispositional properties** that include causal powers.
- Eg. being an inertial force → having a mass → having a mass of 2 grams .
- **Categorical properties** that include the various ways in which things can be structured.
- Eg. being spherical → being a sphere of radius 5mm.

There are consequently laws of nature specific to each of these categories, which are also hierarchically ordered.

5.3 The hierarchies of laws of nature.

At the most general level, we might speak then of 'world-objects', 'world-processes' and 'world-properties'.

The corresponding laws are those we recognise as global.

- Eg. the conservation laws.

Corresponding to the category of **objects**:

- Eg. matter-anti-matter symmetry principle: every kind of material particle has an anti-material counterpart.

Corresponding to the category of **events** and **processes**:

- Includes all the causal and statistical laws of nature concerning the actions or interactions of things: laws of particle interaction, laws of electromagnetic radiation, …

[4] They are also limited by speed of light, initiated and terminated by causal interactions, inertial, conservative and 'quantum-mechanically indeterminate'.

In the category of **properties**:

- For each **dispositional property**, there is a definite function: a mapping from its *magnitude*, and the quantified properties of its triggering circumstances, to the properties of the display.
- For **structural properties**, eg. the laws of general relativity.
- Many laws appear to belong to both subcategories: eg. general relativity describes both structure and the causal powers of space-time.

5.4 Desiderata for a theory of laws

It is generally agreed that laws of natural should

i. be fundamentally **universal** in form (eg. "All things of class A are things of class B").

ii. have classes of reference **extending beyond known cases** – not limited spatially or temporally.

- They should provide a basis for making predictions beyond what is known.

iii. support **counterfactuals**.

- They must be able to support hypothetical reasoning.
- They must have some kind of necessity (the '**necessity problem'**).

An adequate theory of laws should address these features. In addition, it should address their

iv. abstract or idealised nature

- Few laws apply directly to anything regularly observable in the world. 'Our laws are… a kind of compromise between truth and intelligibility' ('the **idealisation problem'**).
- 'Typically, the emphasis in science is not on forecasting, but on understanding'.

v. objectivity and discoverability.

- What is their ontological foundation ('the **ontological problem'**)?

vi. hierarchical nature.

- There are different hierarchical categories of laws ('the **structural problem'**).

Ellis finds the conventional accounts of laws unsatisfactory:

- Humeanism does not answer the necessity or idealisation problems.
- Conventionalism do not offer a satisfactory ontology of laws.
- Natural necessitation theories appear contrived.

5.5 Comparing accounts of the laws of nature

- **The regularity theory** (Humeanism)

Laws of nature are causal laws; causal laws are regularities of some kind. Logically, the events are 'loose and separate'.

i. The **necessity problem**: Hume can only say that we *perceive* them to be necessary. The production or necessitation of an effect is illusory.

ii. The **idealisation problem**: what can a Humean say about an idealisation like the universal thermodynamic generalisation concerning the efficiency of a perfectly reversible heat engine viz a vis an irreversible engine working between the same temperature limits?

We cannot perfect a perfect heat engine (not even close to perfect). What is the status of this law? Some Humeans offer an 'approximation defense': such laws are really approximations in place of the true laws – a compromise between accuracy and comprehensibility.

However, this does not seem to capture the real motivation:

a. Ideal laws in science often remain the fundamental ones even when more realistic laws are known. Eg. the perfect gas laws viz a vis Van der Waals equation of state. The latter is a less interesting modification.
b. Some of the most fundamental laws of nature are abstract. Conservations laws apply to idealised systems, but it is implausible to refer to them approximations or compromises. How can they apply locally when none of the open and interactive systems we find in nature obey them?

- **Conventionalist theories of laws**

The laws are conventions adopted for their utility in organising and systematising experience.

- They have a status similar to that of a geometrical theorem.

Their necessity can be accounted for: the laws are true by definition or convention. Their abstract and ideal nature can also be explained: they have a status similar to geometric theorems.

However, conventionalism is ontologically weak: realism must be rejected in all areas, including chemistry where the case is stronger. Also, no satisfactory account can be given of why some conventions are much better than others.

- 'Viable alternatives that do not piggy-back on existing theories are hard to find'.

- **Natural necessitation theories.**

The laws of nature are true in virtue of some real relation of necessitation.

The primary difficulty with this theory is that it seems contrived: an ad hoc combination of an Aristotelian theory of natural necessitation with a Humean contingency thesis about laws.

- **Essentialism.**

The laws of nature 'spell out' the essential properties of natural kinds.

This explains the varieties and hierarchies of laws of nature and their necessity. It enables an account of their abstractness and ideal quality, since abstraction is necessary to get at the essential and intrinsic properties. It offers an ontology in virtue of which a law can be true.

For many, however, the claim that all the laws are necessary may seem too strong.

6 Natural necessity

6.1 Causal necessity

Hume argues that there are no necessary connections, just regularities:

i. when we reflect on our experience, all we observe is one thing following another; two events *conjoined*, but never *connected*.
ii. The idea of a necessary connection is without foundation in experience.
iii. It can only be *repetition* that illicitly gives rise to the idea of necessity.

However, *Hume's account assumes that we are only passive observers*. Restricting our domain of experience to passive observation, of course, 'all events seem loose and separate'.

But as active participants, events no longer seem so; we are constantly *causing* things to happen, and being affected by things. These are the primary experiences from which our ideas of cause and effect derive. A passive stance, on the other hand, is clearly a sophisticated abstraction, from which these ideas have been removed.

'The world is not just the object of our contemplation. The world is what we have to wrestle with.'

6.2 Kant and modern philosophy on a priori and empirical knowledge

- **The synthetic a priori**

For Kant, any proposition that is necessary or strictly universal is *a priori*. However, Kant also argued that some *a priori* propositions could be *synthetic*[5].

Empiricist philosophers of the 19th/20th centuries denied there were any such propositions.

- Frege was able to show that Kant's examples of arithmetical and geometrical truths are analytical *a priori* truths, and *not* synthetic *a priori* truths.
- The discovery of the non-Euclidean geometry of space-time also poses a problem to some of Kant's examples.

- **The standard position**

For most modern philosophers, and for many today:

i. If a proposition is *a posteriori* then it is not necessary.
ii. If a proposition is necessary, then it is *a priori*.

- **The necessary a posteriori**

Essentialists reject Kantianism. They reject the link between necessity and a priority in the standard position. They hold that the laws of nature are both *necessary* and *a posteriori*.

- They are metaphysically necessary, because they are grounded in the real natures of things, not language.
- They are *a posteriori*, because they have to be discovered by the sciences.

[5] A proposition whose predicate concept is not contained in its subject concept. Synthetic propositions are true, not by virtue of their meaning, but by how their meaning relates to the world.

Eg. that water is H_2O is something that had to be discovered; however, the fact that it is so is something that exists independently of our knowledge or language. It is true in virtue of its essential properties.

For the essentialist, all of the laws of nature are necessary *de re*; they are not true in virtue of what things are *called*, but in virtue of what they *are*.

This category of necessity has been called **metaphysical necessity**, though it could be called ***de re* necessity**. For the *scientific* essentialist, it might be called **physical necessity** or **natural necessity**.

- True in all possible worlds in which the relevant things exist.

6.3 Real and imagined possibilities

Hume argues against the necessary character of causal connections. His argument take the form:

i. If an alleged causal connection between a cause and its effect were *necessary*, then it would have to be logically impossible for the cause not to occur.
ii. However, the contrary of any causal law is always conceivable (*imaginable*).
iii. Therefore, it is always logically possible that the cause should occur without its effect.
iv. Therefore, the causal connection between the cause and its effect is *not* necessary.

The argument is widely accepted, but unsound: the *imaginable* is not the same as the *possible*.

- A thing's behavioural possibilities is restricted by its nature, not our imaginative abilities.

The reliance on imagination as a test for possibility depends on the assumption that a thing's possibilities depend only on its **manifest image**.

- It represents (to the essentialist) a failure to preserve in mind the distinction between what a thing is, and what it looks like.

It is **epistemically possible** that we think y is an x, when it is not an x, and therefore epistemically possible that y could behave in ways that an x could not possibility behave.

Conclusion: the imaginability test confuses what is *metaphysically* possible (what is possible, given what is the case) with what is only *epistemically* possible (what it is possible for us to know).

6.4 Defining the limits of the possible

For (NE), one of the primary aims of science is to 'define the limits of the possible'.

Generally in the philosophy of science, however, the sciences are perceived to be discovering what is true in general about the world.

- **Humean supervenience thesis**

For Humeans, laws of nature are just universal generalisations, and moral properties must supervene on non-modal properties.

This **Humean supervenience thesis** implies that any modalities/modal properties occurring in scientific discourse must, in principle, be *eliminable*. The primary goal of science should be to describe reality as it is (in terms of regularities and patterns).

However, this position is problematic:

i. Some laws of nature are *explicitly* modal.

- eg. the 2nd law of thermodynamics: an 'impossibility principle' which cannot be rewritten as the empirical generalisation that there are no perpetual motion machines.
- Eg. Pauli's exclusion principle.

ii. Other laws are *implicitly* moral: they do not merely report generalisations, but how things must happen.

- This is evidenced by their restriction to ideal circumstances and ceterius paribus clauses.

Conclusion: science needs a language with modalities. An extensional language that can only describe what does happen is clearly *not* adequate for science.

Though many Humeans now concede this point, they continue to believe that there must be a non-modal language fit for describing the world simply in terms of what exists.

- There can be no modal properties in nature.
- No potentialities.
- The modal must supervene on non-modal (categorical) properties.

The problem of explaining necessities in this schema prompts such speculations as modal realism (evaluating possibility and necessity in terms of an infinite ensemble of real 'possible worlds').

For essentialists, however, possible world semantics may be useful, but is without ontological significance. The actual world has 'in-built natural necessities'.

6.5 The world as one of a kind

See discussion pp. 118-120.

6.6 Is metaphysical necessity too strong?

It may seem presumptuous to claim that what we know about the natural world is necessarily true.

Such claims can be put in the form of a conditional: if it is true, it is necessarily true, 'because what is true of most kinds of objects and events in this world must be true of the most general kinds of objects and events in all worlds of the same natural kind as ours'.

Ellis writes:

> 'Of course, it is epistemically possible that the world is a very different kind of world from the kind we think it is. There might well be, for all we know, all sorts of monsters lurking in the dark… which violate these laws, in which case we may have to conclude that the world is truly, and perhaps necessarily, very different from the way we think it is.
>
> But epistemic possibility is not real possibility, and ignorance is not a source of knowledge. If you want to know what kind of world we actually live in, and therefore what is true of all worlds of the same natural kind as ours, you have to rely on the best theories available to you…'