**Lecture 4:
The Laws of Nature – A Metaphysical Perspective**

Good afternoon, everyone. Thank you for attending today’s lecture and for your continued engagement in this course. This is our fourth session, and we will now transition from our previous historical and epistemological discussions to a more philosophical and metaphysical exploration of the laws of nature.

Today, we will examine the concept of the laws of nature, not from an empirical or experimental standpoint, but from a metaphysical perspective. This discussion will encompass the regularity and necessitarian approaches to understanding these laws. Additionally, we will briefly touch upon the relationship between truth and the laws of physics, and how scientific inquiry aims to approximate these fundamental principles.

**Recap and Conceptual Foundations**

Rather than conducting an extensive review of our last session, I want to clarify a few key theoretical concepts. Our previous discussion integrated perspectives from Popper, Lakatos, and Kuhn. As you may recall, Kuhn emphasized that scientific progress occurs through paradigm shifts rather than a linear accumulation of knowledge. This idea of incommensurability—where paradigms may not be directly comparable—highlights the evolving nature of scientific understanding.

Philosophers are sometimes perceived as being detached from empirical science, merely engaging in abstract thought. However, philosophy of science is deeply intertwined with experimental and observational challenges. Notably, the meaning of fundamental scientific concepts changes with paradigm shifts. Consider how the concept of mass evolved from Newtonian mechanics to Einsteinian relativity—these shifts necessitate philosophical scrutiny.

It is a common misconception that falsifying a theory necessarily advances science. While falsifiability remains a cornerstone of scientific methodology, not all falsifications lead to meaningful progress. Instead, scientific breakthroughs occur when bold conjectures are confirmed or refined, rather than when already established knowledge is merely reiterated.

This brings us to a fundamental question: What is the overarching goal of scientific research? The primary aim, in most cases, is to uncover the fundamental laws that govern nature. However, this goal leads us to a critical philosophical distinction—what exactly do we mean by ‘laws of nature’?

**The Epistemological vs. Ontological Approach**

In previous lectures, our discussions were rooted in an epistemological framework, focusing on what constitutes scientific knowledge. Today, we transition toward an ontological and metaphysical perspective, questioning the very existence and nature of these laws. While ‘metaphysics’ may sometimes carry connotations of the abstract or esoteric, it is essential for understanding the presuppositions underlying scientific inquiry. Specifically, we must consider what kinds of entities we assume exist and how these assumptions shape our scientific framework.

**Defining the Laws of Nature**

It is crucial to distinguish between scientific laws and laws of nature. *Scientific laws* represent our best approximations of fundamental truths, but they are not necessarily the ultimate laws governing reality. The notion of ‘*natural laws*’ is often conflated with ethical or legal principles, yet these are entirely distinct categories.

Niels Bohr once remarked that physics is not about nature itself, but about what we can say about nature—a view rooted in positivism. However, if we shift from discussing how we describe nature to addressing what actually constitutes nature, we enter the domain of metaphysics. This distinction forms the foundation of today’s discussion.

**The Regularity and Necessitarian Theories**

One of the central questions in metaphysics concerns whether the laws of nature are merely descriptive regularities (the *Regularity Theory*) or if they possess an inherent necessity (the *Necessitarian Theory*). The former suggests that laws of nature simply describe consistent patterns we observe, whereas the latter posits that these laws are fundamental, governing principles that cannot be otherwise.

The notion of stability and regularity in the natural world is foundational to scientific inquiry. It is the assumption that the same physical principles apply universally, allowing us to generalize observations beyond specific experimental conditions. However, this assumption requires philosophical justification.

The concept of laws governing nature has evolved over time. Ancient Stoic philosophers viewed the harmony between natural and ethical laws as essential to human understanding. In the modern era, Descartes and many scientists up to the 19th century viewed the laws of nature as divine ordinances, with figures like Galileo describing the universe as a book written in mathematical language by God. This theological perspective provided early scientists with a framework for investigating nature, though it has largely been supplanted by secular scientific interpretations.

In the 20th century, philosopher David Lewis and others distinguished between laws of science—our formulated approximations—and the true, fundamental laws of nature, which remain elusive. Philosopher Nancy Cartwright further developed this idea, arguing that scientific laws are inherently inaccurate representations of deeper metaphysical principles.

**The Challenge of Universality and Causality**

A critical issue in the philosophy of science is whether laws discovered through experimentation are universally valid. Galileo, for example, never conducted free-fall experiments in a vacuum but inferred his conclusions from inclined plane experiments. Similarly, we must question whether findings from contemporary particle physics experiments apply universally.

This brings us to the concept of causality. Many scientific laws, particularly in classical mechanics, are framed in causal terms: event A causes event B. However, fundamental laws in physics, such as those in thermodynamics and quantum mechanics, do not always adhere to a causal structure. The principle of conservation of energy, for instance, does not specify causal relationships but rather describes invariant properties of physical systems. Additionally, relativity challenges traditional notions of simultaneity and causality, further complicating our understanding.

*David Hume*’s skepticism about causality is relevant here. While often interpreted as denying causality altogether, his view was more nuanced—he argued that causality is not something we can deduce purely through reason but must be inferred from experience. This perspective remains influential in contemporary debates about the metaphysical foundations of science.

To ensure clarity and avoid potential misunderstandings, I will refer to the two principal schools of thought regarding the nature of laws as the “*Necessitarian Theory*" and the “*Regularity Theory*”, rather than the previously used term “*Humean*”. Let’s repeat this concept: the Regularity Theory posits that the laws of nature are mere descriptions of observed regularities: for instance, if we consistently observe that event A is followed by event B, we infer a law of nature from this pattern. Conversely, the Necessitarian Theory maintains that laws of nature are not just observed regularities but are underpinned by an inherent necessity that governs the behavior of entities in the universe.

**Regularity Theory**

Proponents of the Regularity Theory reject the notion that the laws of nature possess physical necessity. When an object falls, this is merely an observed phenomenon rather than an outcome dictated by an inherent causal force. According to this view, there is no metaphysical necessity linking causes and effects; rather, the laws of nature simply describe what is observed without imposing constraints on what must occur. This perspective maintains a minimal metaphysical commitment, relying solely on empirical observation. Key figures associated with this theory include A.J. Ayer and David Lewis, who were strong advocates of empiricism.

While Regularity Theory provides an elegant and parsimonious framework, it faces several challenges. One major issue is that it does not account for why observed regularities persist—why, for example, gravitational attraction remains consistent over time. Furthermore, it does not distinguish between accidental truths and necessary truths in a satisfying way.

**Necessitarian Theory**

In contrast, the Necessitarian Theory asserts that laws of nature possess an intrinsic necessity, often described as nomological necessity. According to this perspective, natural laws do not merely describe observed regularities; they actively govern the behavior of physical entities. For instance, electrons have a specific charge not simply because we observe them to, but because they are compelled to by the fundamental laws of nature. These laws are not just descriptive; they exert a governing force over physical reality.

Within this framework, the universe is structured by these necessary laws, which dictate and constrain physical phenomena. This perspective finds strong support in physics, particularly in theories such as quantum mechanics and quantum field theory, which suggest that fundamental particles behave according to deeply embedded principles of nature. Prominent philosophers supporting this view include figures such as Dretske, Tooley, and Armstrong, who argue that laws of nature must possess an inherent necessity to account for their stability and universality.

**The Laws of Nature**

Regardless of which theory one adheres to, a law of nature must meet several criteria:

1. **Empirical Truth**: A law must be based on empirical observations of the external world.
2. **Universality**: A law must hold at all times and in all locations across the universe.
3. **Absence of Proper Names**: A law cannot reference specific individuals or particular places (e.g., "William goes shopping" is not a law of nature).
4. **Universal or Statistical Nature**: A law must either be universally true or statistically probable (e.g., the probabilistic nature of radioactive decay).
5. **Conditional Structure**: A law is typically expressed in a conditional form rather than a categorical statement (e.g., "There is no perpetual motion machine of the first kind" rather than "The sun exists").

For Regularity Theorists, these five conditions suffice to define a law of nature. However, Necessitarian Theorists add a sixth requirement:

1. **Nomological Necessity**: A law must not only describe observed patterns but must also impose a necessary structure upon reality.

**Differentiating Accidental and Necessary Truths**

A key distinction in this debate is the difference between accidental truths and necessary truths. Karl Popper illustrates this with the example of the extinct moa birds of Australia. Suppose the last moa to exist lived for N years; the statement "No moa lived beyond N years" is factually correct. However, it does not qualify as a law of nature because it is contingent upon historical circumstances rather than an underlying necessity. By contrast, the statement "No object with mass can exceed the speed of light" is considered a law of nature because it expresses a fundamental physical constraint rather than a contingent fact.

This distinction highlights a core argument of the Necessitarian position: laws of nature actively prohibit certain possibilities, whereas accidental truths merely describe historical occurrences. The Necessitarian view asserts that laws of nature are not just patterns that emerge from observation but constraints that define what is possible in the universe.

**Physical Impossibility and Nomological Necessity**

To further illustrate this point, consider two statements: "Silver burns at -22°C" and "There exists a river of cola". Both statements might be factually incorrect, but they differ in their impossibility. The first statement is physically impossible because it contradicts fundamental chemical properties of silver. The second, however, is not physically impossible—under certain catastrophic or artificial conditions, a river of cola could conceivably exist. This distinction underscores the Necessitarian argument: certain statements are false because the laws of nature prohibit them, while others are merely contingently false due to external circumstances.

**The Role of Information and Scientific Progress**

A crucial question in this debate is how we determine whether a given law is necessary. If all knowledge is based on empirical observation, as the Regularity Theorists argue, then our understanding of natural laws is subject to revision as new information becomes available. However, if laws of nature possess inherent necessity, as the Necessitarian Theorists maintain, then our scientific inquiries are attempts to uncover these pre-existing constraints.

For instance, if a catastrophic event had wiped out human civilization before the Wright brothers' first flight in 1903, would that imply that heavier-than-air flight was impossible? Clearly not—it merely means that the technology was not developed in that historical context. This example demonstrates the importance of distinguishing between what is truly impossible and what is merely unrealized due to historical contingencies.

In the discussion of Necessitarianism and Regularism, we encounter two distinct perspectives on the nature of scientific laws. One viewpoint suggests that scientific inquiry should remain purely descriptive, focusing solely on calculations and empirical observations without delving into deeper metaphysical implications. The other considers the philosophical significance of scientific laws and their role in shaping our understanding of reality.

For Necessitarians, the failure of a model or theory does not necessarily imply that it is fundamentally flawed or “doomed.” Some failures may arise from limitations in our current understanding or technological constraints, rather than from intrinsic impossibilities. However, certain phenomena—such as objects exceeding the speed of light or the prospect of perpetual motion—are not merely cases of failure but are considered metaphysically impossible within the frameworks of established physical laws. This distinction underscores an important aspect of Necessitarian thought: the belief that the laws of nature are not merely descriptive but instead govern the universe in an essential and inescapable way.

Conversely, Regularists argue that laws of nature do nothing more than accurately describe observed regularities. They liken scientific laws to a newspaper, which reports events without imposing causality or necessity. This perspective, however, faces significant challenges, particularly in explaining the principle of the uniformity of nature. While a newspaper reports varied events, scientific laws consistently describe the same fundamental phenomena, such as gravitational attraction or the speed of light in a vacuum. Regularists accept the uniformity of nature as a given, without seeking to explain why it holds universally.

This raises a deeper philosophical question: are the laws of nature merely human constructs based on observation, or do they reflect a deeper metaphysical necessity? Necessitarians argue for the latter, believing that a small set of fundamental laws underpin the universe, with all other scientific principles derivable from them. However, these fundamental laws remain elusive, and our understanding of them is inevitably shaped by the limitations of our observational and theoretical frameworks.

A key issue in this debate is whether the search for fundamental laws is ultimately constrained by human cognition and language. Our understanding of nature is shaped by our position in a specific physical and conceptual framework, and it is conceivable that alternative formulations of natural laws could emerge from different perspectives or in different regions of the universe. This suggests that our current scientific theories, while progressively refined, may never fully encapsulate an ultimate truth but instead represent successive approximations.

Furthermore, the discussion touches on the epistemological distinction between scientific theories and ontological claims. While physics provides the most rigorous empirical tools for describing the universe, it may not be sufficient to address deeper metaphysical questions about the nature of reality. The progression of scientific knowledge, influenced by logic, mathematics, and philosophy, suggests that while we can refine our understanding, we may never attain absolute certainty regarding the fundamental structure of reality.

Ultimately, while empirical science remains the most powerful tool for understanding the natural world, it is essential to recognize the philosophical and methodological assumptions underlying it. Measurement and observation are crucial, but they do not exhaust all avenues of inquiry. As Wittgenstein suggested, scientific reasoning provides a ladder for understanding reality, but at a certain point, we must acknowledge the limits of empirical methodologies and consider broader metaphysical perspectives.

**Necessitarianism: Laws as Governing Principles**

In this framework, the notion of modality plays a crucial role. Modal logic, influenced by Aristotelian thought, considers certain states of affairs not just as unrealized possibilities but as metaphysically impossible. For instance, objects exceeding the speed of light or perpetual motion machines are not merely unlikely or unobserved—they are fundamentally impossible because they violate the governing laws of nature.

**Regularism: Laws as Descriptive Generalizations**

By contrast, Regularists reject the idea that scientific laws impose necessary constraints on reality. Instead, they argue that laws simply describe patterns in observed phenomena.

For a Regularist, something is physically impossible only in the sense that it has never been observed. Consider the example of a river of cola—we have never observed such a phenomenon, so we might describe it as “physically impossible” in a weak sense. However, unlike Necessitarians, Regularists would not argue that such a river could not exist in principle; it simply hasn’t happened yet.

In essence, the Regularist perspective lacks a modal dimension. There is no deeper necessity governing the world—only descriptions of what has been observed so far. This approach raises an important question: Does the mere absence of an event make it physically impossible? If we discovered tomorrow that neutrinos travel faster than light, a Regularist would have no fundamental problem accommodating this new observation. A Necessitarian, however, would face a deeper metaphysical challenge, as this would require a revision of what is considered fundamentally impossible.

**Primitive Laws**

Some philosophers argue that laws of nature are primitive, meaning that they do not depend on anything more fundamental. Philosopher Mario Hubert, for example, suggests that the laws of physics may simply be the constraints on what is physically possible in the world. This idea echoes Aristotelian perspectives, in which the world might contain an infinite number of possible configurations, but the laws of nature constrain which of these possibilities can manifest.

This view has significant advantages: it is simpler and more elegant than strict Necessitarianism; it acknowledges that while we may live in a multiverse, there must still be some fundamental principles governing how different universes operate; it avoids the problems associated with Regularism, where scientific laws risk being mere summaries of experience rather than genuine explanations.

However, this perspective does not fully explain how laws constrain the world. This brings us to the problem of truth and laws of nature.

**Truth and Laws of Nature**

One major debate in the philosophy of science is whether laws of nature determine truth or whether truth is determined by the way the world happens to be.

In the Necessitarian view, laws actively impose structure on reality. In contrast, Regularists argue that truth emerges from empirical observations, rather than from an abstract set of governing principles.

This distinction recalls *Alfred Tarski*’s correspondence theory of truth. If I say, “The snow is white,” this statement is true because the world is such that snow is white.Necessitarians, however, introduce a stronger claim: “Snow is white because there is a law that imposes whiteness on snow.” Regularists argue that this reverses the natural order of truth—instead of deriving truth from the world, Necessitarians derive truth from statements about laws. This is a point of contention, as it suggests that laws dictate reality rather than simply describe it.

**The Problem of Statistical Laws**

One significant challenge for Necessitarianism is the existence of statistical laws, particularly in quantum mechanics. For regularists there is no issue with statistical laws—they simply describe observed probabilities. Necessitarians, however, struggle to explain how a law of nature can be probabilistic.For instance, if a law states that an event occurs 50% of the time, does this mean the event is both permitted and forbidden in equal measure? This raises a deep question: Can a law of nature be probabilistic and still be a true constraint?

**Implications for Cosmology**

This issue is particularly relevant in cosmology, where scientists rely on statistical models to describe the early universe. If laws of nature were entirely deterministic, this would pose challenges for our understanding of quantum fluctuations and radioactive decay.

The distinction between Regularism and Necessitarianism has major consequences for cosmology and our understanding of the universe’s origins. Regularists argue that we can only describe what we observe and that the universe’s laws may change over time or in different regions of space. Necessitarians maintain that the laws of nature must impose fundamental constraints, allowing us to extrapolate backward to the conditions of the early universe.

If the Regularist approach were correct, how could we be certain that the laws of physics applied consistently immediately after the Big Bang? For Necessitarians, this is not a problem—laws of nature must have been in place, ensuring consistency throughout cosmic history. However, Regularists cannot guarantee this, which raises questions about the reliability of cosmological models.

**Why Does Science Need Metaphysics?**

One criticism often directed at philosophers is that scientific practice is merely about calculations and predictions—not metaphysical speculation. However, as physicist Richard Feynman pointed out, science becomes truly interesting when the unexpected happens.

The discussion between Regularists and Necessitarians is not just academic—it shapes the way we think about the nature of science itself. If Regularism is correct, science is an ever-evolving description of what happens, and we should not assume the permanence of natural laws. If Necessitarianism is correct, there are fundamental truths about reality that impose constraints, shaping the very fabric of existence.

We may never resolve these questions definitively, but engaging with them is essential. Philosophy of science challenges us not only to compute but to question, to probe deeper into the assumptions that underpin our theories.

Ultimately, our goal is not to convince, but to explore. Science is an open-ended inquiry, and as long as we continue asking profound questions, we will keep advancing our understanding of the universe.