Thinking about Natural Science

An introduction to philosophy for scientists Lecture IV

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10.03.2025

- I) [3 Feb. 2025] Introduction and quick historical background
- II) [10 Feb. 2025] Modern science and philosophical difficulties...
- III) [17 Feb. 2025] (Neo)Positivism, Popper and post-popperian debate
- IV) [10 Mar. 2025] Case study: Laws of Physics, Reality, hints of the Truth
- V) [24 Mar. 2025] ...
- VI) [31 Mar. 2025] Guest lecture.

Overview of today

- 1. Laws of Nature
- 2. Regularity and Necessitarian
- 3. Truth and Laws
- 4. Open discussions
- 5. References

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Progress through revolutions

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Advances in science confirmation of bold conjectures

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 \Rightarrow Laws of Nature



Laws of Nature

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- Now ontological/metaphysical questions:

what kinds of entities are assumed or shown to exist in the world by modern science?

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Natural Laws \Rightarrow legal or ethical theories Scientific Laws \Rightarrow scientists' attempts to state or approximate the Laws of Nature

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Metaphysical question

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The word *Laws* not particularly appropriate: we can choose to follow a law (we have the 'freedom' not to follow the law) ... an electron can't decide not to bear a charge of -1.6×10^{-19} Coulombs

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God makes matter behave in accordance with the laws He has ordained

The Laws of Nature



In 1959 *M. Scriven* (1928 - 2023) at the American Association for the Advancement of Sciences:

Laws of Science (*physical laws*) are inaccurate, best approximations of the *truth*, and are of limited range of application

N. Cartwright (b. 1944)

Stanford School, emphasis on scientific practice as opposed to abstract scientific theories

- how actual science achieves the successes it does

- what sort of metaphysical and epistemological presuppositions are needed to understand that success

Scientific laws are inaccurate

Scientific laws are inaccurate

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Other laws

more complex ACCURATE literally true

Scientific laws are inaccurate





If scientific laws are assumed to apply outside, as well as inside, of experimental situations then laws cannot be identified with the regularities that are achievable in experimental situations

Contemporary Aristotelian view



Nature is active

The Laws describing those *powers* and *capacities*, identified in experimental situations can be presumed to apply outside of those situations too

W. Simpson, E. Klein

A wide range of laws within physics can be understood as causal laws

There are fundamental laws in physics that cannot be construed as causal laws

David Hume (1711 – 1776) and a brief clarification

Historically (until beginnig of XXI century) the Humean account of Laws of Nature Dismissed the standard accounts of causality \rightarrow our conceptions of cause-effect relations are grounded in habits of thinking

Hume \rightarrow a *Necessitarian* – Laws of Nature are in some sense *necessary* (although of course not logically necessary)

Hume's skepticism was epistemological





Regularity Theory and Necessitarian Theory

Denies that Laws of Nature are *physically necessary*

 \Rightarrow No physical necessity, either in laws or in nature itself

- No intermediate state between logical necessity on the one hand and sheer contingency on the other

F Ramsey (1903–1930), A.J. Ayer (1910–1989), D. Lewis (1941–2001), J. Earman (b. 1942)

Physical (or as they sometimes call it nomic or nomological) necessity

- a. Physical necessity is a property of the Laws of Nature electrons \rightarrow electrical charge of -1.6×10^{-19} Coulombs because there is a Law of Nature, and the universe conforms to, or is *governed* by, this physically necessary (*nomological*) principle
- b. Physical necessity inheres in the very stuff and structure of the universe It is of the very *nature* of an electron, by necessity, to have this particular electrical charge;

 \Rightarrow 'All electrons bear a charge of -1.6×10^{-19} Coulombs' is a Law of Nature because it correctly (veridically) describes a physical necessity in the universe

D. Armstrong (1926–2014), S. Kripke (b. 1940), S. Shoemaker (1931–2022), S. Mumford (b. 1965)

The Law of Nature conditions

Five conditions necessary for a statement's being a Law of Nature

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- 1. Factual truths, not logical ones
- 2. True for every time and every place in the universe
- 3. Without proper names
- 4. Universal or statistical claims
- 5. Conditional claims, not categorical ones

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Necessitarians \rightarrow a sixth condition: *natural* (physical/nomic/nomological) necessity

Necessitarian Theory

Accidental Truths

Moas have been extinct for more than a century. One was the oldest moa ever to have lived. It died at the age of n years

- \Rightarrow 'No moa lives beyond the age of *n* years' is true
- This statement satisfies all the other necessary conditions specified above

K. R. Popper, *The Logic of Scientific Discovery*, Appendix X

Necessitarians \rightarrow 'No moa lives beyond the age of *n* years' is NOT a Law of Nature

Different value than 'No object having mass is accelerated beyond the speed of light' or 'No perpetual motion machine of the first kind exists' His death was an accident not mandated by a law of nature \rightarrow a mere accidental truth

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Laws of Nature *forbid* certain things to happen

accidental truths do not

'Some silver burns at -22^o Celsius' and 'There is a river of cola' logically equivalent, satisfying all of the five conditions

- Physically impossible \Rightarrow logically inconsistent with a Law of Nature False existential statement ('Some S is P') \Rightarrow not just false, but physically impossible

'There is a river of cola' (false) but NOT physically impossible There *could* be such a river

Not to be regarded as physically impossible

 \Rightarrow further conditions must be added to the set of necessary conditions for lawfulness


Earth the only planet to have supported intelligent life. All life on Earth perished in 1900, when the planet is struck by a meteor

 \Rightarrow Wright Brothers would never have flown their plane in 1903

A long history of failures to produce a motorised flying machine heavier than air But their failure was merely *failure*; these projects were NOT doomed

Necessitarians \rightarrow not all projects that fail are doomed \Rightarrow Massy object beyond the speed of light, or to build a perpetual motion machine of the first kind

Distinction between doom and failure

Regularity Theory

Metaphysical questions

- Until modern science no one suspected the sweep of this order

 \rightarrow Order 'revealed' by physics, chemistry, biology... sociology, psychology... logic

- Questions:

Why is there anything, rather than nothing?

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Why is the world orderly, rather than chaotic?

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\Downarrow

Why is the world orderly, rather than chaotic?

- Until XVIII Century \Rightarrow hand of God

Human beings 'free' to break God's moral laws

Neither humans nor the other parts of creation are free to break God's physical laws

- XX Century \Rightarrow abandoned theistic elements

However, say the Regularists, the Necessitarians have merely replaced God with Physical Necessity

Regularists

Necessitarians: older prescriptivist view of Laws of Nature \rightarrow the Laws of Nature *govern* the world

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 \rightarrow Newspaper model: Laws merely summarise the history of physical objects



Newspaper Model: metaphysical thinness

The newspaper model, however, faces its own problem. Since there is no causal relation binding objects in the world, there is no reason why billiard ball B ought to move when being hit by billiard ball A. [...] Anything goes. If that were the case, the laws of nature would constantly change because they describe changing facts in the world. And still, billiard ball B always behaves the same way, and the laws remain the same too. How does that happen?

M. Hubert, The nature of natural laws, p.6

Principle of the uniformity of nature

A primitive unexplained fact within the newspaper model that the world always behaves the same way

Newton's laws remain as they were when written down by Newton regardless if they *produce* the future or they *describe* the world \Rightarrow You cannot see from the formulation of the law what the metaphysical underpinning is Newton's laws remain as they were when written down by Newton regardless if they *produce* the future or they *describe* the world \Rightarrow You cannot see from the formulation of the law what the metaphysical underpinning is

But we have more information: Newton's laws tell us that the future state of the world can be calculated and deduced from the present How can the newspaper model support a formulation of a law that looks 'force' the future to be in certain way?

 \Rightarrow Newton's laws are the most efficient description of the world (within the domain of Newtonian physics), balancing simplicity and informativeness

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For Regularists

no distinction between accidental generalizations and 'genuine' Laws of Nature

If limitless number of Laws of Nature, every false existential statement turns out to be physically impossible and the distinction between failure and doom is obliterated

Different meanings in the two theories:

- Common meaning: 'physically impossible' is inconsistent with a Law of Nature what is physically impossible never, ever, occurs
- A. For Necessitarians: simply could not occur or exist \Rightarrow a *modal* element, entirely lacking in the Regularists' theory
- B. For Regularists: simply that there is no such a phenomena (as a river of cola)
 ⇒ no nomic dimension to the claim
 No modal claim that there could not be such a event, but simply the factual (non-modal) claim that there is no such event

Physical impossibility only a special case of the concept of timeless falsity

M. Hubert (b. 1980)

Laws may be primitive they 'merely' constrain the physical possibilities in the world

Advantages of the *Newspaper/Regularists Model* with the ones of the *Layer-cake/Necessitarians Model*:

 \rightarrow generality of the former and a reason for stable behaviour from the latter

However does not specify how laws can constrain what happens in the world

Truth and Laws

'God' commanded the world to be certain ways

 \rightarrow it was God's will that all electrons should have a charge of -1.6×10^{-19} Coulombs

Strange (and unempirical) that science ultimately rests on an unintelligible power of a/the deity

In XX Century \rightarrow Physical necessity has assumed God's role; God does not 'drive' the universe, physical laws do But how? Beyond the ability of science to uncover

 \Rightarrow It is the transmuted remnant of a supernatural theory, one which science, emphatically, does not need

Tarski's (1901 – 1983) theory of truth (the semantic theory of truth, correspondence theory of truth)

Truth-making Relation II

Statements (or propositions) are true if they describe the world the way it is, and they are false otherwise

Truth flows to propositions from the way the world is

Do not impose their truth on the world

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- XVIII Century empiricists: experience \rightarrow provides at best only data about how the world is, not how it must be

- XX Century empiricists: more concerned with the justification of our concepts than with their origins

von Wright and others \rightarrow thought experiments no more than a pervasive regularity in nature; none could demonstrate that regularity flowed from an underlying necessity



If two kinds of money in circulation have the same denominational value but different intrinsic values, the money with higher intrinsic value will be hoarded and eventually driven out of circulation by the money with lesser intrinsic value 'bad money drives out good'

People do not hoard gold under such circumstances because Gresham's (1519–1579) Law forces them to do so

The 'Law' is purely descriptive (not prescriptive)

Problematic conception of truth

Necessitarianism tacitly adopts an anti-semantic theory of truth

Statistical Laws



The half-life of radium is 1,600 years (*in any sample of radium, 50% of the radium atoms will radioactively decay within a period of 1,600 years*)

Can the underlying, the real Laws of Nature itself be statistical?

- A. Regularists take the prospect (the existence) of statistical Laws of Nature in stride as deterministic laws are descriptions of the world, not prescriptions or disguised prescriptions, so too are statistical laws
- A. Necessitarians have severe problems in accommodating the notion of statistical Laws of Nature

Could there be such a thing as stochastic nomicity?

Popper's approach: each radium atom, for example, would have its "own" (?) 50% propensity to decay within the next 1,600 years

Debate about the very concepts we need to 'make sense' of the universe

- A. Regularists \rightarrow the way-the-world-is is the rock bottom of their intellectual reconstruction
 - The supposed explanatory advantage of Necessitarianism is illusory
- B. Necessitarians \rightarrow there has to be some reason, some explanation, why the world is as it is and is not some other way
 - A cosmic coincidence of an unimaginable improbability \Rightarrow NO, this is no coincidence
 - The laws of physics which, were true from time immemorial

Open discussions

Regularities in our world

The metaphysically interesting aspect of the Laws of Nature is not that they constrain physical possibilities

but how they do that?



Many questions (maybe unsolvable?)

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Open and ongoing discussion... can be vital for science!

- A. Chalmers, What is this thing called science?, Univ. of Queensland Press, 1976.
- P. Shaver, The Rise of Science, Springer, 2018.
- M. Hubert, The nature of natural laws, on Aeon magazine, 14 November 2024.
- N. Swartz, *Laws of Nature*, The Internet Encyclopedia of Philosophy, https://iep.utm.edu/lawofnat/.

Backup

Recap

- Ancient Philosophy
 - \rightarrow Greek Philosophy: Plato, Aristotle
 - \rightarrow Medieval Philosophy: Thomas Aquinas
- New modern science
 - \rightarrow XVI XVIII century:

R. Descartes, I. Newton, G. Galilei and J. Locke, D. Hume, G. Berkeley

- \rightarrow XVIII century:
 - I. Kant
- $\rightarrow~$ XX century: Neopositivism
 - L. Wittgenstein, The Vienna Circle: M. Schlick, R. Carnap, O. Neurath, H. Hahn
- XX centuries philosophers
 - $\rightarrow\,$ K. R. Popper, T. Kuhn, I. Lakatos

Ethical aspect of the Law

Distinction between

- \rightarrow *nature* (physis, $\phi \acute{v} \sigma \iota \varsigma$)
- \rightarrow law, custom, or convention (nomos, $u \delta \mu o \varsigma$)

Stoicism: development from *natural justice* into *natural law* Existence of a rational and purposeful order to the universe (a divine or eternal law) God is everywhere and in everyone (*pantheism*)

The universe has been designed in a precise way \Rightarrow the natural laws help us to harmonize with this

The problem of causality

- 1. Newton's laws can be interpreted as causal laws respond to specified forces
 - Considering *forces*: objects to exert and respond to specified forces
 - Or *Hamiltonian and Lagrangian* formulations: potential and kinetic energy of a system
- \Rightarrow Without a detailed knowledge of the causal processes at work

Lagrange's equations do not state causal law

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2. Thermodynamic and conservation laws

- First Law: the energy of an isolated system is constant
- *Second Law*: the entropy of an isolated system cannot decrease (heat flows from hot to cold bodies and not the other way round)
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- 3. Quantum Mechanics and retrocausal models

In detail, the statement "There is a river of cola" is an existential affirmative statement (a classical so-called I-proposition). Its contradictory (or better, among its contradictories) is the statement "No river is constituted of cola" (a classical so-called E-proposition). Now, given that "There is a river of cola" is, ex hypothesi, timelessly false, then the universal negative proposition, "No river is constituted of cola", is timelessly true. But since the latter satisfies all five of the necessary conditions specified (above) for being a law of nature, it would turn out to be a law of nature

David Hume (1711 – 1776)

- Rejecting innate ideas \rightarrow all human knowledge derives solely from experience
- Inductive reasoning and belief in causality cannot be justified rationally
- We never actually perceive that one event causes another but only experience the constant conjunction of events

empiricism, philosophical scepticism and metaphysical naturalism Opponent of philosophical rationalists

A Treatise of Human Nature, 1739-40. Book 1: Of the Understanding

Baffled as to how the knowledge of the physical necessity could arise \rightarrow What, in experience, provided evidence of the existence of the property?

- J. Wright, T. Beauchamp, A. Rosenberg \Rightarrow Hume epistemological skepticism, however he persisted in his belief that laws of nature are (physical) necessities

- Laws of Nature are primitive entities

- Produce the future from the state of the present

 $Primitive \Rightarrow$ non-reducible to anything else They exist by themselves, but not as concrete objects

T. Maudlin, The Metaphysics Within Physics

How can laws influence any physical object in the world?

Along with his contemporary, Kurt Gödel, he changed the face of logic in the twentieth century, especially through his work on the concept of truth and the theory of models

A. B. Feferman and A. Feferman, Alfred Tarski: Life and Logic, p.1

Truth for formalized languages can be seen as a correspondence theory of truth

"p" is true if and only if p

"Snow is white" is true if and only if snow is white

- Semantic theory of truth: truth is a property of sentences
- Distinguish the language that one is talking about (the *object language*) from the language that one is using to do the talking (the *metalanguage*)

- For Regularists, Laws of Nature are (a subclass of the) true descriptions of the world Don't get to choose the laws that describe the charge on an electron, But you do get to choose a great many other laws

- Necessitarians' claim - that the laws of nature are not of our choosing

Regularists argue that a very great many Laws of Nature are of our choosing

It is not that laws of nature govern the world. We are not 'forced' to choose one action rather than another

 \rightarrow The other way round: we choose, and the laws of nature accommodate themselves to our choice